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Environmental and Social Impact Assessment of the CBG Mine Extension Project

Chapter 2 – Physical Environment Study

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Compagnie des bauxites de Guinée

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ABBREVIATIONS AND ACRONYMS

(Note: Text in square brackets [] is a translation of a French term for which there is no official English version.)

°C: Degrees Celsius

AFD Agence Française de Développement [French development agency]

AIDS: Acquired immune deficiency syndrome

AIP: Annual investment plan

AMC: Alliance Mining Commodities Ltd.

ANAÏM: Agence Nationale d'Aménagement des Infrastructures Minières [national agency for mining infrastructure development]

APA: Laboratoire Archéologie et Peuplement de l'Afrique [African archeology and settlement laboratory]

APAÉ: Association des parents et amis d'élèves [parents and friends of students]

ARV: Antiretroviral

BAP: Biodiversity action plan

BEPC: *Brevet d'études du premier cycle du second degré* [middle-school leaving certificate]

BGÉÉE: Bureau Guinéen d'Études et d'Évaluation Environnementale [Guinean bureau of environmental studies and assessment]

BM: Banque Mondiale / World Bank (WB)

BPII: *Bonnes pratiques industrielles internationales* / Industrial international best practices

C/P: Frontline fishing camps and ports

CA: *Chiffre d'affaires* [revenues]

CBG: Compagnie des Bauxites de Guinée

CCME: Canadian Council of Ministers of the Environment

CCNUCC: *Convention-cadre des Nations Unies sur le changement climatique* / World Bank United Nations Framework Convention on Climate Change (UNFCCC**)**

CDD: *Contrat de durée déterminée* [contract of defined length]

CDI: *Contrat de durée indéterminée* [contract of indefinite length]

CÉCI: *Centre d'études et de coopération internationale* / Centre for international Studies and Cooperation

CECIDE: Centre du Commerce International pour le Développement [international trade center for development]

CEDEAO: Communauté économique des États de l'Afrique de l'Ouest / United Nations Economic Commission for Africa (UNECA)

CFB: Chemin de Fer de Boké [Boké railroad]

CITES: Convention on International Trade in Endangered Species

CMG: Chambre des Mines de Guinée [Guinean chamber of mines]

COD: Chemical oxygen demand

COPC: Contaminant of potential concern

CoPSAM: Comité Préfectoral de Suivi des Activités des Miniers [prefectoral mining activity monitoring committee]

CPC: *Contaminant potentiellement préoccupant* / contaminant of potential concern (COPC)

CPD: Comité Préfectoral de Développement [prefectoral development committee]

CPÉ: *Consultation et participation éclairées* / informed prior consent (IPC)

CR: *Commune rurale* [rural commune]

CRD: *Commune rurale de développement* [rural development commune]

CSA: Centre de santé amélioré [improved health center]

CSO: Civil society organizations

CSR: Corporate social responsibility

CU: *Commune urbaine* [urban commune]

CVÉ: *Composante valorisée de l'écosystème* / valued ecosystem component (VEC)

dB: Decibel

dBA: A-weighted decibel

dBZ: Decibel relative to Z

DEP Direction Préfectorale de l'Éducation [prefectoral directorate for education]

DPUHC: Direction préfectorale de l'urbanisme de l'habitat et de la construction [prefectoral directorate for housing and construction]

DUDH: *Déclaration universelle des droits de l'homme* / Universal Declaration of Human Rights (UDHR)

ÉDG: Électricité de Guinée

EIA: Environmental impact assessment

ÉIE: *Étude d'impact environnemental* / environmental impact assessment

ÉIS: *Étude d'impact social* / social impact assessment

EITI: Extractive Industries Transparency Initiative

EPA: Environmental Protection Agency (United States)

EPI: Extended Program on Immunization

EPT: Ephemeroptera, Plecoptera and Trichoptera (types of aquatic insects)

ESCOMB: *Enquête de surveillance comportementale et biologique sur le VIH/SIDA* [HIV/AIDS behavioral and biological surveillance survey]

ESIA: Environmental and social impact assessment

ESMP: Environmental and social management plan

ETAE: *Eaux tropicales de l'Atlantique Est* [tropical waters of the Eastern Atlantic]

FEL 1: Front-end loading – preliminary economic assessment

FEL 2: Front-end loading – prefeasibility study

FEL 3: Front-end loading – detailed engineering study

FPIC: Free prior and informed consent

GAC: Guinea Alumina Corporation

GdG: *Gouvernement de la Guinée* / Government of Guinea (GoG)

GDP: Gross domestic product

GES: *Gaz à effet de serre* / greenhouse gas (GHG)

GHG: Greenhouse gas

GIEC: Groupe d'experts intergouvernemental sur l'évolution du climat / Intergovernmental Panel on Climate Change (IPCC)

GIS: Geographic information system

GNF: Guinean franc

GoG: Government of Guinea

GPS: Global positioning system

GRI: Global Reporting Initiative

GTP: Ground truth point methodology

Ha: Hectare

HAP: *Hydrocarbure aromatique polycyclique* / polycyclic aromatic hydrocarbon (PAH)

HFO: Heavy fuel oil

HP: Horsepower

HSE: Health, safety and environment

IBA: Important bird area

ICCPR: International Covenant on Civil and Political Rights

ICESCR: International Covenant on Economic, Social and Cultural Rights

ICMM: International Council on Mining and Metals / Conseil International des Mines et des Métaux

IFC: International Finance Corporation / *Société Financière Internationale* (SFI)

IFI: International finance institutions / *institutions financières internationales*

ILO: International Labor Organization

IPCC: Intergovernmental Panel on Climate Change

ISQG: CCME Interim Sediment Quality Guideline

IST: *Infections sexuellement transmissibles* / sexually transmitted infections (STIs)

ITIE: Initiative pour la Transparence des Industries Extractives / Extractive Industries Transparency Initiative (EITI)

IUCN: International Union for Conservation of Nature / Union internationale pour la conservation de la nature (UICN)

km: Kilometer

km^2: Square kilometer

LA_{eq}: Equivalent sound level (dBA)

LDIQS: CCME Interim Sediment Quality Guideline

L_{eq}: Equivalent sound level (dB)

m: Meter

m^2: Square meter

m^3: Cubic meter

m^3/h: Cubic meters per hour

MDDEP: Ministère du Développement durable, de l'Environnement et des Parcs du Québec, now called the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques [Quebec ministry of sustainable development, environment and parks, now called the ministry of sustainable development, environment and the fight against climate change]

MDT: *Matières dissoutes totales* / total dissolved solids (TDS)

ml: Milliliter

mm: Millimeter

MME: Ministère des Mines et de l'Énergie / Ministry of Mines and Energy

MTPA: Million tonnes per annum

MW: Megawatt

N/A: Not applicable

NEP: *Niveau d'effet probable du CCME* / CCME probable effects level (PEL)

NGO: Nongovernmental organization

NP: *Norme de performance de la SFI* / IFC Performance Standard (PS)

NSP: *Ne s'applique pas* / not applicable (N/A)

OAU: Organization of African Unity

OCDE: Organisation de Coopération et de Développement Économique / Organization for Economic Cooperation and Development (OECD)

OECD: Organization for Economic Cooperation and Development

OIT: Organisation internationale du Travail / International Labor Organization (ILO)

OMS: Organisation mondiale de la Santé / World Health Organization

ONG: *Organisme non-gouvernemental* / nongovernmental organization

ONU: Organisation des Nations-Unies / United Nations

OSC: *Organisations de la société civile* / civil society organizations

OUA: Organisation de l'unité africaine / Organization of African Unity

OWINFS: Our World Is Not for Sale

PACV: *Programme d'appui aux organisations villageoises* [village support program]

PAH Polycyclic aromatic hydrocarbon

PAI: *Plan annuel d'investissement* / annual investment plan

PARC: *Plan d'action de réinstallation et de compensation* / resettlement and compensation action plan (RAP)

PCB: *Plan de conservation de la biodiversité* / biodiversity action plan (BAP)

PCS: *Partenaires contre le SIDA* [AIDS prevention group]

PDL: *Plan de développement local* [local development plan]

PEL: CCME probable effects level

PEPP: *Plan d'engagement des parties prenantes* / stakeholder engagement plan (SEP)

PÉV: *Programme élargi de vaccination* / Expanded Programme on Immunization (EPI)

PGES: *Plan de gestion environnementale et sociale* / environmental and social management plan (ESMP)

PIB: *Produit intérieur brut* / gross domestic product (GDP)

PIDCP: *Pacte international relatif aux droits civiles et politiques* / International Covenant on Civil and Political Rights (ICCPR)

PIDESC: *Pacte international relatif aux droits économiques, sociaux et culturels* / International Covenant on Economic, Social and Cultural Rights (ICESCR)

PK: Point kilométrique / kilometer point

PM_{10}: Particulate matter in air up to 10 micrometers in size

$PM_{2.5}$: Particulate matter in air up to 2.5 micrometers in size

PMH: *Pompe à motricité humaine* / manually operated pump

PNUD: Programme des Nations-Unies pour le Développement / United Nations Development Program (UNDP)

PP: *Parties prenantes* / stakeholders

PPV: Peak particle velocity

PRCB: Projet de renforcement des capacités de Boké [Boké rural community development project]

PS: IFC Performance Standard

QSE: Quality, safety and environment

RAP: Resettlement and compensation action plan

RAP: Rapid assessment program / rapid biological assessment

RSE: *Responsabilité sociale des entreprises* / corporate social responsibility (CSR)

RTA: Rio Tinto Alcan

SAG: Société Aurifère de Guinée [Guinea gold corporation]

SDT: *Solides dissous totaux* / total dissolved solids (TDS)

SEG: Société des Eaux de Guinée [Guinea water corporation]

SEP: Stakeholder engagement plan

SFI: Société Financière Internationale / International Finance Corporation (IFC)

SIA: Social impact assessment

SIDA: *Syndrome d'immunodéficience acquise* / acquired immune deficiency syndrome (AIDS)

SIG: *Système d'information géographique* / geographic information system (GIS)

SNAPE: Service national des points d'eau [national water supply points service]

SO_x: Sulphur oxides

SP: *Sous-préfecture* [subprefecture]

SSC: Species Survival Commission

SSE: *Santé, sécurité, environnement* / health, safety and environment (HSE)

SST: *Solides en suspension totaux* / total suspended solids (TSS)

STI: Sexually transmitted infections

TDR: *Termes de référence* / terms of reference (TOR)

TDS: Total dissolved solids

TOR: Terms of reference

TPE: *Très petite entreprise* / very small business

TPH: Tonnes per hour

TSP: Total suspended particulates

TSS: Total suspended solids

UDHR: Universal Declaration of Human Rights

UICN: Union internationale pour la conservation de la nature / International Union for Conservation of Nature (IUCN)

UN: United Nations

UNDP: United Nations Development Program

UNECA: United Nations Economic Commission for Africa

UNESCO: United Nations Organization for Education, Science and Culture / Organisation des Nations unies pour l'éducation, la science et la culture

UNFCC: United Nations Framework Convention on Climate Change

UniGE: Université de Genève / University of Geneva

UTM: Universal Transverse Mercator

VEC: Valued ecosystem component

VIH: *Virus de l'immunodéficience humaine* / human immunodeficiency virus (HIV)

WB: World Bank / Banque Mondiale (BM)

WHO: World Health Organization / Organisation mondiale de la Santé (OMS)

ZÉE: *Zone économique exclusive de la Guinée* [Guinea economic exclusive zone]

ZICO: *Zone importante pour la conservation des oiseaux* / important bird area (IBA)

CHAPTER 2 – PHYSICAL ENVIRONMENT STUDY

2.1 Introduction

2.1.1 Description of the Project

The Extension Project of the CBG mine is described in Chapter 1.

This physical baseline and impact study contributes to a good understanding of the physical aspects in the area potentially affected and forms, with the biological and social studies, the foundations of a thorough study of the impacts associated with the increase in extraction rate.

2.1.2 Goals of the study

2.1.2.1 Objectives

The physical study had as goals:

- to assemble and evaluate the existing prior data;
- to document the methodology used in the field studies undertaken for the ESIA;
- to present the results of the field studies undertaken for the ESIA;
- to summarize knowledge of the baseline;
- to analyze the impacts of the Extension Project;
- to propose mitigation, control and monitoring measures; and
- to present the residual impacts.

2.1.2.2 Aspects studied

The physical environment study concentrates on the following major topics:

- climate;
- air quality;

- noise;
- vibration;
- surface and groundwater quality;
- sediments;
- landscape;
- geology;
- soils; and
- seismology.

2.1.2.3 Field studies

The following field studies were undertaken in 2014 and are described in the appropriate sections:

- meteorology;
- air quality (gases, particulates, heavy metals):
- ambient noise levels;
- surface water and groundwater quality;
- sediment quality;
- lndscapes ; and
- soil quality.

2.1.3 Study Areas

2.1.3.1 Areas affected by the Project

The Study Areas are identified in a general way in Chapter 1. Only some specific clarifications for the physical studies are presented in the following sections.

2.1.3.2 Zone 1

The environmental Study Area for Zone 1 was defined by the perimeter of the areas to be mined according to the 2013-2028 Mining Plan, plus an additional three kilometer zone around this perimeter to take into account the effects related to working the deposits (noise, dust, etc.). This three kilometer zone seems reasonable in view of the size of the deposits and relatively short period required to mine them.

2.1.3.3 Zone 2

The environmental Study Area for Zone 2 was defined by the superposition of two potential impact areas. The first is an area extending ten kilometers around the CBG plant and port. This area accounts, in a conservative manner, for impacts related to air quality and noise. The second is a marine area linked to potential impacts from port modifications and the increase in marine traffic.

2.1.3.4 Zone 3

Zone 3 was not the subject of specific field studies, however noise levels following the increase in train traffic were evaluated. The impact zone extends in a variable fashion out from the railroad (see Section 2.3).

2.1.4 Participants

The ESIA study team is described in a general way in Chapter 1.

For this physical study, the key personnel are described in the following sections:

The CBG elected to conduct the field studies for the physical part of the ESIA itself, with the support of the ÉEM team. The ÉEM team determined the field sampling program. The ÉEM team also helped CBG in the selection of appropriate equipment (including spares and supplies required) and in the coordination of the delivery of the equipment to CBG personnel in Guinea. The CBG technicians followed the procedures established by the ÉEM team for correct sampling and were responsible for the following tasks:

- installation and operation of equipment;
- changing of filters, re-initialization of the units, recharging of the batteries, etc.;
- storage of the samples after collection and recording in a protocol all the pertinent required and supplementary data required;
- shipping of the samples to Canada for analysis, including completing the chain of custody elements; and
- required routine maintenance.

CBG was also responsible for the greenhouse gas assessment presented in Section 2.2.5.2.

The key persons are:

- Stéphane Dallaire, responsible for the *Hygiène, Sécurité, Environnement, Relations communautaires du Projet d'extension de la CBG*, responsible for the baseline field studies and principal client contact for the ÉEM physical study team;
- M. Mamadou Oury Diallo, chauffeur and logistical support;
- M. Raymond Marie Coumbassa, HSE (*hygiène industrielle*) counselor; and
- M. Abraham Richard Camara, HSE (*hygiène industrielle*) counselor.

2.1.4.1 ÉEM

ÉEM had the overall responsibility for the studies, the reports and the management of the ESIA. The key person is:

- Eric Muller – leader for the environmental studies

2.1.4.2 SENES Consulting Ltd.

SENES Consulting Ltd. (SENES Consultants) had the specific responsibility of the studies for air quality, noise and vibrations, water and sediments.

- Jennifer Kirkaldy – responsible at SENES Consultants for the Extension Project

Air Quality:

- Kim Theobald;
- James Fletcher; and
- Abby Salb.

Noise and vibrations:

- Nick Shinbin; and
- Paul Kirby

Water and sediments:

- Stacey Fernandes;
- Helen Manolopoulos; and
- Craig Kelly.

2.1.4.3 Sylvatrop Consulting

Sylvatrop Consulting had the responsibility for the landscape study. The key person is:

- Michel Bureau – scientific director

2.1.5 Prior studies

All of the ÉEM teams (the physical, biological and social teams) tried to obtain and consult all prior reports that could reduce or target the field work required.

Two relatively recent studies had important data for this ESIA.

2.1.5.1 The GAC ESIA

The Guinea Alumina Corporation (GAC) has a bauxite mine project in an area close to the CBG mine site and that is physiographically similar. GAC also has projects in Kamsar. The GAC studies (Knight Piésold and Co., 2008) thus include useful data for Kamsar and the CBG mine site area.

2.1.5.2 The AECOM ESIA for CBG

In 2011, AECOM produced an ESIA for CBG for a production increase from 13.5 MTPA to 16.5 MTPA (AECOM, 2011). The ÉEM team has integrated the pertinent baseline data from the 2011 AECOM ESIA to reduce needless duplication of effort.

2.1.6 Structure du rapport

The complete SENES Consultants reports (in English) for air quality, noise and vibrations and water and sediments are presented as appendices (Annexe 2-2 air quality, Annexe 2-9 noise and vibrations, Annexe 2-10 surface and groundwater). Only the summaries of the reports are presented in this report.

2.2 Air quality

2.2.1 Introduction

SENES Consultants was mandated by ÉEM (who is managing the ESIA for the Project) to produce a study on air quality. This section is a summary of the full air quality report: CBG Extension Project – Environmental Impact Assessment – Air Quality Impact Assessment (SENES Consultants, 2014a) included in the appendices (Annexe 2-2).

2.2.2 Regulatory framework

The methodology applied for the development of the air quality impact assessment conformed to the requirements of the Bureau guinéen des évaluations environnementales (BGÉEE) and its relevant legal framework. Concordance with the International Finance Corporation (IFC) *Performance Standards on Environmental and Social Sustainability* was also assured. The *IFC Environmental, Health and Safety (EHS) Guidelines for Air Emissions and Ambient Air Quality*, specify that:

> Projects should prevent or minimize impacts by ensuring that emissions do not result in pollution concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines (Table 2.1) or other internationally recognized sources (IFC 2007).

Table 2-1: World Health Organization Ambient Air Quality Guidelines [1,2]

Contaminant	Averaging Period	Guideline Value (µg/m^3)			
		Interim Target 1	Interim Target 2	Interim Target 3	Guideline
SO_2	24 hour	125	50		20
	10 minute				500
NO_2	1 year				40
	1 hour				200
PM_{10}	1 year	70	50	30	20
	24 hour	150	100	75	50
$PM_{2.5}$	1 year	35	25	15	10
	24 hour	75	50	37.5	25

1 World Health Organization (WHO). *Air Quality Guidelines Global Update, 2005*. PM 24-hour value is the 99th percentile
2 Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines

The IFC (IFC, 2007) *EHS Guidelines for Air Emissions and Ambient Air Quality*, include the most recent WHO guidelines. The WHO guidelines recognize the need for a staged approach to achieving the recommended guidelines and consequently provide interim targets for SO_2, PM_{10} and $PM_{2.5}$, in particular when the pollution is already high in the target areas.

The existing air quality environment in Kamsar and Sangarédi is affected by the bauxite processing and mining and transportation activities, as well as activities undertaken by the local population such as local traffic, cooking fires and burning to clear brush. Other sources that contribute to the air quality environment are hot dry winds (the Harmattan) during the dry season that blow out of the east and northeast, carrying warm air and dust from the Sahara Desert to the Gulf of Guinea. Further, windblown dust from open exposed areas and brush fires also contribute greatly to the elevated levels measured in the local environment.

The current air quality at Kamsar and Sangarédi can be considered as having high pollution levels. In the absence of national applicable standards the WHO Interim Target 1 is applied and referenced.

2.2.3 Baseline assessment methodology

2.2.3.1 Ambient air quality baseline measurements

In an effort to characterize the existing ambient air quality within the Project area (both Kamsar and Sangarédi), an ambient air quality monitoring program was completed at the Project site between February and May 2014. Air quality monitoring was completed in accordance with the *IFC EHS Guidelines – General EHS Guidelines: Environmental* (IFC, 2007) requirements. The baseline monitoring was completed by CBG staff in accordance with detailed U.S. EPA-based methods and procedures. Sample analysis was completed by Maxxam Analytics, an accredited Canadian laboratory. The basic procedure consisted of:

- Selecting representative monitoring locations;
- Collecting measurements of ambient air concentrations of both particulate and gaseous Contaminants of Potential Concern (COPCs) (PST, PM_{10}, $PM_{2,5}$ SO_2 and NO_2) at the identified locations over a period of 24 hours (for particulates) or 30 days (for gaseous contaminants); and
- Validating and correcting the sample analysis data and field notes to remove anomalous values.

The results of the ambient air quality monitoring program were also compared to ambient air quality data collected for the previous air quality impact assessment (AECOM, 2011).

2.2.3.2 Air quality

In addition to the measurement activities described in the previous section, atmospheric dispersion modeling of the baseline conditions in due to the CBG operations in Kamsar and Sangarédi was conducted. This allows for a direct comparison between the baseline and future models to predict future effects (Section 7.0). The ambient baseline monitoring data was also used to validate the baseline model. Air dispersion modeling was undertaken using the CALMET/CALPUFF modeling system (Scire et. al. 1999, 2000a,b), a current state-of-the-art dispersion model to predict the incremental concentrations of COPCs (TSP, PM_{10}, $PM_{2.5}$ SO_2 and NO_2) within a modeling region or domain. The CALPUFF model has the ability to handle both complex meteorology and an array of multiple emissions sources from facilities and activities located over a large area and is the U.S. EPA regulatory model for long-range transport studies (U.S. EPA 2005). The CALPUFF modeling system is superior to AERMOD in areas of significant local terrain relief (i.e., hilly or mountainous areas with valley channeled air flows) or shoreline effects due to the proximity of a large water body (i.e., the Atlantic Ocean) that alters the meteorological flow regime.

In general, the recommended methodologies outlined in the *IFC EHS Guidelines – General EHS Guidelines: Environmental* (IFC, 2007) document were followed when completing the atmospheric dispersion modeling. The details of the modeling methodology are provided in the CBG Extension Project air quality impact assessment (SENES Consultants, 2014a).

This approach for baseline air quality assessment is necessary where there is an existing facility that will be expanded in order to provide a meaningful benchmark against which the model predictions for the future expansion scenarios can be compared. In this manner, the incremental change resulting from implementation of the project can be reliably determined.

2.2.4 Baseline assessment

2.2.4.1 Climate and meteorology

Climate

Maritime Guinea is characterized by a tropical and humid climate that has two seasons:

- The dry season (mid-November through to May) is typified by hot dry winds (the Harmattan) that blow out of the east and northeast, carrying warm air and dust from the Sahara Desert to the Gulf of Guinea; and
- The rainy season (lasting the balance of the year) brings heavy monsoon rains, high humidity and winds from the southwest. Rainfall is heaviest in the south of Guinea, diminishing towards northern coastal areas and the eastern interior.

Due to its proximity to the equator, the day-night cycle in Guinea varies little throughout the year. Average daily temperatures also vary only slightly throughout the year. There are no long-term climate stations in the vicinity of Kamsar or Sangarédi. Boké, located approximately, 45 km inland, northeast of Kamsar, and 70 km southwest of Sangarédi has a long term climate data. Summary statistics based on data collected by the World Meteorological Organization are provided in Table 2-2. Detailed historical weather and climate data are generally unavailable for Kamsar and Sangarédi, with the exception of a limited precipitation record in Sangarédi, which has been collected by CBG (Table 2-3). The monthly rainfall statistics for Boké are also provided.

Table 2-2: Boké Climate Normals (1961-1990)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Temp. 30y Mean (°C)	26.3	27.9	29.1	29.7	28.3	27.1	27.4	25.4	24	26.8	28.2	27.2	27.28
High Temp. 30y Mean (°C)	39.7	38.4	40.5	40.1	38.5	35	32.8	32.4	33.1	33.9	35.5	35.7	36.3
Low Temp. 30y Mean(°C)	14.4	15.7	17.7	19.9	20.9	20.4	20.7	20.5	19.7	20.1	18.1	14.4	18.54
Precip. Mean (mm)	0	0.1	0.2	9	105	258	485	424	545	317	67	2	184.36
Relative Humidity Mean (%)	53	58	53	55	67	76	75	82	92	78	69	58	68

Source (World Climate, 2014)

Table 2-3: Monthly Precipitation in Sangarédi and Boké

Month	Monthly Precipitation (mm)			
	Sangarédi (1974 to 1978 & 1980 to 2000)		Boké (1974 to 1978 & 1980 to 2000)	
	Average	Maximum	Average	Maximum
Jan	2.3	31.0	0.5	7.1
Feb	0.8	19.8	1.0	22.1
Mar	1.8	35.8	0.3	4.7
Apr	18.6	95.0	5.0	42.6
May	111.3	222.2	89.3	217.0
Jun	270.9	514.2	240.7	440.1
Jul	427.4	711.2	463.7	691.2
Aug	447.1	648.5	522.1	789.1
Sep	437.8	745.5	456.5	807.6
Oct	316.2	498.6	313.0	468.0
Nov	71.9	195.9	59.5	232.3
Dec	0.5	10.8	1.2	14.3
Annual	2105.2	2995.8	2152.8	2990.8

Source: SNC Lavalin 2005 (Table 3.1)

Meteorological modeling

In order to overcome the limited observing record in Kamsar and Sangarédi, five years of site-specific meteorology was developed for both sites for the 2009 – 2013 period. Hourly meteorology was developed as described in the CBG Extension Project air quality impact assessment (SENES Consultants, 2014a).

2.2.4.2 Ambient air quality

Ambient air quality monitoring in Kamsar

Tables 2-4 and 2-5 present a summary of the monitoring results for the two ambient air quality monitoring stations (AQ-1 and AQ-2) located in Kamsar for the spring 2014 monitoring campaign. Table 2-4 also presents the results of the ambient air quality PM_{10} and $PM_{2.5}$ monitoring undertaken in January 2011 around the CBG Bauxite processing facility in Kamsar (AECOM 2011).

The locations of the ambient air quality monitoring stations are shown in Map 2-1. The ambient monitoring locations for the 2011 particulate monitoring were further away from the CBG property than the 2014 measurement locations. Sample location AA1 was selected to be representative of a background air concentration located on farmland north of Kamsar. Sample location AA7 was selected to be representative of the Kamsar urban environment.

Map 2-1 Air quality sampling points in Kamsar (2014)

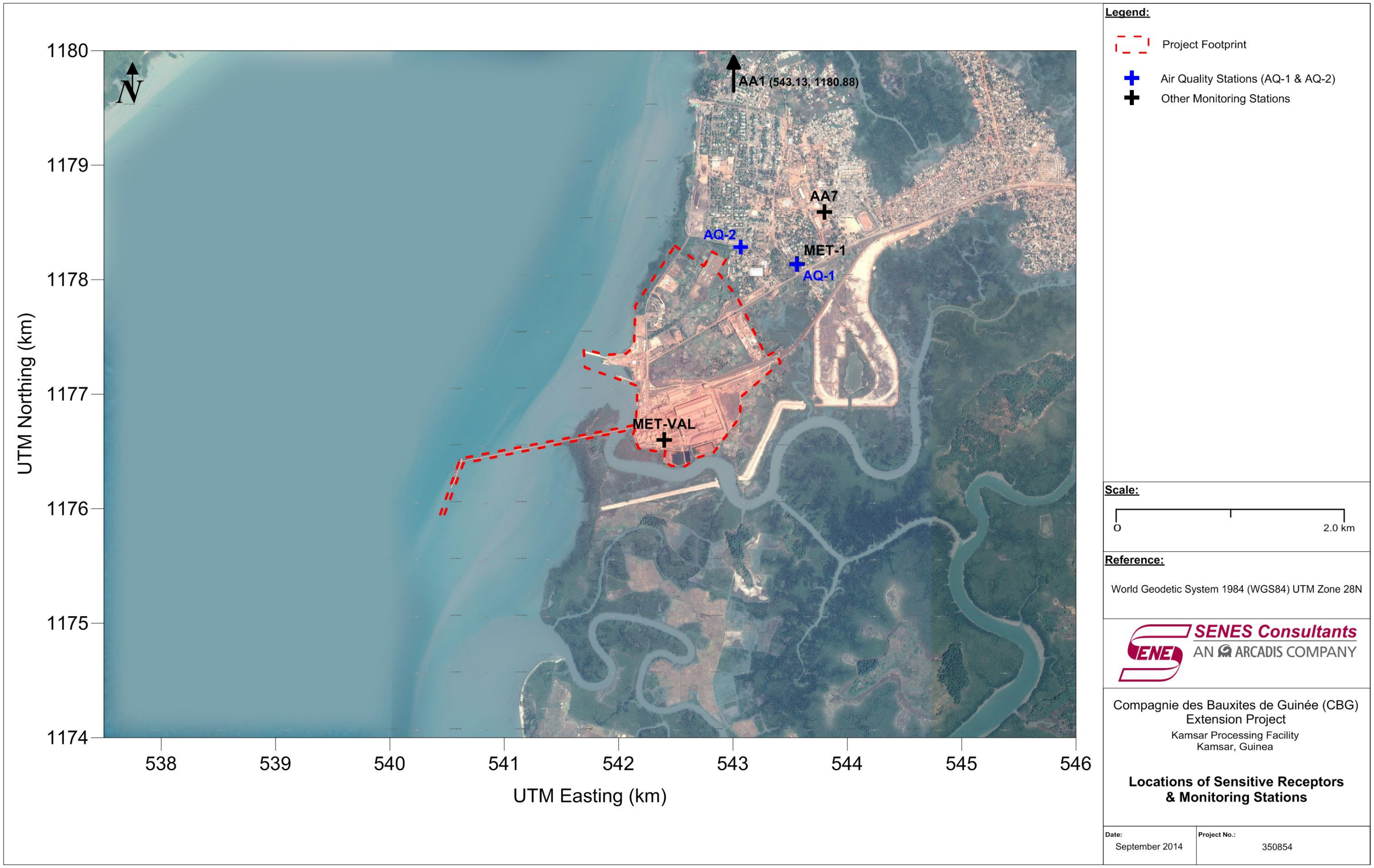

Table 2-4: Results of Baseline Particulate Monitoring in Kamsar (μg/m^3)

Sample Location	No. Sample Days	Average Daily Concentration (μg/m³)			Max Daily Concentration (μg/m³)		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ-1 Alcoa (2014)	12	160.3	112.6	70.5	300.2	244.4	117.7
AQ-2 École (2014)	12	170.0	122.5	70.3	317.8	245.3	123.5
AA1 (North Kamsar) (2011)[a]	2	-	218.0	48.6	-	223.5	57.5
AA7 (CBG Garage) (2011)[a]	1	-	134.2	34.0	-	134.2	34.0
WHO Interim Target-1			150	75		150	75
WHO Interim Target-2			100	50		100	50
WHO Interim Target-3			75	37.5		75	37.5
WHO Guideline			50	25		50	25

TSP: total suspended particulate; PM_{10}: fine particulate < 10 μm; $PM_{2.5}$: fine particulate < 2.5 μm.
[a] – AECOM 2011

The results of the ambient air quality monitoring campaign indicate that the Kamsar airshed is already burdened with fine particulates. While the observed average daily concentrations of PM_{10} and $PM_{2.5}$ measurements conducted in 2014 are below the WHO Interim Target-1, maximum daily concentrations of PM_{10} and $PM_{2.5}$ at AQ-1 and AQ-2 are approximately 60% higher than the WHO Interim Target-1. The results at AQ-1 and AQ-2 are generally consistent with the limited sampling conducted for the previous assessment of ambient air quality in Kamsar (AECOM, 2011).

Table 2-5: Results of Baseline Gaseous Contaminant Monitoring in Kamsar (μg/m^3) (30 Day Average)

Sample Location	No. of Samples	Average Monthly Concentration (μg/m³)			Max Monthly Concentration (μg/m³)		
		NO_2	NOx	SO_2	NO_2	NOx	SO_2
AQ-1 Alcoa	4	5.0	13.6	5.0	5.5	15.2	7.1

NO_2: nitrogen dioxide; NOx: oxides of nitrogen; SO_2: sulfur dioxide.

Ambient NO_2 and SO_2 measurements at AQ-1 are approximately 10% of applicable WHO guidelines, even after converting the 30-day measurements to common (i.e., 10-minute, 24-hour and annual) averaging times (as described in the CBG Extension Project air quality impact assessment (SENES Consultants, 2014a).

Modeling of existing air quality in Kamsar

As described previously, atmospheric dispersion modeling was conducted in order to evaluate the success of the ambient air quality monitoring campaign and characterize existing air quality conditions in Kamsar. Contour plots for contaminants having WHO guidelines are presented in Annexe 2-1.

The contour plots show maximum model predicted concentrations resulting from emissions from the Kamsar Processing Facility. It is important to note that the maximum predicted concentrations (for 10 min, 1 hour or 24 hour timeframes) shown in the figures represent the single highest concentration predicted to occur at each location, at any time during the 5-year assessment period. Therefore, the contours shown do not represent a "snapshot" in time as these maxima may occur on different days, under different meteorological conditions. Further, all COPCs were modeled as gases which does not consider plume depletion for particulate. Consequently the TSP, PM_{10} and $PM_{2.5}$ air concentrations are overestimated. Given the variability of background particulate concentrations as well as the local source contribution (i.e. domestic cooking, local roads and open burning), the predicted particulate concentrations presented in this assessment are generally considered to be reflective of the increment from the Extension Project as well as background.

Maximum daily modeling results at AQ-1 and AQ-2 are presented in Table 2.6, and annual results in Table 2.7. Table 2.8 presents model results for 10 minute SO_2, and 1 hour NO_2.

Table 2-6: Predicted Maximum Daily Concentrations in Kamsar (μg/m^3)

Receptor Location	Predicted Maximum Daily Concentration (μg/m³)			
	PM_{10}	$PM_{2.5}$	NO_2	SO_2
AQ-1 Alcoa - Maximum	243	122	48	66
AQ-1 Alcoa – 99th percentile[a]	186 (10)	93 (11)		
AQ-2 École – Maximum	246	120	53	71
AQ-2 École – 99th percentile[a]	160 (5)	80 (6)		
WHO Interim Target-1	150	75	-	125
WHO Interim Target-2	100	50	-	50
WHO Interim Target-3	75	37.5	-	-
WHO Guideline	50	25	-	20

a – 99th percentile of modeled data to compare to WHO guidelines. The number of exceedances is per year is indicated in parentheses ()

Model-predicted air concentrations of fine particulate (PM_{10} and $PM_{2.5}$) are above the WHO Interim Target-1. However, the model results show good agreement with ambient particulate and gaseous measurements.

Table 2-7: Predicted Average Annual Concentrations in Kamsar (μg/m^3)

Receptor Location	Predicted Average Annual Concentration (μg/m³)			
	PM_{10}	$PM_{2.5}$	NO_2	SO_2
AQ-1 Alcoa	44	23	11	14
AQ-2 École	34	18	8	11
WHO Interim Target-1	70	35	-	-
WHO Interim Target-2	50	25	-	-
WHO Interim Target-3	30	15	-	-
WHO Guideline	20	10	40	-

Table 2-8: Predicted Concentrations for Other Averaging Periods in Kamsar (μg/m^3)

Receptor Location	Predicted Average Annual Concentration (μg/m³)	
	NO_2	SO_2
	1-hour	10-minute[a]
AQ-1 Alcoa	141	347
AQ-2 École	176	410
WHO Guideline	200	500

a – Converted from 1 hour average using the time averaging calculation in SENES Consultants (2014a)

While the predicted annual concentrations of NO_2 are higher than the observed 30-day average values, this is explained by the limited monitoring period, the difference in averaging times (i.e., annual versus 30-day) and the conservative assumption of a 70% conversion of NO_x to NO_2 (see SENES, 2014a). After taking these considerations into account, predicted and monitored concentrations of gaseous COPCs agreed well (i.e., within a factor of 2x, which is considered acceptable for air dispersion modeling).

The close agreement between the modeling predictions and the maximum observed baseline concentrations supports the inference that the CBG Bauxite Processing Facility at Kamsar is a primary source of fine particulate at AQ-1 and AQ-2. However, as previously mentioned, it is likely that other local sources of fine particulate are contributing to the baseline totals and only a portion of the measurements can be attributed to emissions from the Kamsar Processing Facility.

Ambient air quality monitoring in Sangarédi

Table 2-9 presents a summary of the particulate monitoring results for the four ambient air quality monitoring stations (AQ-10, AQ-11, AQ-12 and AQ-13) located in Sangarédi for the spring 2014 monitoring campaign. The locations or the ambient air quality monitoring stations are shown in Map 2-2. The results at AQ-10, AQ-11, AQ-12 and AQ-13 are broadly consistent with the limited sampling conducted for the previous assessment of ambient air quality in Sangarédi (AECOM, 2011). In the previous assessment, daily concentrations of PM_{10} and $PM_{2.5}$ were measured only once at three locations (AA-1, AA-2, AA-3) (Table 2-9).

Map 2-2 Air quality sampling points in Sangarédi (2014)

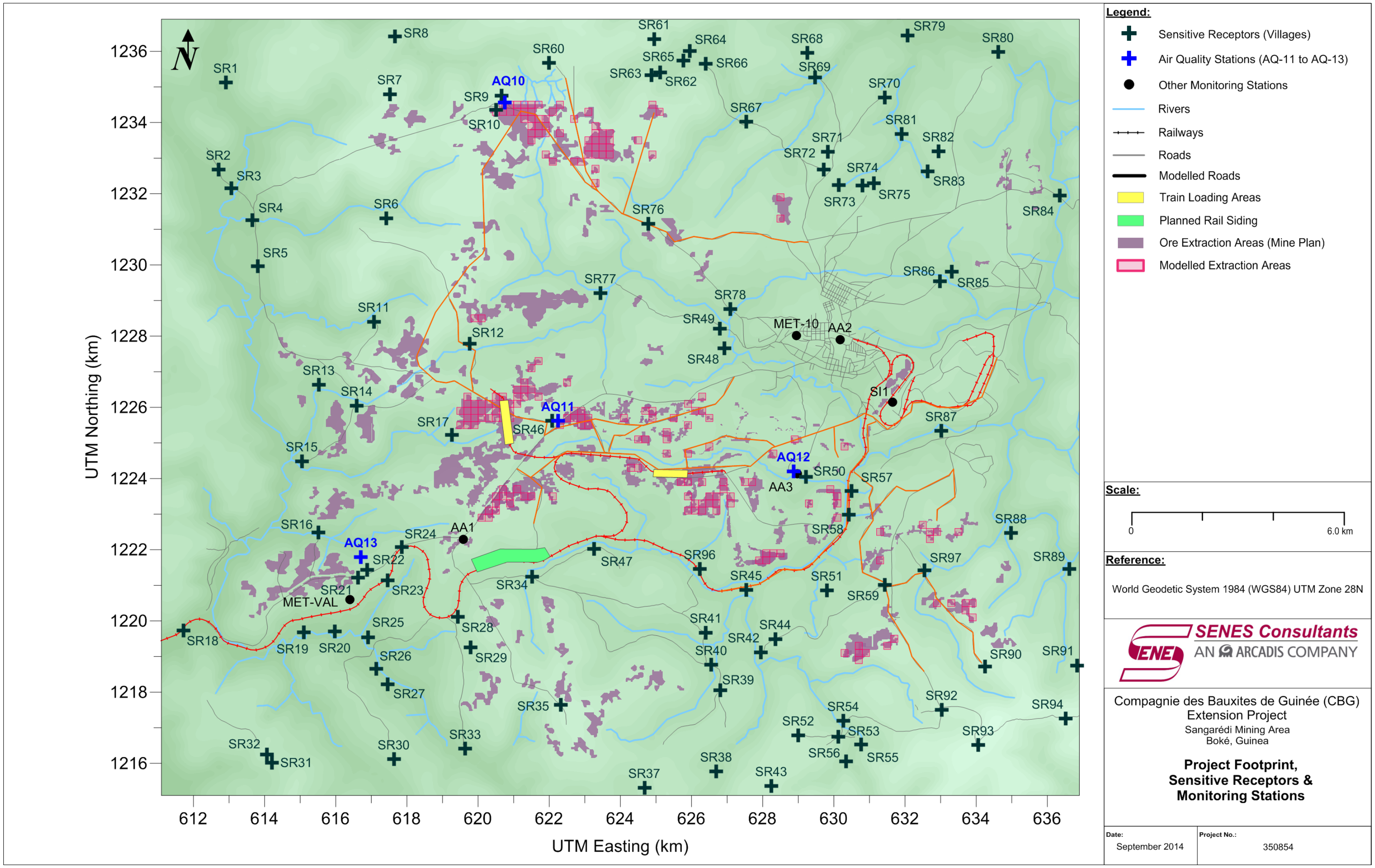

Table 2-9: Results of Baseline Particulate Monitoring in Sangarédi (µg/m^3)

Sample Location	No. of Sample Days	Average Daily Concentration (µg/m³)			Max Daily Concentration (µg/m³)		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
AQ-10 Kourawel (2014)	5	150.5	124.5	76.0	211.0	195.0	152.6
AQ-11 Hamdallay (2014)	6	129.7	95.7	62.6	150.1	115.2	85.0
AQ-12 Petoun BW (2014)	6	127.6	111.0	72.7	162.0	133.0	85.2
AQ-13 Paravi (2014)	5	124.6	80.7	35.9	162.9	89.7	54.4
AA-1 Sangarédi – (2011)[a]	1	1	116.3	34.5	1	116.3	34.5
AA-2 Hamdallaye – (2011)[a]	1	1	66.5	14.0	1	66.5	14.0
AA-3 BW – (2011)[a]	1	1	75.4	15.8	1	75.4	15.8
WHO Interim Target-1			150	75	-	150	75
WHO Interim Target-2			100	50	-	100	50
WHO Interim Target-3			75	37.5	-	75	37.5
WHO Guideline			50	25	-	50	25

TSP: total suspended particulate; PM_{10}: fine particulate < 10 µm; $PM_{2.5}$: fine particulate < 2.5 µm.

[a] – *AECOM 2011*

Similar to Kamsar, the results of the ambient air quality monitoring campaign indicate that the Sangarédi airshed is already burdened with fine particulates. The maximum measurements from the 2014 sampling conducted at AQ-10, AQ-11 and AQ-12 exceeded the WHO Interim Target 1 for both PM_{10} and $PM_{2.5}$. During the 2014 sampling campaign, CBG staff noted that all four ambient air quality monitoring stations were influenced to some degree by local sources of dust that are unrelated to CBG activities (e.g., brush fires and from charcoal cooking fires). At AQ-10, which is not currently affected by mining activities, the average and maximum daily concentrations of PM_{10} and $PM_{2.5}$ were approximately 30 to 100% above the WHO Interim Target 1. By contrast, PM_{10} and $PM_{2.5}$ concentrations at AQ-13 are 30% to 40% below WHO guidelines, showing the least influence from local sources of dust and CBG activities.

As for Kamsar, ambient NO_2 and SO_2 measurements at AQ-12 and AQ-13 (Table 2-10) were less than 10% of applicable WHO guidelines, even after converting the 30-day measurements to common averaging times.

Table 2-10: Results of Baseline Gaseous Contaminant Monitoring in Sangarédi (µg/m^3)

Sample Location	No. of Samples	Average Monthly Concentration (µg/m³)			Max Monthly Concentration (µg/m³)		
		NO_2	NOx	SO_2	NO_2	NOx	SO_2
AQ-12 Petoun BW	2	2.4	4.4	0.3	2.6	5.3	0.3
AQ-13 Paravi	2	0.9	1.6	0.5	0.9	2.1	0.5

NO_2: nitrogen dioxide; NOx: oxides of nitrogen; SO_2: sulfur dioxide.

Modeling of existing air quality in Sangarédi

As described previously, atmospheric dispersion modeling was conducted to characterize existing air quality conditions in Sangarédi. Annual contour plots for contaminants having WHO guidelines are presented in Annexe 2-1. Average annual modeling results at AQ-10, AQ-11, AQ-12 and AQ-13 are presented in Table 2-11.

Table 2-11: Average Annual Concentrations in Sangarédi (µg/m3)

Receptor ID	Description	UTM Easting (km)	UTM Northing (km)	Annual Concentration (µg/m³)[a]		
				PM_{10}	$PM_{2.5}$	NO_2
AQ10	AQ-10 Kourawel	620.746	1234.554	1.0	0.1	0.1
AQ11	AQ-11 Hamdallaye	622.252	1225.617	8.1	1.0	0.8
AQ12	AQ-12 Petoun BW	628.870	1224.203	2.9	0.5	0.4
AQ13	AQ-13 Paravi	616.710	1221.796	0.8	0.1	0.1
SR9	Kourawel	620.668	1234.753	1.0	0.1	0.1
SR10	Sintiourou Kourawel	620.513	1234.360	1.0	0.1	0.1
SR46	Hamdalaye	622.082	1225.627	7.3	0.9	0.7
SR58	Pora PK130	630.420	1222.985	0.9	0.1	0.1
SR59	Carrefour Parawol	631.430	1221.004	0.8	0.1	0.1
SR60	Kahel Mbody	621.990	1235.671	1.1	0.1	0.1
SR97	Madina Dian	632.551	1221.418	0.6	0.1	0.1
WHO Interim Target-1				70	35	-
WHO Interim Target-2				50	25	-
WHO Interim Target-3				30	15	-
WHO Guideline				20	10	40

a – Model predictions without background

2.2.5 Impact assessment methodology

The CALPUFF/CALMET modeling package was used to predict Project-related incremental ambient air concentrations of COPCs at a network of receptor locations within the study areas over a 5-year period (2009 to 2013). In order to assess whether there were any potential effects from the Project, model-predicted COPC concentrations were compared to the WHO guidelines.

The emission inventories developed for the impact assessment area are outlined below along with an overview of the assessment approach. Details on the development of the emission inventory are provided in the CBG Air Quality Assessment. Detailed CALPUFF dispersion modeling (as described in the CBG Extension Project air quality impact assessment SENES Consultants, 2014a) was undertaken for the existing conditions as well as each expansion scenario for Kamsar and the Sangarédi mining area.

2.2.5.1 Air quality assessment

For each assessment scenario described below, emissions inventories for particulate matter (TSP, PM_{10} and $PM_{2.5}$, gaseous compounds (NO_x and SO_2), and metallic components of TSP were developed. The inventories were developed primarily using US EPA AP-42 emission factors (US EPA 1995) and guidance provided in the Australian Government's National Pollutant Inventory (NPI) (Australian Government 2014). These emission factors were used to estimate the maximum emission rates of the specified COPCs for each source and/or activity in each of the CBG phases. In addition to the existing conditions (13.5 MTPA), three expansion scenarios were considered in the assessment:

- increase to 18.5 MTPA production
- increase to 22.5 MTPA production; and
- increase to 27.5 MTPA production

For each of these production scenarios, emissions were estimated for the CBG Bauxite processing area at Kamsar, the mining activities at Sangarédi, and a proposed rail siding considering the activities outlined in the following Sections.

CBG bauxite treatment facility in Kamsar

Emissions from the crushing and processing activities at the Kamsar port including the following activities were considered in the development of the site emissions inventory:

- dust emissions (and its metallic constituents) generated by bauxite processing, including:
  - rail unloading (i.e., ore handling);
  - primary and secondary crushing;
  - material conveyor transfers;
  - drying; and
  - wind erosion of stockpiles and open areas.
- emissions of fuel combustion products (i.e., NOx, SO2, and fine particulate matter) from the following equipment:
  - dryers;
  - generators;
  - boilers;

- line-haul and switching locomotives; and
- idling shipping vessels.

Air quality effects from the processing activities at Kamsar were estimated based on both a short-term (maximum 1- and 24 hour) and long-term (average annual) emissions for the existing and three future production scenarios.

Mitigation measures incorporated into the current Project plan for Kamsar

The following mitigation measures have been incorporated into the current Project plans and are considered inherently part of the Project for all scenarios:

- enclosure and/or efficient dust suppression of storage areas for dusty materials;
- loading, transfer, and discharge of materials is shielded against the wind;
- loading, transfer, and discharge of materials employs additional dust suppression systems, including dry fogging or dust collectors (future scenarios only, does not exist as part of the existing controls);
- conveyor systems for dusty materials are covered;
- dryer stacks are equipped with wet scrubbers operating at 99% efficiency for particulates, including fine particulates.

Table 2-12: Emission Estimates Used in Dispersion Modeling – Kamsar (μg/m^3)

Scenario	COPC	24 hour Average (g/s)				Annual Average (tonnes/year)			
		Dryers	Boilers & Electric Generators	Material Handling & Processing	Misc.	Dryers	Boilers & Electric Generators	Material Handling & Processing	Misc.
Existing	TSP	70.9	3.9	70.5	0.2	2236	123	2217	6
	PM_{10}	35.5	2.8	34.8	0.2	1120	88	1094	6
	$PM_{2.5}$	35.2	2	17.3	0.1	1110	63	542	3
	NO_x	19.1	55.5	--	4	602	1750	--	126
	SO_2	22	59.7	--	0.6	694	1883	--	19
18.5 MTPA	TSP	107.8	5.4	54.5	0.2	3400	170	1709	6
	PM_{10}	53.9	3.8	27.1	0.2	1700	120	851	6
	$PM_{2.5}$	53.4	2.8	13.4	0.2	1684	88	423	6
	NO_x	29.1	76.5	--	5.5	918	2413	--	173
	SO_2	33.4	82.7	--	0.7	1053	2608	--	22
22.5	TSP	107.8	5.8	27.4	0.3	3400	183	855	9

Scenario	COPC	24 hour Average (g/s)				Annual Average (tonnes/year)			
		Dryers	Boilers & Electric Generators	Material Handling & Processing	Misc.	Dryers	Boilers & Electric Generators	Material Handling & Processing	Misc.
MTPA	PM_{10}	53.9	4.1	13.6	0.3	1700	129	423	9
	$PM_{2.5}$	53.4	3	6.6	0.2	1684	95	208	6
	NO_x	29.1	81.4	--	6.5	918	2567	--	205
	SO_2	33.4	88.1	--	0.8	1053	2778	--	25
27.5 MTPA	TSP	145	7.7	42	0.3	4573	243	1315	9
	PM_{10}	72.5	5.4	20.8	0.3	2286	170	653	9
	$PM_{2.5}$	71.8	4	10.3	0.3	2264	126	322	9
	NO_x	39	107.8	--	8.1	1230	3400	--	255
	SO_2	44.8	117	--	1.1	1413	3690	--	35

NOTE: Annual emissions of dust (TSP, PM_{10}, $PM_{2.5}$) for outside material handling and processing sources (e.g., outdoor storage piles) have been assumed to have 28% natural dust control (i.e., from precipitation).

Mining activities at Sangarédi

The following activities were considered in the development of the emission inventory for the mining activities at Sangarédi:

- dust emissions (and its metallic constituents) generated by bauxite mining and shipping activities, including:
  - drilling;
  - blasting;
  - ore handling;
  - land clearing (i.e., dozing);
  - road maintenance (i.e., grading);
  - wind erosion of stockpiles and open areas; and
  - haul road traffic.
- emissions of fuel combustion products (i.e., NO_x, SO_2, and fine particulate matter) from the power generation and from the operation of diesel powered mining equipment and vehicles; and
- emissions of wind-blown dust and gaseous COPCs from rail transportation.

In air dispersion modeling, it is generally not practical to model every year of scheduled production due to the excessive amount of computational time involved in carrying out the model runs and in processing the output data. Hence, it is common practice to select certain years for modeling purposes that are considered to be representative of activities at the site over consecutive periods spanning the operating life of the Project. As a result, long-term (or annual) potential effects to air quality were assessed for each future production level. The selected years to represent each production level are:

- 18.5 MTPA: 2017;
- 22.5 MTPA: 2019; and
- 27.5 MTPA: 2027.

The years selected to assess against annual Project Effects Criteria were chosen based on the proximity of the mining areas to nearby sensitive receptors (Figure 3 in Annexe 2-1). This approach also assumes a consecutive progression through the mining plan (i.e., extraction areas will be decommissioned and rehabilitated in each subsequent year).

Given the spatial extent of the areas proposed for mining, it was not possible to complete a separate model run for each individual mining area to assess short-term effects, as the areas are interspersed over a domain that is more than 400 km^2. Instead, a generic modeling approach was used to represent typical daily mining activities occurring within an area of 200 m by 200 m. The future road network is also unknown at this time. Therefore, a generic road stretching 2 km on either side of the mining area was also modeled concurrently with extraction activities. A separate model run was also completed to assess the impacts of blasting on 1-hour NO_2 concentrations. In order to assess the potential short-term effects to air quality, setback distances that would be required for the predicted results to comply with the WHO guidelines at each sensitive receptor was calculated. Work at any of the proposed mining areas that appear within the calculated setback distances are predicted to result in an exceedance of the WHO guidelines at the associated sensitive receptor.

Mitigation measures incorporated into the current Project plan for Sangarédi

The following mitigation measures have been incorporated into the current Project plans and are considered inherently part of the Project for all scenarios:

- dust suppression techniques (e.g., watering, chemical dust suppressants) are applied to unpaved haul roads to achieve 80% control
- vehicle speed in the vicinity of rail loading areas and active mining areas will be restricted to 40 km/hour
- prompt re-vegetation of exposed soils and other erodible materials, especially when areas are inactive

Table 2-13: Emission Estimates Used in Dispersion Modeling – Sangarédi (µg/m^3)

Scenario	COPC	24 hour Average (g/s)				Annual Average (tonnes/year)			
		Ore Extraction Areas	Haul Roads	Rail Loading Area & Stockpiles	Misc.	Ore Extraction Areas	Haul Roads	Rail Loading Area & Stockpiles	Misc.
Existing	TSP	7	60.3	1.1	2	246	1680	24	47
	PM_{10}	2.3	17.8	0.5	1.1	97	498	12	26
	$PM_{2.5}$	0.2	1.8	0.1	0.3	29	53	2	9
	NO_x	0.9	0.3	0.01	11.8	53	37	0.4	373
	SO_2	0.01	0.05	0.002	1.2	5	6	0.1	39
18.5 MTPA	TSP	9.7	82.3	1.3	2.3	355	4605	28	53
	PM_{10}	3.2	24.3	0.6	1.2	141	1362	14	29
	$PM_{2.5}$	0.3	2.4	0.1	0.4	40	140	2	10
	NO_x	1.2	0.2	0.02	13.2	71	49	0.6	418
	SO_2	0.01	0.03	0.003	1.4	7	8	0.1	44
22.5 MTPA	TSP	11.9	99.6	1.5	2.7	427	5573	34	64
	PM_{10}	3.9	29.4	0.8	1.5	169	1649	17	35
	$PM_{2.5}$	0.4	3	0.1	0.4	48	169	3	11
	NO_x	1.4	0.2	0.03	14.7	84	56	0.9	464
	SO_2	0.01	0.04	0.01	1.5	8	10	0.2	49
27.5 MTPA	TSP	14.8	121.2	1.8	3.3	511	19294	40	77
	PM_{10}	4.9	35.8	0.9	1.7	201	5699	20	41
	$PM_{2.5}$	0.5	3.6	0.1	0.5	58	575	3	13
	NO_x	1.7	0.3	0.03	15.4	98	67	1	487
	SO_2	0.01	0.04	0.01	1.6	9	11	0.2	51

NOTE: Annual emissions of dust (TSP, PM10, PM2.5) for outside material handling and processing sources (e.g., outdoor storage piles) have been assumed to have 28% natural dust control (i.e., from precipitation).

Table 2-14: Maximum 1 Hour NOx Emission Estimates (g/s) for Blasting – Sangarédi (µg/m^3)

Emissions Source	Existing	18.5 MTPA	22.5 MTPA	27.5 MTPA
Blasting	115.7	159.8	194.4	237.6

Proposed rail siding operation

The proposed expansion of the Kamsar processing facility and Sangarédi mining operations will require additional rail sidings along the existing railroad network. To optimize shipping for the expansion, two new rail sidings are proposed at 14 km and 118 km as described in the Project Description. One of the existing rail sidings, PK 72, will also be expanded.

The assessment of potential effects from increased railroad traffic with no siding was included in the modeling scenarios for Sangaredi mining operations (Section 2.2.7.2). The effects of the proposed rail sidings were assessed using a separate, generic model run which included an idling train with three locomotives on a siding. The expected emissions are combustion products (i.e., gases and fine particulate) from the locomotives, estimated at approximately 10.5 g/s NO_x on a 1-hour average. The results from this modeled scenario were compared to applicable WHO guidelines to determine the effect of a rail siding on local ambient air quality.

Construction

On-land construction activities have the potential to result in Project-related environmental effects that could result in increased concentrations of ambient COPCs. Construction activities are anticipated at both the Kamsar processing facility, and at Sangarédi, and are described in brief below.

Expansion of the Kamsar Processing Facility will require the following construction activities:

- modification to the existing rail yard;
- installation of the new rotary rail car dumper, primary and secondary crushers and dryer(s);
- modifications/upgrades to the conveyor system; and
- construction of new storage building additions and modifications.

Expansion of the Sangarédi mining operations will require the following construction activities:

- construction of a new rail siding and a new rail loading area near Parawi (applicable to 22.5 MTPA or 27.5 MTPA production levels only); and,
- development of new haul roads.

The construction emissions will be generated within the same footprint as site operations at the Kamsar processing facility and Sangarédi mine site operations. At Kamsar, the construction activities are largely limited to building construction, and there are no major earthworks planned. Consequently, the emissions of COPCs during construction will be much less than during the operations phase. At Sangarédi, although minor earthworks are planned, the spatial and temporal extent of the construction activities are much smaller than the operational activities, which are major earthworks. For both Kamsar and Sangarédi, the maximum emission scenarios presented adequately capture the effects of construction, consequently detailed dispersion modeling has not been undertaken.

2.2.5.2 Greenhouse gas assessment

This section was written by CBG and CBG made the calculations presented in Table 2-15.

Most of the greenhouse gas (GHG) emissions come from the use of fuel in the production of electricity and the use of machinery and heavy vehicles. It is recommended that the Project adopt good practices in the management of energy so as to minimize fuel consumption and GHG emissions. The reduction strategies are examined in Section 2.2.8.3.

Introduction

The GHG, although non-toxic for humans and animals in usual concentrations, are of concern because of their contribution to global climate change. There is no specific enforced legislation in Guinea to control the emission of GHG. However Guinea has signed the UN Framework Convention on Climate Change (UNFCCC) and is a non-Annex 1 party of the Convention.

Legal and other requirements

The following international guidelines are pertinent for the approach taken for the measure of GHG emissions as described below:

- IFC Performance Standard 3;
- IFC EHS Guidelines Directives (IFC, 2007); and
- IFC EHS Guidelines for Mining (IFC, 2007b).

Performance Standard 3 of the IFC (resource efficiency and pollution prevention) demands that GHG emissions be estimated for development projects supported by the IFC that might produce more than 25,000 tonnes of CO_2 equivalent per year. This estimate must include all significant direct and indirect sources and must conform to methodologies and practices that are recognized internationally.

Methodology

Within the framework of its estimations, the Project used as references methods of calculating and values dictated by the 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*. Reference data on fuel consumption were derived from the 2012 CBG report on consumption. Data on land use were derived from the annual plan on the rehabilitation of mining areas.

The GHG emissions for Guinea are derived from data supplied to the UN Framework Convention on Climate Change (UNFCCC). The most recent data are given in *Communication de la Guinée à l'UNFCCC* (2005). This document uses an initial profile estimated, in 1994, at 5,057.70 $ktCO_2e$ (kilotonnes of CO_2 equivalent) by year without taking into account land use changes. This would be equivalent to 0.78 tonnes per capita (6.5 million inhabitants in 1994) whereas the African regional emissions are 2.4 tonnes per capita.

Results

It is important to note that CBG is the largest private industrial and commercial company in the Republic of Guinea. The CBG GHG emissions represent approximately 3% of the total national emissions (2014). In 2022, when the production will be at 27.5 MTPA, the contribution of CBG will have increased to 3.6% of the national emissions and then reduced to less than 2.3% at the end of the long-term mining plan in 2042. The contribution of CBG will be less important than its current contribution, taking into account an annual average increase of 3.1 for the national emissions.

The Extension Project will increase local GHG emissions. This increase however will not be directly proportional to the increase in production since there will be improvements in efficiency and productivity related to the Project. There will be a decrease in 2012 from 0.020 tCO_2e/tonne of shipped bauxite to 0.018 tCO_2e/tonne of shipped bauxite for a production of 27.5 MTPA in 2022.

To reduce the impact of the increase of production on GHG emissions, the CBG has committed to different programs to reduce fuel consumption.

Table 2-15 shows following the application of mitigation measures, the emissions of carbon dioxide (CO_2), of methane (CH_4), and of nitrous oxide (N_2O) as well as the total GHG emissions in equivalent CO_2 (t), for the different phases of the operation. The emissions for 2012 have been calculated including fuel consumption and data relative to land use (deforestation).

Most of the GHG come from the use of fuel in the production of electricity and the use of machinery and heavy vehicles. It is recommended that the Project adopt good practices in the management of energy so as to minimize fuel consumption and GHG emissions. The reduction strategies are examined in Section 2.2.8.3.

Table 2-15: Inventory of greenhouse gases for different phases of the Project

	Emissions of CO_2 equivalent (t)			
	2012	**18.5 MTPA**	**22.5 MTPA**	**27.5 MTPA**
Kamsar plant	105,500.42	139,920.64	149,011.98	197,316.58
Drying ovens	101,474.12	134,603.99	163,707.55	183,872.16
Mining machinery	31,122.20	40,482.73	46,772.90	54,467.18
Locomotives	22,938.94	25,184.69	28,892.02	34,845.75
Sangarédi plant	18,195.47	20,222.97	22,432.42	23,446.17
Vehicles	4,195.01	4,193.99	4,193.99	4,193.99
Electrical generators	2,353.59	2,353.59	2,353.59	2,353.59
Deforestation	1,919.87	1,919.87	1,919.87	1,919.87
Roads	177.70	274.42	427.64	455.20
Personal allocation	121.48	122.69	120.22	120.22
TOTAL	**287,998.8**	**369,279.6**	**419,832.2**	**502,990.7**
Increase relative to 2012	-	28.2%	45.8%	74.7%
CO_2 equivalent (t) / Tonne de bauxite	**0.01986**	**0.01996**	**0.01866**	**0.01829**
Difference between the various phases and 2012	-	0.5%	-6.1%	-7.9%

2.2.6 VEC identification

Valued Ecosystem Components (VECs) are features of the environment selected to be the focus of the ESIA because of their ecological, social, cultural or economic value and their potential vulnerability to effects of the Project. In the case of Air Quality the project will result in an increase in the amount of contaminants which will be released into the air due to the increased mining activities, bauxite processing and shipping and transport activities. Air quality is important for the health and safety of the people living in the vicinity of the Project sites and haul routes. Air quality is also importation to the local wildlife and vegetation.

For this assessment, the VEC was identified to be air quality, which is assessed through the potential change in air concentrations of:

- total suspended particulate (TSP);
- particulate matter <10 µm (PM_{10});

- particulate matter <2.5 µm ($PM_{2.5}$);
- nitrogen dioxide (NO_2); and
- sulfur dioxide (SO_2).

2.2.7 Air quality impact assessment

The assessment methodology described in Section 2.2.5 was applied to the construction and operations phases of the Project for the existing and future production levels in order to quantify how the Project, with the mitigation incorporated in the current Project Plan, might result in changes to ambient air quality.

The following sections outline the potential effects of the Project for each project phase and production scenario. Where applicable, the results from the CALPUFF air dispersion modeling have been presented in both graphical format showing the results in the study areas, and tabular format at specific receptor locations. Complete results are provided in the full report on air quality for the Extension Project (SENES Consultants, 2014a – Annexe 2-2). It is important to note that the maximum short-term predicted concentrations (for 10-min, 1-hour or 24-hour timeframes) shown on the contour plots represent the single highest incremental concentration (i.e., no background included) predicted to occur at each location, at any time during the 5-year assessment period. Therefore, the contours shown do not represent a "snapshot" in time as these maxima may occur on different days, under different meteorological conditions.

2.2.7.1 Kamsar plant operations

Graphical results for maximum predicted concentrations of COPCs for the 18.5, 22.5 and 27.5 MTPA production scenarios are presented in Annexe 2-1. As discussed below, the concentrations of all COPCs exceed their respective WHO guidelines beyond the Project footprint into a limited area of the study area for all levels of production. The exceedances of the PM_{10} and $PM_{2.5}$ criteria can largely be attributed to emissions of particulate matter from the transfer towers, followed by the dryer stacks. In contrast, predicted exceedances of the NO_2 and SO_2 WHO guidelines are due to fuel combustion. In particular, elevated concentrations of SO_2 can be linked to the sulfur content in the fuel (3%).

18.5 MTPA production scenario

The maximum predicted concentrations of COPCs for the 18.5 MTPA scenario are presented graphically in Annexe 2-1 along with plots showing the frequencies of exceedances of short-term WHO guidelines. The figures demonstrate that there are few exceedances of the WHO guidelines for PM_{10}, $PM_{2.5}$, NO_2 and SO_2 beyond the Project footprint. In particular, there are no more than 10 days of exceedances per year within 800 m of the Project footprint for any of the COPCs. The exceedance plots also show that exceedances of the WHO guidelines only occur up to about one km beyond the Project footprint for any of the COPCs assessed.

22.5 MTPA production scenario

The maximum predicted concentrations of COPCs for the 22.5 MTPA scenario are presented graphically in Annexe 2-1 along with plots showing the frequencies of exceedances of short-term WHO guidelines. The figures demonstrate that there are very few exceedances of the WHO guidelines for PM_{10} and $PM_{2.5}$ beyond the Project footprint. In particular, there are no more than 10 days of exceedances per year within 300 m of the Project footprint for either 24-hour concentrations PM_{10} and $PM_{2.5}$. The exceedance plots also show that exceedances of the 24-hour PM_{10} and $PM_{2.5}$ WHO guidelines only occur up to about 500 m beyond the Project footprint.

In addition, the figures in Annexe 2-1 show that there are no more than 10 exceedances per year of the 1-hour NO_2 or 10-minute SO_2 WHO guideline within 400 m of the Project footprint. The exceedance plots also show that exceedances of the NO_2 or SO_2 WHO Guidelines only occur up to about 1.1 km beyond the Project footprint.

27.5 MTPA production scenario

The maximum predicted concentrations of COPCs for the 27.5 MTPA scenario are presented as graphically in Annexe 2-1 along with plots showing the frequencies of exceedances of short-term WHO guidelines. The figures demonstrate that there are very few exceedances of the WHO guidelines for PM_{10} and $PM_{2.5}$ beyond the Project footprint. In particular, there are no more than 10 days of exceedances per year within 600 m of the Project footprint for either 24-hour concentrations PM_{10} and $PM_{2.5}$. The exceedance plots also show that exceedances of the 24-hour PM_{10} and $PM_{2.5}$ WHO guidelines occur up to about one km beyond the Project footprint.

In addition, the figures in Annexe 2-1 show that there are no more than 10 exceedances per year of the 1-hour NO_2 or 10-minute SO_2 WHO guidelines within 1.2 km of the Project footprint. The exceedance plots also show that exceedances of the NO_2 or SO_2 WHO guideline only occur up to about 2.5 km beyond the Project footprint.

Comparison with existing operations

In addition, Table 2-16 shows the maximum predicted annual, 1-hour and 24-hour concentrations the COPCs for each future production level at the air quality monitoring locations, with the percent change in concentration from existing operations shown in Table 2-5.

As can be seen in Table 2-17, there is an increase in NO_2 and SO_2 concentrations for each future production level relative to existing operations. For example, concentrations of NO_2 and SO_2 more than double in the 27.5 MTPA scenario relative to existing operations. This increase can be attributed to increased consumption of No. 6 fuel oil and diesel.

Despite the increase in production level, Table 2-17 shows that there is a decrease in predicted particulate concentrations between existing and all future production levels operations. The decreases can be attributed to the increased level of dust control assumed to be installed on new processing equipment. The most significant change is between existing and 22.5 MTPA, when all of the existing equipment is finally upgraded to include additional dust suppression such as dry fogging.

Table 2-16: 18.5, 22.5 and 27.5 MTPA model predicted COPC concentrations in Kamsar (µg/m³)[a]

	18.5 MTPA				22.5 MTPA				27.5 MTPA			
	PM_{10}		$PM_{2,5}$		PM_{10}		$PM_{2,5}$		PM_{10}		$PM_{2,5}$	
	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual
AQ-1	154 (4)	38	79 (6)	22	89	24	48	14	119	33	65	20
AQ-2	141	30	70	17	79	18	43	11	104	26	58	15
WHO Interim Target-1	150	70	75	35	150	70	75	35	150	70	75	35
WHO Interim Target-2	100	50	50	25	100	50	50	25	100	50	50	25
WHO Interim Target-3	75	30	37,5	15	75	30	37,5	15	75	30	37,5	15
WHO Guideline	50	20	25	10	50	20	25	10	50	20	25	10

	18.5 MTPA				**22.5 MTPA**				**27.5 MTPA**			
	NO_2		SO_2		NO_2		SO_2		NO_2		SO_2	
	1-hour	annual	10-min	24-hours	1-hour	annual	10-min	24-hours	1-hour	annual	10-min	24-hours
AQ-1	187	15	465	88	197	16	488	93	263 (5)	21	655 (3)	124
AQ-2	265 (1)	11	634 (1)	88	284 (1)	11	672 (1)	93	380 (5)	15	914 (3)	126 (1)
WHO Interim Target-1	-	-	-	125	-	-	-	125	-	-	-	125
WHO Interim Target-2	-	-	-	50	-	-	-	50	-	-	-	50
WHO Interim Target-3	200	40	500	20	200	40	500	20	200	40	500	20

a = Predicted model values, without background. The number of WHO Interim Target-1 during a year is within parentheses ().

Table 2-17: Change in Future Model Predicted COPC Concentrations in Kamsar Compared to Existing Conditions (µg/m³)

	18.5 MTPA				22.5 MTPA				27.5 MTPA			
	PM_{10}		$PM_{2,5}$		PM_{10}		$PM_{2,5}$		PM_{10}		$PM_{2,5}$	
	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual	24-hours	annual
AQ-1	-17%	-14%	-15%	-4%	-52%	-45%	-48%	-39%	-36%	-25%	-30%	-13%
AQ-2	-12%	-12%	-13%	-6%	-51%	-47%	-46%	-39%	-35%	-24%	-28%	-17%

	18.5 MTPA				22.5 MTPA				27.5 MTPA			
	NO_2		SO_2		NO_2		SO_2		NO_2		SO_2	
	1-hour	annual	10-min	24-hours	1-hour	annual	10-min	24-hours	1-hour	annual	10-min	24-hours
AQ-1	33%	36%	34%	33%	40%	45%	41%	41%	87%	91%	89%	88%
AQ-2	51%	38%	55%	24%	61%	38%	64%	31%	116%	88%	123%	77%

2.2.7.2 Mining operations at Sangarédi

Annual air quality effects

Graphical results for predicted annual concentrations of COPCs for the 18.5, 22.5 and 27.5 MTPA production scenarios are presented in Annexe 2-1. As discussed below, the predicted annual concentrations NO_2 and SO_2 are well within applicable WHO guidelines beyond the Project footprint. Annual concentrations of $PM_{2.5}$ are only predicted to exceed the WHO guidelines into a limited area of the study area for the 22.5 MTPA and 27.5 MTPA production levels. The largest effects are for annual PM_{10} concentrations, which are predicted to exceed the WHO Interim Target-1 criteria into a limited area of the study area for all levels of production. The exceedances of the PM_{10} and $PM_{2.5}$ criteria can largely be attributed to emissions of particulate matter from unpaved road dust.

18.5 MTPA production scenario

The annual predicted concentrations of COPCs for the 18.5 MTPA scenario are presented graphically in the figures provided in Annexe 2-1. As the figures demonstrate, there is a limited area within the vicinity of the modeled road network where the annual WHO guidelines for PM_{10} are exceeded. Specifically, the WHO Interim Target-1 criterion for annual PM_{10} is predicted to be exceeded within about one km of the road network. All other COPCs are predicted to be below their applicable annual WHO guidelines.

In addition to the contour plots, Table 2-18 presents the model-predicted annual COPC concentrations for those sensitive receptors where annual WHO guidelines are predicted to be exceeded. The air quality monitoring locations are also provided in Table 2-18 for completeness. As can be seen in the Table, there are three sensitive receptors where an annual WHO guideline for PM_{10} is exceeded in the 18.5 MTPA scenario: Hamdallaye, Pora PK130 and Carrefour Parawol. However, there are no sensitive receptor locations where the WHO Interim Target Level-1 PM_{10} criterion is exceeded. There are also no sensitive receptor locations that have predicted annual $PM_{2.5}$ concentrations above the WHO guidelines.

Table 2-18: 18.5 MTPA production scenario model-predicted average annual concentrations in Sangarédi (µg/m^3)

Receptor ID	Description	UTM Easting (km)	UTM Northing (km)	Annual concentration (µg/m³)[a]		
				PM_{10}	$PM_{2,5}$	NO_2
QA-0	AQ-10 Kourawel	620.746	1234.554	1.5	0.2	0.2
QA-1	AQ-11 Hamdallaye	622.252	1225.617	**83.7**	15.2	13.6
QA-12	AQ-12 Petoun BW	628.870	1224.203	5.7	0.8	0.5
QA-13	AQ-13 Parawi	616.710	1221.796	1.0	0.2	0.2
SR-46	Hamdallaye	622.082	1225.627	**46.6**	6.4	3.8
SR-58	Pora PK130	630.420	1222.985	**59.3**	6.4	1.9
SR-59	Carrefour Parawol	631.430	1221.004	**27.8**	2.9	0.8
WHO Interim Target-1				70	35	-
WHO Interim Target-2				50	25	-
WHO Interim Target-3				30	15	-
WHO Guideline				20	10	40

a = Predicted model values, without background.

22.5 MTPA production scenario

The annual predicted concentrations of COPCs for the 22.5 MTPA scenario are presented graphically in the figures provided in Annexe 2-1. As the figures demonstrate, there is a limited area within the vicinity of the modeled road network and proposed rail loading location near Hamdalaye where the annual WHO guidelines for PM_{10} and $PM_{2.5}$ are predicted to be exceeded. In particular the WHO Interim Target-1 criterion for annual PM_{10} is predicted to be exceeded within about 600 m of the road network/proposed rail loading area near Hamdallaye. Similarly, the WHO Interim Target-3 criterion for annual $PM_{2.5}$ is predicted to be exceeded within about 200 m of the road network/proposed rail loading area near Hamdallaye. In contrast, annual NO_2 concentrations are predicted to be below their applicable annual WHO guidelines.

In addition to the contour plots, Table 2-10 presents the model predicted annual COPC concentrations for those sensitive receptors where the annual WHO guidelines are predicted to be exceeded in addition to concentrations predicted at the air quality monitoring locations. As can be seen in the Table, there are three sensitive receptors where an annual WHO guidelines for PM_{10} is predicted to be exceeded in the 22.5 MTPA scenario: Hamdallaye, Carrefour Parawol, and Madina Dian. The highest predicted concentrations occur at Hamdallaye where the annual WHO Interim Target-1 level for PM_{10} and the annual Interim Target-3 level for $PM_{2.5}$ are predicted to be exceeded. This is a result of Hamdallaye's proximity to both a modeled road network and the new rail loading area in the 22.5 MTPA scenario.

Table 2-19: 22.5 MTPA production scenario model-predicted average annual concentrations in Sangarédi (µg/m^3)

Receptor ID	Description	UTM Easting (km)	UTM Northing (km)	Annual concentration (µg/m³)[a]		
				PM_{10}	$PM_{2,5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1234.554	3.5	0.5	0.3
AQ-11	AQ-11 Hamdallaye	622.252	1225.617	**121.1**	**12.8**	4.0
AQ-12	AQ-12 Petoun BW	628.870	1224.203	5.0	0.5	0.2
AQ-13	AQ-13 Parawi	616.710	1221.796	1.7	0.2	0.3
SR-46	Hamdallaye	622.082	1225.627	**203.8**	**21.0**	7.4
SR-59	Carrefour Parawol	631.430	1221.004	**83.1**	8.7	2.0
SR-97	Madina Dian	632.551	1221.418	**22.0**	2.4	0.8
WHO Interim Target-1				70	35	-
WHO Interim Target-2				50	25	-
WHO Interim Target-3				30	15	-
WHO Guideline				20	10	40

a = Predicted model values, without background.

27.5 MTPA production scenario

The annual predicted concentrations of COPCs for the 27.5 MTPA scenario are presented as graphically in figures provided in Annexe 2-1. As the figures demonstrate, there is a limited area within the vicinity of the modeled road network where the annual WHO guidelines for PM_{10} and $PM_{2.5}$ are predicted to be exceeded. The WHO Interim Target-1 criteria for annual PM_{10} is limited to within about 800 m of the road network and has the highest concentrations predicted in the vicinity of Kourawel. Similarly, the WHO Interim Target-1 criterion for annual $PM_{2.5}$ is predicted to be exceeded within about 250 m of the road network near Kourawel. Annual NO_2 concentrations are predicted to be below their applicable annual WHO guidelines.

In addition to the contour plots, Table 2-20 presents the model predicted annual COPC concentrations for those sensitive receptors where an annual WHO guidelines is predicted to be exceeded in addition to concentrations predicted at the air quality monitoring locations. As can be seen in the Table, there are four sensitive receptors where the annual WHO guideline for PM_{10} is exceeded in the 27.5 MTPA scenario: Kourawel, Sintiourou Kourawel, Hamdallaye, and Kahel Mbody. The highest predicted concentrations occur at Hamdallaye where the annual Interim Target-1 level for PM_{10} and the annual WHO Interim Target-3 level for $PM_{2.5}$ are predicted to be exceeded. This is a result of Hamdallaye's proximity to both a modeled road network and the new rail loading area in the 27.5 MTPA scenario.

Table 2-20: 18.5 MTPA production scenario model predicted average annual concentrations in Sangarédi (μg/m^3)

Receptor ID	Description	UTM Easting (km)	UTM Northing (km)	Annual concentration (μg/m³)[a]		
				PM_{10}	$PM_{2,5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1234.554	**47.5**	**11.0**	11.8
AQ-11	AQ-11 Hamdallaye	622.252	1225.617	**53.0**	5.4	1.0
AQ-12	AQ-12 Petoun BW	628.870	1224.203	0.6	0.1	0.04
AQ-13	AQ-13 Parawi	616.710	1221.796	1.5	0.2	0.2
SR-9	Kourawel	620.668	1234.753	**26.4**	5.2	4.9
SR-10	Sinthiourou Kourawel	620.513	1234.360	**52.2**	**12.9**	14.4
SR-46	Hamdallaye	622.082	1225.627	**175.0**	**17.6**	2.7
-	Kahel Mbody	621.990	1235.671	**29.7**	4.2	2.4
WHO Interim Target-1				70	35	-
WHO Interim Target-2				50	25	-
WHO Interim Target-3				30	15	-
WHO Guideline				20	10	40

a = Predicted model values, without background.

Comparison to existing operations

Tables 2-21 to 2-23 show the maximum predicted annual concentrations of COPCs for each future production level at the air quality monitoring locations along with the percent change in concentration from existing operations. As can be seen in the tables, the predicted change in concentration relative to existing operations is highly variable. The change in concentration not only reflects the change in quantity of bauxite being mined, but the proximity of each receptor to the road network as well as the extraction areas and rail loading areas. This is evident in the contour plots provided in Annexe 2-1, which show how the shapes of the contours closely follow the road network, particularly for particulate matter concentrations.

Table 2-21: Percentage change in annual predicted COPC concentrations from existing to 18.5 MTPA - Sangarédi mining operations

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percentage change from existing		
				PM_{10}	$PM_{2,5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1,234.554	43%	42%	-17%
AQ-11	AQ-11 Hamdallaye	622.252	1,225.617	937%	1,356%	674%
AQ-12	AQ-12 Petoun BW	628.870	1,224.203	99%	76%	-40%
AQ-13	AQ-13 Parawi	616.710	1,221.796	23%	66%	-36%
SR-46	Hamdallaye	622.082	1,225.627	539%	576%	137%
SR-58	Pora PK130	630.420	1,222.985	6,559%	4,886%	740%
SR-59	Carrefour Parawol	631.430	1,221.004	3,575%	2,636%	336%

Table 2-22: Percentage change in annual predicted COPC concentrations from existing to 22.5 MTPA - Sangarédi mining operations

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percentage change from existing		
				PM_{10}	$PM_{2,5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1,234.554	234%	255%	25%
AQ-11	AQ-11 Hamdallaye	622.252	1,225.617	1,400%	1,126%	128%
AQ-12	AQ-12 Petoun BW	628.870	1,224.203	74%	10%	-76%
AQ-13	AQ-13 Parawi	616.710	1,221.796	110%	66%	-4%
SR-46	Hamdallaye	622.082	1,225.627	2,693%	2,119%	362%
SR-59	Carrefour Parawol	631.430	1,221.004	10,884%	8,109%	990%
SR-97	Madina Dian	632.551	1,221.418	3,570%	2,784%	458%

Table 2-23: Percentage change in annual predicted COPC concentrations from existing to 27.5 MTPA - Sangarédi mining operations)

Receptor Id.	Description	UTM Easting (km)	UTM Northing (km)	Percentage change from existing		
				PM_{10}	$PM_{2,5}$	NO_2
AQ-10	AQ-10 Kourawel	620.746	1,234.554	4,427%	7,703%	4,799%
AQ-11	AQ-11 Hamdallaye	622.252	1,225.617	556%	417%	-43%
AQ-12	AQ-12 Petoun BW	628.870	1,224.203	-79%	-78%	-95%
AQ-13	AQ-13 Parawi	616.710	1,221.796	85%	66%	-36%
SR-9	Kourawel	620.668	1,234.753	2,556%	3,793%	2,046%
SR-10	Sinthiourou Kourawel	620.513	1,234.360	4,989%	9,256%	5997%
SR-46	Hamdallaye	622.082	1,225.627	2,298%	1,759%	69%
SR-60	Kahel Mbody	621.990	1,235.671	2,619%	2,760%	865%

Short-term air quality effects

As described previously, short-term air quality effects of particulate matter and SO_2 were assessed by modeling a generic extraction area together with a generic road, in order to represent a worst-case daily emissions scenario. Short-term effects of NO_2 are dominated by emissions from blasting and explosives detonation. For NO_2, an additional generic blasting scenario was considered separately from the generic extraction area.

Table 2-24 provides the predicted particulate concentrations for all villages where exceedances of 24-hour WHO guidelines for PM_{10} and $PM_{2.5}$ are predicted. The bold values are those that exceed the WHO Interim Target 1 at least 1 time in the 5-year modeling period. Note that there are no predicted exceedances of the WHO Interim Target 1 guideline for $PM_{2.5}$. There were no exceedances of the 10-minute or 24-hour SO_2 WHO guidelines. As a result, these results are not presented here but can be found in the CBG air quality impact assessment (SENES Consultants, 2014a - Annexe 2-2).

Table 2-24: Predicted 99th percentile 24-hour PM_{10} and $PM_{2.5}$ concentrations at villages exceeding WHO guidelines [a]

ID	Description	UTM Easting (km)	UTM Northing (km)	99th 24h PM_{10} Concentration (µg/m³)				99th 24h $PM_{2.5}$ Concentration (µg/m³)			
				Existing	18.5MTPY	22.5MTPY	27.5MTPY	Existing	18.5MTPY	22.5MTPY	27.5MTPY
SR7	Daara	617.521	1234.795	38.7	53.4	65.1	79.5	3.7	5.1	6.2	7.6
SR9	Kourawel	620.668	1234.753	65.6	90.6	110.4	134.9	6.3	8.7	10.6	12.9
SR10	Sinthiourou Kourawel	620.513	1234.36	**188.4**	**439.4**	**534.6**	**653.5**	18.0	42.0	51.1	62.5
SR12	Mbourore	619.769	1227.786	**188.6**	**260.4**	**317.9**	**388.6**	18.0	24.9	30.5	37.3
SR14	Guégueré	616.594	1226.045	58.8	81.1	98.7	120.7	5.6	7.8	9.5	11.6
SR16	Parawi	615.513	1222.477	37.6	51.8	63.0	77.0	3.6	5.0	6.1	7.4
SR17	Fassaly Foutabhé	619.263	1225.23	82.6	113.9	138.7	**169.6**	7.9	10.9	13.3	16.3
SR21	Kankalare	616.622	1221.213	93.0	127.9	**155.4**	**190.1**	9.0	12.4	15.1	18.4
SR22	Kankalaré Hacoude	616.889	1221.438	27.3	37.1	45.1	55.2	2.8	3.7	4.5	5.5
SR35	Kagnaka	622.325	1217.638	105.9	146.2	**177.7**	**217.2**	10.1	14.0	17.0	20.8
SR45	Sakidje	627.54	1220.872	**188.4**	**260.2**	**316.3**	**386.7**	18.0	24.9	30.2	37.0
SR46	Hamdallaye	622.082	1225.627	133.2	**183.5**	**227.2**	**277.5**	12.8	17.7	22.1	27.0
SR50	Boundou Wandé	629.21	1224.05	29.0	39.9	48.3	59.0	2.8	3.8	4.6	5.7
SR57	Daroul	630.497	1223.646	**188.4**	**260.2**	**316.3**	**386.7**	18.0	24.9	30.2	37.0
SR58	Pora PK130	630.42	1222.985	**188.4**	**260.2**	**316.3**	**386.7**	18.0	24.9	30.2	37.0

ID	Description	UTM Easting (km)	UTM Northing (km)	99th 24h PM_{10} Concentration (µg/m³)				99th 24h $PM_{2.5}$ Concentration (µg/m³)			
				Existing	18.5MTPY	22.5MTPY	27.5MTPY	Existing	18.5MTPY	22.5MTPY	27.5MTPY
SR59	Carrefour Parawol	631.43	1221.004	**188.4**	**260.2**	**316.3**	**386.6**	18.0	24.9	30.2	37.0
SR76	Parawol Aliou	624.789	1231.158	**188.7**	**260.5**	**316.8**	**387.3**	18.1	24.9	30.3	37.1
SR90	Sitako	634.252	1218.719	126.2	174.3	211.9	259.1	12.1	16.7	20.3	24.8
SR97	Madina Dian	632.551	1221.418	**188.4**	**260.1**	**316.2**	**386.6**	18.0	24.9	30.2	36.9
WHO Interim Target-1				150				75			
WHO Interim Target-2				100				50			
WHO Interim Target-3				75				37.5			
WHO Guideline				50				25			

Note: Bold values are predicted to exceed WHO Interim Target-1 (at least one time in 5 years)

a = Predicted model values, without background.

Similarly, Table 2-25 presents the maximum predicted 1-hour NO_2 concentrations resulting from blasting for those villages where an exceedance is predicted. The bold values are those that exceed the WHO guideline at least 1 time in the 5 year modeling period.

Table 2-25: Predicted 1-hour NO_2 concentrations at villages exceeding WHO guidelines

ID	Description	UTM Easting (km)	UTM Northing (km)	1h NO_2 (µg/m³)			
				Existing	18.5 MTPA	22.5 MTPA	27.5 MTPA
SR7	Daara	617.52	1234.80	**2484**	**3431**	**4172**	**5101**
SR9	Kourawel	620.67	1234.75	**5146**	**7108**	**8643**	**10566**
SR10	Sinthiourou Kourawel	620.51	1234.36	**21993**	**62493**	**75991**	**92901**
SR11	Bandodji Touguidje	617.07	1228.40	157	**217**	**264**	**323**
SR12	M'Bouroré	619.77	1227.79	106	146	177	**217**
SR13	Sinthiourou Lengueré	615.53	1226.64	**238**	**329**	**400**	**489**
SR14	Guégueré	616.59	1226.05	**4398**	**6075**	**7387**	**9031**
SR15	Fassaly Belenderé	615.05	1224.49	**317**	**438**	**532**	**651**
SR16	Parawi	615.51	1222.48	**2364**	**3265**	**3971**	**4854**
SR17	Fassaly Foutabhé	619.26	1225.23	**7014**	**9688**	**11780**	**14402**
SR21	Kankalare	616.62	1221.21	**8072**	**11149**	**13557**	**16573**
SR22	Kankalaré Hacoudé	616.89	1221.44	**1363**	**1882**	**2289**	**2798**
SR35	Kagnaka	622.33	1217.64	**9930**	**13715**	**16678**	**20389**
SR46	Hamdallaye	622.08	1225.63	**8628**	**11917**	**14491**	**17715**
SR50	Boundou Wandé	629.21	1224.05	**1641**	**2266**	**2756**	**3369**
SR57	Daroul	630.50	1223.65	**2846**	**3931**	**4780**	**5844**
SR58	Pora PK130	630.42	1222.99	**2389**	**3299**	**4012**	**4905**
SR59	Carrefour Parawol	631.43	1221.00	**314**	**433**	**527**	**644**
SR76	Parawol Aliou	624.79	1231.16	**8781**	**12128**	**14747**	**18029**
SR77	Paragogo	623.44	1229.21	**1080**	**1492**	**1814**	**2218**
SR84	Cogon Lengué	636.35	1231.95	165	**227**	**276**	**338**
SR90	Sitako	634.25	1218.72	99	137	167	**204**
WHO Guideline				200			

While it is possible to achieve additional control of emissions of particulate and gaseous COPCs in order to meet short-term WHO guidelines, it may be necessary to maintain minimum setback distances between mining activities (including blasting) and villages. As a result, setback distances for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for each of the production levels have also been determined (Table 2-26). In the vicinity of a typical unpaved road, the model results indicate that the largest setback distance required to meet the 24-hour WHO Interim Target 1 guideline for PM_{10} is 220 m. The largest setback distance required to meet the 24-hour WHO Interim Target 2 level for $PM_{2.5}$ in the vicinity of a road is 60 m. The largest setback distance required from a blast is 600 m in order to meet the 1-hour WHO guideline for NO_2.

In general, the setback distances shown in Table 2-26 can be applied directly to village locations within the modeling domain in order to assess whether the Project results in an exceedance of a WHO guideline. However near some villages, there are other persistent Project activities (e.g., wind-blown dust from stockpiles, dust from material handling at the train loading area, etc.) which may also contribute to ambient air concentrations of particulate matter. For example, Hamdallaye (SR46) is within 1.5 km of the future train loading area and is exposed to dust from activities at the loading area as well as emissions from extraction area and roads. In the 27.5 MTPA scenario, the train loading area and rail network contributes an additional 8 $\mu g/m^3$ of PM^{10} to Hamdallaye on a 24-hour basis. When considered in conjunction with the generic extraction area and road that was modeled, this results in a setback distance of 375 m for the WHO guideline of 50 $\mu g/m^3$ (instead of 355 m as shown in Table 2-26).

Table 2-26: Setback distances required to meet short-term WHO guidelines

COPC	Averaging Period	Criteria (µg/m³)		Setback required (m)			
				Existing	18.5 MTPA	22.5 MTPA	27.5 MTPA
PM_{10} (99th percentile)	24-hour	Interim Target-1	150	130	170	195	220
		Interim Target-2	100	180	220	245	270
		Interim Target-3	75	215	255	280	305
		Guideline	50	265	305	330	355
$PM_{2,5}$ (99th percentile)	24-hour	Interim Target-1	75	--	--	--	--
		Interim Target-2	50	--	--	35	60
		Interim Target-3	37.5	--	50	75	100
		Guideline	25	60	100	125	150
NO_2	1-hour	Guideline	200	525	555	575	595

2.2.7.3 *Proposed rail sidings*

A generic model setup was used to assess an idling train with three locomotives idling on a rail siding. For those rail sidings that are isolated from mining or processing activities (i.e., PK 14 and PK 72), the model results indicate that under the worst-case meteorological conditions, the 1-hour NO_2 WHO guideline is exceeded within approximately 625 m of the siding. None of the other WHO guidelines are exceeded.

Unlike PK 14 and PK 72, the proposed PK 118 siding is located in the Sangaredi mining area and within about 1 km of future extraction areas. As a result, there are some sensitive areas that may be influenced by NO_2 emissions from both the rail siding and emissions from regular mining activities and blasting in particular. Therefore, nearby villages located downwind of both a mining area and the proposed PK 118 rail siding (e.g., SR34 or SR47) may experience 1-hour NO_2 concentrations above WHO guidelines if both emission sources are present concurrently. However, it is unlikely that both activities will occur concurrently under worst-case meteorological conditions.

2.2.8 Mitigation measures

In addition to the mitigation measures already considered in the assessment, other mitigation measures to reduce concentrations of COPCs could be considered by CBG. Mitigation measures for Kamsar and Sangarédi are discussed separately below.

2.2.8.1 Plant at Kamsar

In order to reduce off site concentrations of particulate matter and gaseous COPCs in the future, the following measures will be applied:

- implement planned dust management systems during material processing;
- reduce or eliminate the use of Bunker C fuel in favor of diesel; and
- ensure dryer scrubbers are in good working order.

2.2.8.2 Mining at Sangarédi

In order to reduce off site concentrations of PM_{10}, $PM_{2.5}$ and NO_2 from haul roads and blasting activities in the future, the following measures will be applied:

- commit to achieve at least 80% control of road dust via watering, or through the application of a chemical dust suppressant (e.g., calcium chloride);
- reduce vehicle speeds on roads to 40 km/hr. or less where possible;
- if feasible, consider paving the roads, particularly in the vicinity of villages;
- optimize the haul roads to avoid villages, trying to keep 2 km away;
- evaluate the option of using larger trucks to limit the total number of truck trips per day;
- eliminate the new rail siding in the vicinity of Hamdallaye (this would have the most impact in the 22.5 MTPA scenario);
- do a feasibility study to evaluate using conveyors to transport bauxite; and
- investigate feasibility of expanding the rail network to transport bauxite in lieu of using an extended road network.

2.2.8.3 Greenhouse gas reductions

In order to reduce emissions of greenhouse gases from the Project, the following measures will be undertaken:

- maximize fuel efficiency in equipment, vehicles and locomotives by implementing good management practices, including the following:
    - ensure that all equipment, vehicles and locomotives are kept in good working order;
    - optimize vehicle and equipment movements to minimize travel and idling times;
    - optimize rail movements to reduce idling times; and
    - purchase new equipment and vehicles that are as fuel-efficient as possible; and
- minimize greenhouse gas emissions from changes in land use by promptly rehabilitating and revegetating cleared areas after extraction is completed.

2.2.9 Monitoring measures

2.2.9.1 Kamsar plant

One real-time gas monitoring station will be placed to the north of the CBG plant where access to power is possible. The preferred location would be at the baseline air monitoring location AQ-2 École. Use of a standby generator for power is not recommended as emissions from the generator can affect the measurements. A real-time station would be housed in an air conditioned trailer and would contain the following instrumentation (or equivalent):

- chemiluminescence NO-NO_2-NO_X analyzer;
- pulsed fluorescence SO_2 gas analyzer; and
- Beta Attenuation Mass (BAM) monitor(s) for PM_{10} and $PM_{2.5}$.

However, if power is not available at this location and it is necessary to move the station closer to the CBG plant, it should be placed along the northern boundary where power is available in an area with good exposure. If the location is close to roads and other sources that generate large volumes of dust, it is recommended that mini-vol samplers be placed at the AQ-2 to periodically collect dust (TSP, PM_{10} and $PM_{2.5}$) samples at this location.

Sampling must be initiated in advance of expansion activities to confirm the existing conditions and continue through the operational period.

2.2.9.2 Sangarédi mine region

Mini-vol samplers must be used to periodically collect TSP, PM_{10} and $PM_{2.5}$ samples in locations proximate to haul roads and mining areas to validate the results of the air quality assessment.

Passive NO_X and samplers should also be used in locations proximate to the mining areas to confirm the results of the air quality assessment. As mining activities move, similarly the monitoring locations should be moved.

Sampling must be initiated in advance of expansion activities to confirm the existing conditions and continue through the operational period.

2.3 Noise and vibration

2.3.1 Introduction

SENES Consultants was mandated by ÉEM (which is managing the ESIA for the Project) to produce a study on noise and vibration quality. This section is a summary of the full report air quality report: *CBG Extension Project – Environmental Impact Assessment – Noise and Vibration Impact Assessment* (SENES Consultants, 2014b) included in the appendices (Annexe 2-9).

2.3.2 Regulatory framework

2.3.2.1 Guinean legislation

Guinea does not have a community noise criterion.

2.3.2.2 IFC general EHS guidelines: environmental (noise)

The IFC provides a noise assessment approach in its *Environmental, Health, and Safety (EHS) Guidelines – General EHS Guidelines: Environmental* document (IFC, 2007). In addition to recommended sound level limits, the document also outlines preferred approaches to prevent and control noise impacts. The IFC provides sound level criteria for daytime (07:00-22:00) and nighttime (22:00-07:00) hours, to which the predicted maximum impact of the proposed undertaking are to be compared. These criteria are summarized in Table 2-27. Furthermore, the IFC guideline outlines a requirement that the proposed undertaking not result in an increase to background sound levels of more than 3 dB at the nearest receptor location.

Table 2-27: IFC noise level guidelines

Receptor	One hour LA_{eq} (dBA)	
	Daytime (07:00-22:00)	Nighttime (22:00-07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

The absolute limits (55 dBA and 45 dBA) from the IFC guideline are referenced from the World Health Organization (WHO) *Guidelines for Community Noise* (WHO, 1999). According to the source document, the daytime guideline value of 55 dBA is intended to protect against "serious annoyance" stemming from speech interference in an outdoor area of the receptor property, and is intended for application on a 16-hour LA_{eq} (daytime) basis. The nighttime guideline value has been developed to protect against sleep disturbance, and is assessed at the facade of the building structure on the sensitive property. The WHO outlines that this guideline value is to be applied on an 8-hr (nighttime) basis.

2.3.2.3 IFC EHS guidelines for mining

In addition to the IFC *General EHS Guidelines* summarized in section .1, the IFC also provides a guideline specifically for mining operations that include additional noise and vibration considerations. The *EHS Guidelines for Mining* (IFC, 2007) outlines that the noise should be managed by meeting the sound level limits outlined in the *General EHS Guidelines*, and outlines mining-specific noise control techniques. These include the enclosure of processing plants, installation of sound barriers/sound curtains, use of earthen berms at the property boundaries and planning transportation routes to minimize reversing (and associated reverse alarm noise).

Noise and vibration from blasting are discussed qualitatively in this guideline. A list of control measures for noise and vibration associated with blasting are offered, including the practice of mechanical ripping rather than use of explosives and blast design/planning considerations.

2.3.2.4 Evaluation and selection of noise criteria

The incremental limit from the IFC *General EHS Guidelines* (IFC, 2007) of 3 dB above background is not referenced to a specific source, but is known to be the approximate threshold at which the human hearing mechanism will detect a change in sound level (i.e., a change in sound level of less than 3 dB is considered imperceptible to the human ear) (Cowan, 1994). As such, it appears that the objective of this IFC requirement is to limit noise from a proposed undertaking such that it is imperceptible at the nearest sensitive receptor locations.

In terms of rating environmental impacts, typically incremental increases in sound level that are less than 3 dB are assigned a "marginal" or "no impact" rating, due to the imperceptibility of the change in sound level. However, a difference that represents a just perceptible change in sound level is not typically immediately classified as a "high" impact. An incremental increase in sound level of 5 dB is considered to be clearly noticeable but not intrusive; however, sound levels that exceed this increment may result in annoyance (Bies, 1997). A sound level increase of 10 dB is regarded as a perceived doubling of sound level, and is typically associated with a strong community reaction (Bies, 1997). As such, for the purposes of this assessment, the IFC incremental limit of 3 dB has been adopted as the threshold of a "low" impact, and increases of 5 dB and 10 dB have been classified as "medium" and "high", respectively. These impact ratings are summarized in Table 2-28.

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Table 2-28: Relative criteria for assessment of noise effects

Increase over background sound level (dB)	Change in subjective loudness	Impact rating
Up to 3 dB	Not perceptible	Marginal to none
3 to 5 dB	Clearly noticeable	Low
5 to 10 dB	Almost twice as loud	Medium
Greater than 10 dB	More than twice as loud	High

2.3.2.5 Blasting noise and vibration

Noise impacts from blasting are related to the airblast overpressure, and may result in startle response and potential rattling of building components such as windows or walls. Noise from blasting is evaluated in terms of peak noise levels measured in linear decibels, or dBL. Blasting will also have the potential to cause ground vibration impacts in the areas surrounding the proposed mine sites. There are two aspects to the evaluation of vibration effects: human annoyance and structural damage. Human perception of vibration occurs at levels that are lower than those required to cause structural damage, and therefore designing limits that protect against annoyance will also address the possibility of structural damage. Vibration impacts are evaluated in terms of peak particle velocity (PPV), measured in mm/s.

There are currently no regulations in Guinea that govern allowable noise or vibration levels from blasting activities. As such, a jurisdictional review was completed, and criteria levels from the Australian and New Zealand Environmental Council (ANZEC, 1990) have been adopted. These are summarized in Table 2-29.

Table 2-29: Selected criteria for blasting effects

Blasting effect	Recommended maximum level (95th percentile)[1]	Maximum level
Airblast overpressure	115 dBL	120 dBL
Ground vibration	5 mm/s	10 mm/s
1 – level may be exceeded up to 5% of the total number of blasts over a 12 month period		

2.3.3 Baseline assessment methodology

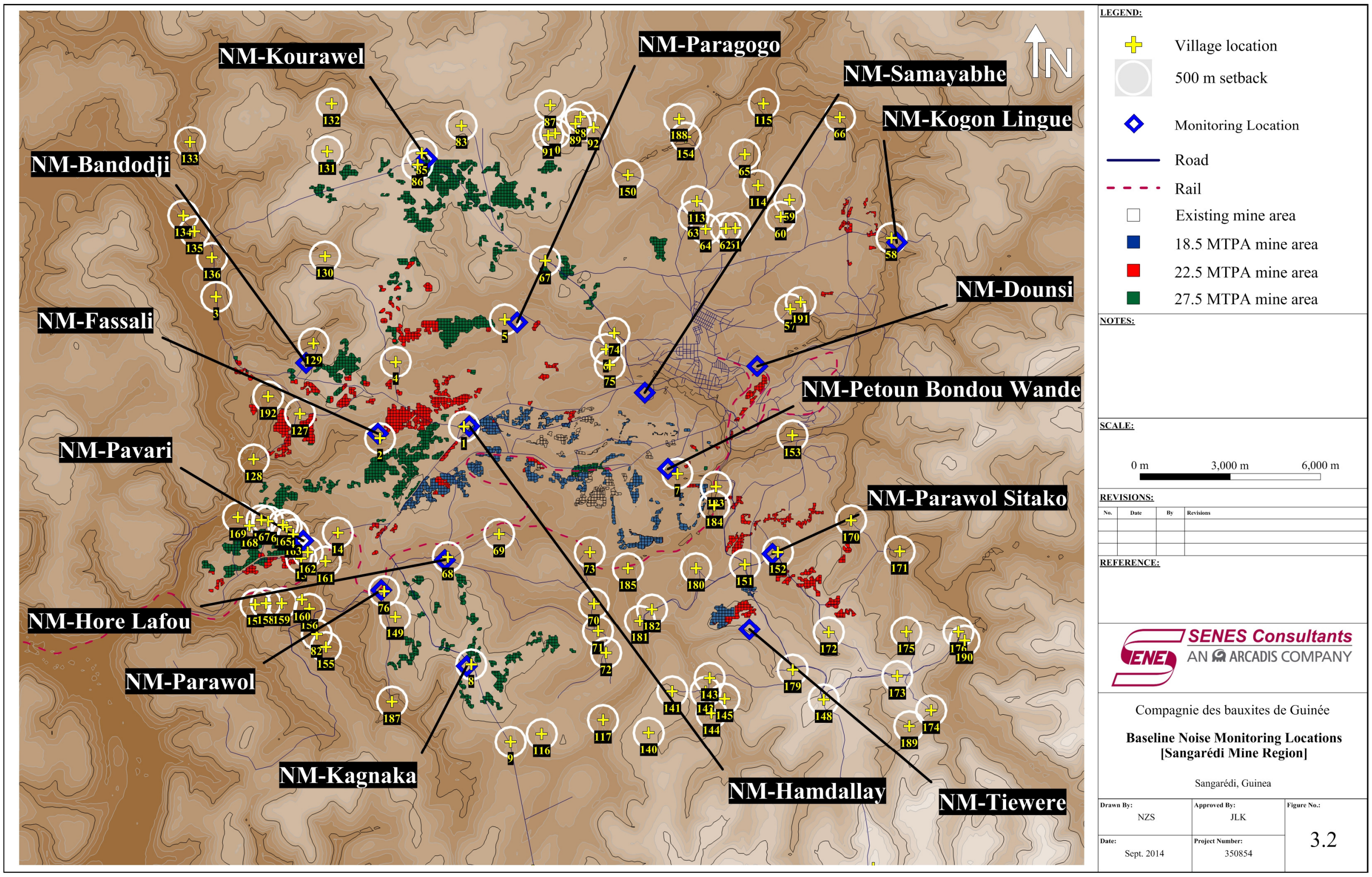
2.3.3.1 Baseline noise monitoring

The existing sound environment in the vicinity of the Kamsar processing facility and throughout the area bounding the proposed mine footprints in the Sangaredi region was characterized through an extensive ambient noise measurement program.

Aerial photography and recent GIS information were utilized to identify the locations of the nearest sensitive noise receptors to the Kamsar processing facility and the areas proposed for mining in the Sangarédi area. On this basis, a total of five (5) noise monitoring locations were selected around the Kamsar facility, and fifteen (15) were selected throughout the mine area (refer to Maps 2-3 and 2-4 and the larger maps in Annexe 2-6). Continuous sound level data were collected for approximately 48 hours at each location, as required by the IFC noise guidelines.

Map 2-3 Air quality sampling points in Kamsar (2014)

Map 2-4 Air quality sampling points in Sangarédi (2014)



The measured baseline data was validated against meteorological data being collected concurrently as part of the air quality baseline characterization study. Sound levels that were measured under unrepresentative meteorological conditions were removed from the data sets, based on meteorological thresholds outlined by the instrument manufacturer and industry best practices. This included considerations toward wind speed, temperature, relative humidity and precipitation. The remaining data was applied in the description of existing conditions in each locale.

2.3.3.2 Baseline noise modeling

Kamsar

A baseline acoustic model was developed for the existing site operations at the Kamsar processing facility, to use as the basis for estimating future sound levels attributable to the plant expansion. This baseline model was also used in conjunction with the baseline monitoring data to estimate the contribution of non-plant related sources to the existing background sound environment in the vicinity of the Kamsar processing facility.

The Cadna-A modeling software (DataKustik, 2005) was utilized to complete the baseline model for Kamsar. The outdoor noise propagation model is based on ISO 9613, Part 1: Calculation of the absorption of sound by the atmosphere, 1993 and Part 2: General method of calculation (ISO, 1996). Using this model, a three-dimensional representation of the project site and surrounding area is created, and noise sources are placed as appropriate according to the existing or planned layout. Noise sources are characterized using representative sound level data derived outside of the model (typically measured, calculated or provided by manufacturers), and are assigned to source locations in the model, as appropriate. The model executes a calculation of the sound attenuation that occurs between the sources and user-specified points of reception according to the standardized ISO method, resulting in an overall predicted sound level at each receptor location. The model accounts for distance, atmospheric absorption and the effect of the intervening ground surface type(s), as well as any obstructions to noise propagation. Obstructions to noise propagation that may be incorporated into the modeling include buildings, acoustic barriers, earthen berms and natural changes in ground elevation. These are also configured to act as reflecting surfaces, which may result in additional source-receptor paths. The ISO 9613 method has been developed to result in the prediction of "downwind" sound levels, meaning all receptors are considered downwind of all sources. This results in a conservatively high prediction of sound levels. The predictions are valid for wind speeds between 1 and 5 m/s at 3 to 11 m above the ground.

The baseline model was developed for the existing site operations at the Kamsar processing facility was based on process and equipment information available in the

Expansion Project FEL2 Study Preliminary Engineering Report (Fluor, 2014), source-specific sound level measurement data, and site plans provided by CBG

Rail activity

Acoustic modeling was applied in the assessment of potential noise impacts from projected increases in rail traffic volumes between the Sangaredi mine region and the Kamsar processing facility. Given the length of track between the mine site and processing plant, the rail line was assessed in terms of a unit length of track. This approach provides typical sound levels that may be applied generally for any segment of track. A baseline model was prepared based on existing rail traffic volumes, which were approximated at 5 trips per day. According to the project description, a typical train consists of two locomotives and 120 rail cars travelling at approximately 60 km/hr. These were modeled in Cadna-A using rail source data that is referenced to the United States Federal Railroad Administration (FRA, 2005), and points of reception were evaluated at increasing distance from the rail line

2.3.4 Baseline assessment

2.3.4.1 Kamsar

The sound environment in the vicinity of the Kamsar processing facility is influenced by existing material processing operations at the plant, as well as sounds of nature and urban sounds (e.g., traffic, human activity) closer to the city. An acoustic model was prepared to estimate the existing influence of sounds from the Kamsar processing facility on the measured sound levels, such that the existing non-plant background sound levels could be appropriately accounted for in the modeling assessment of predicted future sound levels. The dominant sources of existing noise from the Kamsar facility include the power generation building, the dryers, the rail unloading/crushing building and rail activity. A summary of the daytime and night-time sound levels in the vicinity of the Kamsar facility, as well as the log-average for the full validated monitoring period are provided in Table 2-30.

Table 2-30: Summary of sound level measurement data at Kamsar

Monitoring Location	Daytime		Nighttime		Log-Average for Monitoring Period	
	L_{eq}	L_{90}	L_{eq}	L_{90}	L_{eq}	L_{90}
NR-1	50.9	45.9	51.7	47.1	51.0	46.1
NR-2	52.8	45.6	47.5	43.7	52.3	45.4
NR-3	60.0	48.3	52.5	47.2	59.3	48.1
NR-4	59.2	55.3	53.4	46.3	58.6	54.6

2.3.4.2 Sangarédi mine region

Sound levels throughout the region proposed for mining varied depending on proximity to existing infrastructure and mining /hauling operations. Many of the villages are sparsely populated and located in areas with little or no infrastructure such as roads or industry that typically contribute to background sound levels in residential areas. As such, the background sound environment in these areas is characterized primarily by sounds of nature and limited human activity, and the associated sound levels are much lower than those measured in the more populated and active areas such as Hamdallay. The background sound levels in the outlying villages were generally in the range of 30 – 40 dBA, which is typical of a rural area. Areas such as Hamdallay are near existing mine operations, are more densely populated and closer to infrastructure such as roads and rail, and so background sound levels are more typical of a populated area (i.e., >50 dBA).

A summary of the background monitoring locations is provided in Table 2-31. The plot in Figure A-2 in Annexe 2-3 shows the monitoring locations in relation to the outlying villages. The villages are numbered and these identifiers may be cross-referenced to the full list of the village names and population information in Annexe 2-4.

Table 2-31: Summary of sound level measurement data at mine sites

Village	Daytime Sound Level (dBA)	Night-time Sound Level (dBA)	Log-Average for Monitoring Period (dBA)
Tiewere	38.2	30.9	35.7
Fassaly	36.5	36.5	36.5
Parawol Sitako	40.1	39.6	39.9
Pavari	39.4	38.8	39.1
Hamdallaye	53.1	55.1	54.1
Dounsi	36.2	37.1	36.5
Cogon Lengué	48.6	45.0	47.8
Kagnaka	50.4	52.3	50.9
Paragogo	NI	NI	NI
Bandodji	38.6	32.1	36.4
Kourawel	38.0	34.0	36.5
Petoun Boundou Wandé	43.9	43.9	43.9
Samayabhe	41.4	39.5	40.9
Horé Lafou	45.5	51.8	47.6
Parawol	NI	NI	NI

NI – no information (data discarded due to unrepresentative meteorological conditions)

2.3.4.3 Rail activity

Baseline noise along the rail corridor between Kamsar and Sangaredi was estimated in Cadna-A using rail source data from the US FRA (locomotives and rail cars). Sound levels were calculated at various distances from the rail line to establish the existing contribution of rail noise on a 1-hour, 15-hour (daytime), 9-hour (night-time) and 24-hour basis. As background sound levels unrelated to rail traffic will vary throughout the corridor, this assessment only considered the sound levels solely attributable to rail traffic as a conservative assessment measure. The predicted sound levels for existing rail traffic, consisting of two (2) locomotives and 120 rail cars are summarized in Table 2-32. For existing conditions, it was assumed that there will be five (5) train trips per day, with three (3) occurring in daytime hours (07:00-22:00) and two (2) occurring during nighttime hours (22:00-07:00).

Table 2-32: Summary of existing sound levels due to rail traffic

Distance from rail line (m)	1-hour Leq (dBA)	Day (15-hr) Leq (dBA)	Night (9-hr) Leq (dBA)	24-hr Leq (dBA)
50	61.7	54.7	55.1	54.9
100	56.7	49.7	50.1	49.9
200	51.6	44.6	45.1	44.8
400	46.5	39.6	40.0	39.7
800	41.3	34.3	34.8	34.5
1,600	35.9	28.9	29.3	29.1

2.3.5 Impact assessment methodology

2.3.5.1 Kamsar

A baseline acoustic model was developed in Cadna-A for the existing site operations at the Kamsar processing facility, based on process and equipment information available in the *Expansion Project FEL2 Study Preliminary Engineering Report* (Fluor, 2014), source-specific sound level measurement data, and site plans provided by CBG.

This baseline model was validated against the baseline measurement data, and was then adapted as necessary for purposes of estimating the incremental increases in sound level associated with the proposed expansion of the plant. The sources of noise associated with the facility expansion were based on process and equipment information available from the FEL2 study report (Fluor, 2014) or assumed to be similar to existing sources at the facility that had been measured. Any available equipment specifications from the FEL2 study report were used as inputs to source sound level calculations based on published calculation techniques for typical equipment types (e.g., motors).

Three future scenarios were set up in the model:

- expansion to 18.5 MTPA production;
- expansion to 22.5 MTPA production; and
- expansion to 27.5 MTPA production.

Points of reception were placed in the model at the actual sensitive properties, which differed slightly from the monitoring locations. The model was executed for each future scenario, and a conservatively low estimate of non-plant background was added to the result to estimate the total future sound level at each receptor. Each scenario was compared to the total sound level for the existing condition to determine the incremental impact of the project. The increments and the total predicted future sound levels were compared to the IFC criteria.

2.3.5.2 Sangarédi mine region

The Cadna-A model was also applied to predict sound levels from future operations at the proposed mine sites. Given the spatial extent of the areas proposed for mining, it was not possible to complete a separate model for each individual mine site, as they are interspersed throughout an area of approximately 400 km^2. Instead, a series of models were run using typical equipment arrangements that may be present at any given mine site. The typical cluster of equipment included:

- two (2) front-end loaders;
- one (1) bulldozer;
- two (2) haul trucks at idle (being loaded); and
- haul trucks in transit to and from the mine site.

Three models were run assuming one cluster, two clusters and three clusters of equipment would operate simultaneously and adjacent to one another in any given area, respectively. The model was configured to calculate sound pressure levels at a series of increasing distances from the center of the activity, and the results were used to prepare curves depicting sound level with distance. A line-of-best-fit was plotted for each scenario, which followed a logarithmic trend of the form $y = c\ln(x) + b$ (where b and c are constants, and ln is the natural logarithm). The constants associated with each line were exported for use in a calculation spreadsheet developed for the estimation of sound levels at each village.

Prior to proceeding with detailed calculations of the predicted sound level at each village, a separate Cadna-A model was developed, in which each village was plotted in the Cadna-A model with a digital terrain model of the surrounding area. The mine plan was imported to the model, a marker was placed at the closest proposed working area to each village, and the source-receptor distance was calculated. The 3D viewing capability of the model was then used to determine whether there was a clear line of sight to the working area, or whether the terrain in the vicinity of the receptor formed a natural barrier. Each village was then identified as having either a clear or blocked line of sight. The sound levels in the propagation curves were adjusted down by 5 dB for villages with a blocked line of sight. The calculations were completed for 102 villages in the vicinity of proposed mining operations.

Each village was assigned a background sound level, based on the background monitoring program data. As a simplifying assumption, the data from the nearest background monitoring location to each village was assumed to describe background conditions at the village under assessment. The sound level propagation curves and village-to-mine distances were then used to calculate the approximate sound level attributable to the nearest mining activity at each village. This predicted sound level was then added logarithmically to the assigned background sound level at each village to arrive at a total projected future sound level at each location. These total sound levels were compared to the IFC absolute limits (55 dBA daytime and 45 dBA nighttime), and difference between the future level and the baseline level was compared to the IFC relative limit of 3 dB.

2.3.5.3 Rail activity

The assessment of potential effects from increased rail traffic was completed by developing two (2) acoustic models, each representing unit segments of rail line identical in geometry to that developed for the baseline model. The first model was representative of a typical section of rail with no adjacent siding. The second model was representative of the locations where a new rail siding is proposed, and may therefore have a train passing on the mainline with a train idling on the siding. The sources representing the mainline were configured with rail traffic volumes that represent the expected traffic based on the future expansion scenarios. The results from each scenario were compared to those for the existing condition to determine the effect of the increase in rail traffic. For the runs that included a siding, measurement data for an idling locomotive from SENES' in-house database of measurements were applied. The sound levels were estimated on an hourly basis, as well as on daytime (15-hr), nighttime (9-hr) and daily (24-hour) basis.

2.3.5.4 Blasting

Ground vibration

The propagation characteristics of ground vibration from blasting are influenced by a number of factors, including the geology of the region, the charge mass being detonated and the distance between the blast and receptors. As propagation is strongly dependent upon geology, and geology is very site-specific, there are no standard models for reliable, repeatable predictions of ground vibration from blasting. Empirical propagation equations derived through experimentation are typically applied in the prediction of ground vibration levels by distance. These may either be from published literature, or from test blast studies conducted at the actual site under assessment. When using published literature, care must be taken to select equations that are based on measurement conditions that are as close as possible to the proposed undertaking (i.e., similar material being blasted).

Analysis of ground borne vibration propagation from blasting typically relies on the use of a scaling factor that relates the size of the charge being detonated in a single delay (usually 8 ms) to the distance at which a vibration level is measured (or predicted). For ground vibration, the square-root scaled distance (SRSD) is typically applied, which is calculated using the charge mass per delay (*W*, kg) and the distance from the blast to the receptor (*D*, m) per equation [1].

$$\textit{Square-root scaled distance } (SRSD) = \frac{D}{\sqrt{W}} \qquad [1]$$

Empirical equations are derived by plotting the measured vibration level (PPV, mm/s) against the applicable SRSD, and fitting a trend-line to the data. The line-of-best-fit for ground vibration typically follows a power-law relationship, per equation [2].

Vibration (PPV, mm/s) = $K\left(\frac{D}{\sqrt{W}}\right)^n$ [2]

The coefficients *K* and *n* for the power law relationship are the constants associated with the line-of-best-fit, and variability in these values is typically a function of geology.

In lieu of site-specific measurement data, a literature review was completed to establish a set of coefficients for use in this analysis. Resources included an Ontario Ministry of the Environment guideline (MOE, 1985), research conducted by the U.S. Bureau of Mines (USBM, 1980), previous SENES project experience, and various journal articles and publications. The average *n* value from the literature review was found to be -1.63, and so this value was considered reasonable for application in this assessment. Values of *K* ranged from 192 to 1729. A 90th percentile value of *K*=1373 was applied in this assessment.

Noise (airblast overpressure)

The assessment of airblast overpressure from blasting is also calculated using empirical equations based on measurement data sets. As with the assessment of ground vibration, the empirical equations describing airblast overpressure propagation utilize a scaled distance, though using the cube root of the charge mass per delay, rather than the square root. This is called the cube-root scaled distance (CRSC), per equation [3].

Cube-root scaled distance (*CRSD*) = $\frac{D}{\sqrt[3]{W}}$ [3]

A plot of airblast overpressure measurements (in lbs/in^2, which can be converted to dBL) versus the *CRSD* typically trend such that the line-of-best-fit to the data follows a power law relationship, similar to that for ground vibration:

Airblast overpressure (lbs/in^2) = $K\left(\frac{D}{\sqrt[3]{W}}\right)^n$ [4]

As with ground vibration, the coefficients *K* and *n* are site specific and are established based on the actual measurement data; however, for this analysis they have been based on a literature review. The USBM has summarized data for collected at a "metal mine", which have been adopted for this assessment. The *K* value was 0.401, and the *n* value was -0.713 for this calculation. Note that the use of these constants, as published by the USBM, require the use of imperial units of distance (ft) and charge mass (lbs). The resulting overpressure in lbs/in^2 is then converted to decibels based on a reference pressure of $2.9x10^{-9}$ lbs/in^2.

2.3.6 VEC identification

Valued ecosystem components (VECs) are features of the environment selected to be the focus of the ESIA because of their ecological, social, cultural or economic value and their potential vulnerability to effects of the Project. In the case of noise and vibration, the Project will result in an increase in local noise and vibration levels due to increased mining activities, and expanded bauxite processing, shipping and transport activities. Noise is primarily associated with nuisance effects; however, may have indirect effects on human health due to increased stress (e.g., from sleep disturbance, interference with communication). Vibration is also typically associated with nuisance effects; however there is also potential for structural damage depending on the magnitude. The perception that structural damage *may* be occurring may also cause stress-related health impacts. Noise and vibration are also important consideration with regard to wildlife, particularly when resulting from strong impulses such as detonation of explosives for mining.

For this assessment the VEC was identified to be Noise and Vibration, with *noise* and *vibration* each representing a subcomponent.

2.3.7 Impact assessment

2.3.7.1 Kamsar

The model of existing conditions at the Kamsar plant was used as the basis to develop models of proposed future operations with the expansion infrastructure in place. For each future scenario, additional sources and buildings were added to the model as appropriate to describe the scenario, and set to toggle on or off depending on the scenario being run.

The sound output from the facility was assumed to be relatively steady, and so separate daytime and nighttime operating scenarios were not evaluated. The predicted sound levels for each scenario are summarized in Table 2-33 (18.5 MTPA), Table 2-34 (22.5 MTPA) and Table 2-35 (27.5 MTPA). The predicted future total sound levels remain at or below the IFC daytime criteria level of 55 dBA for each scenario, and the maximum increment of 3 dB required by the IFC is not exceeded for any future scenario. The predicted future sound levels exceed the IFC night-time criteria of 45 dBA at each location; however, the baseline sound level also exceeded 45 dBA at these locations. The modeling analysis indicates that the expansion of the Kamsar facility is not predicted to result in noise impacts per IFC guidance.

Table 2-33: Summary of predicted noise impacts for the 18.5 MTPA scenario

Receptor	Non-plant background (dBA)	Existing		18.5 MTPA		Increment
		Predicted plant sound level (dBA)	Total sound level (dBA)	Predicted plant sound level (dBA)	Total sound level (dBA)	
POR1	42	44	46	46	47	1
POR2	37	45	46	47	47	1
POR3	40	47	48	49	49	1
POR4	53	50	55	51	55	<1

Table 2-34: Summary of predicted noise impacts for the 22.5 MTPA scenario

Receptor	Non-plant background (dBA)	Existing		22.5 MTPA		Increment
		Predicted plant sound level (dBA)	Total sound level (dBA)	Predicted plant sound level (dBA)	Total sound level (dBA)	
POR1	42	44	46	46	48	2
POR2	37	45	46	47	47	1
POR3	40	47	48	50	50	2
POR4	53	50	55	52	55	<1

Table 2-35: Summary of predicted noise impacts for the 27.5 MTPA scenario

Receptor	Non-plant background (dBA)	Existing		27.5 MTPA		Increment
		Predicted plant sound level (dBA)	Total sound level (dBA)	Predicted plant sound level (dBA)	Total sound level (dBA)	
POR1	42	44	46	47	48	2
POR2	37	45	46	48	48	2
POR3	40	47	48	50	51	3
POR4	53	50	55	52	55	<1

In addition to calculating the sound levels at the nearest points of reception, the model was also configured to calculate sound levels over a 10 m x 10 m grid covering the model extents in order to provide sound level contour plots. The sound level contour plots for each scenario are provided in Appendix C. These plots clearly illustrate the effect of the new infrastructure on sound propagation. For example, when the plots for the existing scenario and the 18.5 MTPA scenario are compared, the impact of the new rail unloading area being added to the northeast of the main site is clearly visible. The contours around this area get wider with the introduction of the second raw material processing line in the 22.5 MTPA scenario. It should be noted that these plots only depict sound propagation from the Kamsar processing facility, and do not include background sound (i.e., the sound levels read from the contours do not represent total sound levels).

As the expanded operations at the Kamsar are not predicted to result in an adverse impact, no mitigation requirements have been evaluated.

2.3.7.2 Sangarédi mine region

As described in section 2.3.4.2, sound levels attributable solely to mining activity were calculated at a total of 102 villages, based on various activity levels at the nearest proposed work areas. These predictions were added logarithmically to the baseline sound levels from the baseline monitoring program, to arrive at total future sound levels. The future sound levels were compared to the baseline condition to determine the increment, which was compared to the IFC criteria of 3 dB and the impact ratings in Table 2-28. The future sound levels were also compared to the absolute IFC criteria in Table 2-27. Exceedances of the absolute and/or relative criteria were predicted at a number of villages, as summarized in Table 2-36.

Table 2-36: Number of villages predicted to exceed IFC criteria for nearest work area

Scenario	Daytime (07:00-22:00)		Nighttime (22:00-07:00)	
	No. of villages Exceeding Absolute Limit (55 dBA)	No. of villages Exceeding Relative Limit (<3 dB)	No. of villages Exceeding Absolute Limit (45 dBA)	No. of villages Exceeding Relative Limit (<3 dB)
1 working area	40	39	63	43
2 working areas	48	48	74	54
3 working areas	53	53	87	67

Note: total number of villages modeled was 102.

In order to present the results, the setback distance that would be required for the prediction results to comply with the IFC criteria (both absolute and relative) at each village was calculated. The calculated setback distances for daytime and nighttime hours have been plotted as a radius around the associated village in Annexe 2-6. Work at any of the proposed mining areas that appear within the displayed setback radius are predicted to result in an exceedance of IFC criteria at the associated village.

As noted in the discussion of criteria, strict adherence to the IFC incremental limit of no more than a 3 dB increase over background means that the Project activities will not be perceptible at the receptor location. Impact ratings for sound level increments that exceed 3 dB were provided in Table 2-28. As noted in that table, an increment of up to 5 dB is considered to have a "low" rating, and an increment up to 10 dB is considered to have a "medium" rating. Additional calculations were completed to determine the setback distances required to limit increments above background to 3 dB ("low" impact), 5 dB ("medium" impact) and 10 dB ("high" impact). These plots are provided in Appendix E for each of the three scenarios. As with the IFC plots, work at any of the proposed mining areas that appear within the setback radius presented are predicted to result in an incremental increase greater than the presented amount. For example, if a mine working area appears inside of a 5 dB setback radius for a given village, it means that village will experience a sound level increase of greater than 5 dB (or a "medium" impact) if work is completed in that area. The number of villages with a predicted "medium" impact is summarized in Table 2-37.

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Table 2-37: Number of villages with medium impact (>5 dB increment)

Scenario	Daytime (07:00-22:00)	Nighttime (22:00-07:00)
1 working area	30	33
2 working areas	36	42
3 working areas	42	45

Note: total number of villages modeled was 102.

The detailed calculation results are provided in Annexe 2-8. Mitigation measures are outlined for these predicted effects in Section 2.3.7.2.

2.3.7.3 Rail activity

The potential noise impact of rail traffic increases was based on an acoustic model of existing rail conditions, with source adjustments to reflect the future increases. The increases in sound level were attributable to additional daily train trips, additional locomotives and freight cars per train (where applicable), and the addition of rail sidings with idling engines. The assumptions are outlined in Table 2-38. The predicted increases in sound level due to projected increases in rail traffic are summarized in Table 2-39.

Table 2-38: Summary of rail traffic modeling assumptions

Production scenario	Daily trips	No. of locomotives per train	No. of cars per train
Existing	5.0	2	120
18.5 MTPA	5.7	3	120
22.5 MTPA	6.9	3	120
27.5 MTPA	8.1	3	126

Table 2-39: Summary of predicted incremental increases in rail traffic noise

Production scenario	Increment increase (Day, 15hr L_{eq}, dBA)		Incremental increase (Night, 9hr L_{eq})		Incremental increase (24hr L_{eq}, dBA)		Incremental increase (1-hr)	
	Mainline only	Mainline + siding	Mainline only	Mainline + siding	Mainline only	Mainline + siding	Mainline only	Mainline + siding
18.5 MTPA	1.7	2.0	0.5	0.5	1.2	1.4	0.5	0.6
22.5 MTPA	1.7	2.1	2.2	2.2	1.9	2.1	0.5	0.6
27.5 MTPA	2.8	3.2	2.4	2.4	2.6	2.8	0.6	0.8

The incremental sound levels on a one-hour basis are not as high as the day/night/24-hr levels since there will only be one train pass-by per hour along the mainline for all operating scenarios. As such, for these runs the incremental differences in sound level per future operating scenario are the result of increases in the number of locomotives and freight cars required for future production rather than increases in train trips over the course of a given day.

All predicted increments are less than 5 dB, and so the increase in rail traffic due to the proposed expansion of operations is assigned a "low" or "marginal" impact rating per Table 2-28, and mitigation has therefore not been considered.

2.3.7.4 Blasting

The assessment of ground vibration and airblast overpressure requires the distance to receptors and the charge mass per delay. The charge mass per delay had not been established at the time of this assessment, so an assessment of the predicted levels with increasing distance could not be calculated. As such, the propagation equations were instead solved for the charge mass per delay (W) at a number of distances, using the criteria from Table 2-29 as the predicted level. When plotted, the resulting curve can be used to establish the maximum charge mass per delay that may be used at any given distance to comply with the limits. These plots are provided in Figures 2-1 and 2-2.

CBG will use the information in these plots to limit the charge mass per delay at any given location to achieve both the ground vibration and airblast overpressure limits.

Figure 2-1 Maximum allowable charge mass per delay by distance (ground vibration)

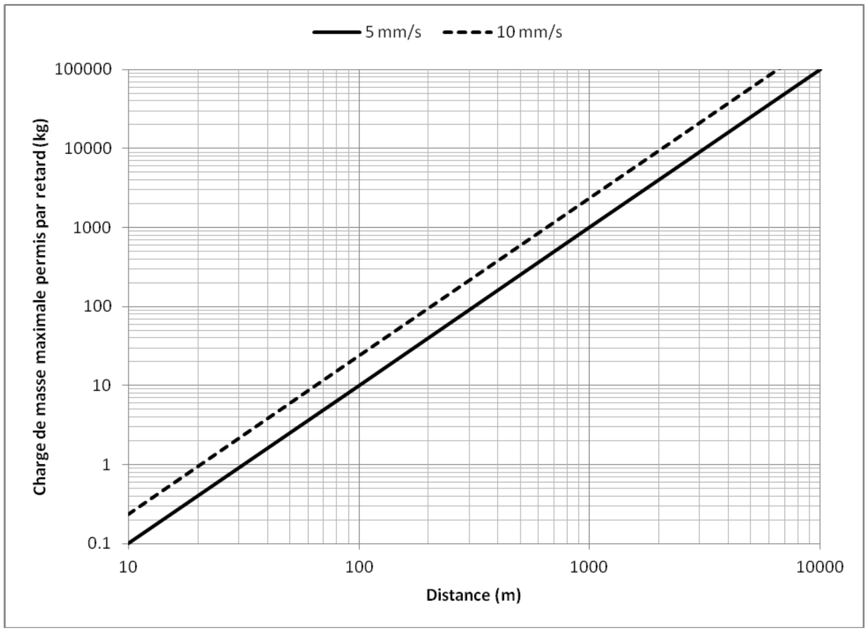
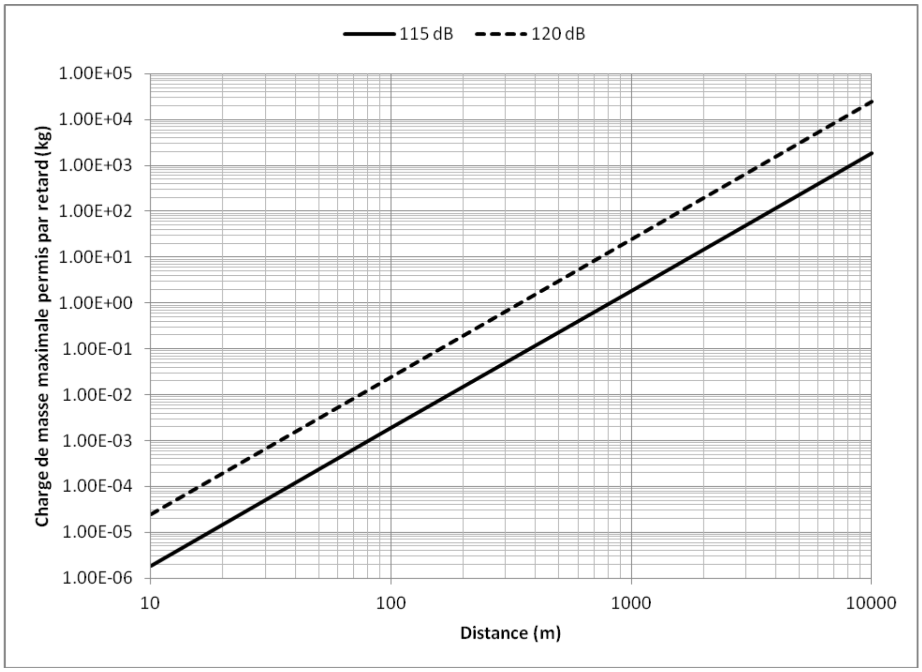


Figure 2-2 Maximum allowable charge mass per delay by distance (airblast)



2.3.8 Mitigation measures

2.3.8.1 Kamsar

The noise effects at Kamsar are predicted to result in impact ratings of "marginal to none". As such, an assessment of noise mitigation was not found to be necessary for the expansion of the Kamsar processing facility.

2.3.8.2 Sangarédi mine region

The evaluation of the mining activities at the proposed mine sites indicate that a number of villages will be adversely affected when equipment is operating at some locations. The following mitigation measures will be taken to control noise from mining operations:

- the required setback distance plots will be consulted to determine the maximum amount of equipment that can be deployed to a given mining location in a given period (day and night) (if the mining location is within the 5 dB setback radius of a village for all equipment scenarios, then mining will not take place at that location);
- similarly, if mining can take place at a given location during one period, but not another (e.g., the mine location is outside the 5 dB setback radius during the daytime hours but not the nighttime hours), this operating restriction will be adhered to;
- CBG will evaluate the feasibility of purchasing equipment with low-noise options, where such options are available (for example, such options are often available from equipment manufacturers and can include high-efficiency motors, cowlings, mufflers and more efficient exhaust pipes);
- CBG will ensure that all mobile equipment is in good repair and properly maintained;
- CBG will ensure that all mobile equipment is outfitted with effective muffling devices that are in good working order;
- CBG will evaluate the feasibility and availability of white-noise reverse alarms for mobile equipment;
- where applicable, material stockpiles will be located between the mining activity and the nearest village(s);

- CBG will evaluate options for haul routes that maximize the distance to community areas;
- CBG will regularly maintain all haul roads such that they are free of potholes or other major surface irregularities that may result in excess noise from passing haul trucks; and
- CBG will develop a noise complaints protocol to record and respond to complaints from the community.

2.3.8.3 Rail activity

The noise effects from increased rail activity are predicted to result in impacts that are either "marginal to none" or "low". As such, an assessment of noise mitigation was not found to be necessary for the increased rail activity.

2.3.8.4 Blasting

Blasting has the potential to cause an adverse noise and/or ground-vibration impact, depending on the charge mass per delay and the distance to the nearest receptor. The following mitigation measures will be taken to control blasting noise and vibration:

- CBG will limit the charge mass per delay on the basis of the actual source-receptor distance, in accordance with Figures 2-1 and 2-2;
- CBG will complete a feasibility study for the use of surface mining techniques when the required charge mass per delay cannot be accommodated; and
- CBG will notify nearest residents of the blasting schedule.

As already stated, it is further recommended that blasting noise and vibration monitoring be conducted to develop site-specific propagation curves for consideration in blast design and planning.

2.3.9 Monitoring measures

Recommendations for follow-up monitoring are outlined in the following sections.

2.3.9.1 Kamsar

As the modeling of the future operating scenarios at the Kamsar facility were largely based on sound level calculations for generic equipment and other assumptions (i.e., that new equipment will be similar to existing equipment for similar processes), it is recommended that a follow-up monitoring program be conducted for each phase of expansion. This program would be similar in scope to the baseline monitoring program that was conducted in support of this study (i.e., 48-hours of continuous monitoring at the selected locations around the Kamsar facility). This monitoring data can be used to validate the modeling predictions and ensure that the evaluation criteria are being met.

2.3.9.2 Sangarédi mine region

The assessment of mining activities was completed using predictive modeling based on generic equipment groupings. As such, follow-up monitoring is recommended to confirm the results of the assessment. This program would be similar in scope to the baseline monitoring program that was conducted in support of this study (i.e., 48-hours of continuous monitoring at the closest village to mining activity). This monitoring data can be used to validate the modeling predictions and ensure that the evaluation criteria are being met.

2.3.9.3 Rail activity

No follow-up monitoring is proposed for the rail line.

2.3.9.4 Blasting

The propagation equations used to predict noise and vibration levels from blasting have been referenced from literature, and are very specific to the geologies of the sites they were developed for. As such, there is uncertainty in how accurate these predictions are for this particular site. Given that this could have implications for the allowable charge mass per delay, it is recommended that blast monitoring be conducted such that site specific propagation equations can be developed for use in blast design for the Extension Project.

2.4 Groundwater, surface water and sediment

SENES Consultants was mandated by ÉEM (which is managing the ESIA for the Project) to produce a study on water and sediments. This section is a summary of the full report air quality report: *CBG Extension Project – Environmental Impact Assessment – Surface water and groundwater* (SENES Consultants, 2014c) included in the appendices (Annexe 2-10).

2.4.1 Regulatory framework

The Guinean regulations relating to the protection of water are primarily in the *Code de l'environnement* (Ordonnance N° 045/PRG/87) of 1987 and the *Code de l'eau* (Loi n° L/94/ 005/CTRN) of 1994. These texts put into context the protection of water and aquatic resources but do not present specific water quality standards. The *Titre 2* of the *Code de l'environnement* deals with the protection and enhancement of the receiving environments including soil and subsoil, continental waters and marine waters and their resources.

The WBG/IFC *EHS Guidelines for Mining* (2007b) provide industry-specific guidance for mining projects with respect to environmental, occupational health and safety, community health and safety and mine closure and reclamation considerations. The guidelines apply to open-pit, underground, alluvial and solution mining techniques as well as marine dredging for economic recovery (this is not applicable to port operation dredging, which is addressed in the *EHS Guidelines for Port and Harbor Facilities* in Section 2.7.5). They define target performance levels for water use and quality, wastes, hazardous materials, land use and biodiversity, air quality, noise and vibrations, energy use and visual impacts. The guidelines include performance levels that can generally be achieved in new facilities using reasonable-cost, currently available control technologies. Where the guidelines are applied to existing facilities, it is stated that it may be necessary to establish site-specific targets and an implementation schedule for achieving them.

Recommended practices for water management include:

- establishing a site-wide water balance with due consideration for mine dewatering;
- developing a sustainable water management plan;

- limiting the amount of water used;
- considering water reuse, recycling and treatment programs where feasible; and
- consultation with stakeholders to address competing water supply demands.

2.4.1.1 Surface water

The methodology applied for the development of the ESIA involves comparison of water and sediment quality data to available guidelines that are intended to be protective of aquatic biota (freshwater and marine) and/or human health. Consistent with International Finance Corporation (IFC) guidance, where Guinea does not have specific guidance, criteria published by other international regulatory agencies can be adopted. In this regard, water and sediment quality guidelines/criteria published by the World Health Organization (WHO), the U.S. Environmental Agency (U.S. EPA), Canadian guidelines and/or European Union (EU) countries, were used as the primary sources of numerical criteria.

2.4.1.2 Groundwater

Within the WBG/IFC Guidelines for Mining (IFC, 2007b), there are general recommendations for groundwater protection, which include the following:

- limiting the infiltration of adverse quality waters through the use of liners and underdrainage systems;
- providing secondary containment for pipelines, storage facilities that contain adverse-quality solutions;
- providing leak detection systems where appropriate; and
- installing monitoring wells sufficient to determine groundwater levels and quality around process solution containment systems.

The WBG/IFC *Guidelines for Mining* (IFC, 2007b) do not contain specific chemical standards or criteria for chemical parameters. Previous environmental impact statements for similar projects in the Guinea bauxite mining industry have employed the World Health Organization's (WHO's) health-based guidelines, where applicable for certain parameters (Knight-Piésold, 2008; AECOM, 2011). Where not available from WHO, there are numerous other institutions (European Union, etc.) that can be referenced to benchmark the existing groundwater quality in the two Project areas.

2.4.2 VEC identification

2.4.2.1 Surface water

Valued ecosystem components (VECs) are features of the environment selected to be the focus of the EIA because of their ecological, social, cultural or economic value and their potential vulnerability to effects of the Project. Increased mining activities, bauxite processing and shipping and transport activities associated with the Project may impact water and sediment quality through contaminant releases into air and subsequent deposition onto surface water or directly into surface water.

For this assessment, the VECs for surface water were identified as:

- freshwater ; and
- marine

For each of these VEC two sub-components were selected:

- water quality ; and
- sediment quality

2.4.2.2 Groundwater

Groundwater is identified as a VEC for this ESIA. The groundwater VEC has three sub-components:

- groundwater flow;
- groundwater quantity; and
- groundwater quality.

The operation of the port at Kamsar and the mine at Sangarédi can alter the shallow groundwater flow regime through the alteration of the infiltration of precipitation into the subsurface, which can affect the groundwater levels locally, and potentially alter the groundwater flow configuration. At the port, this can be accomplished through the creation of impervious surfaces, thus promoting run-off instead of infiltration. At the mine, infiltration can be affected through the excavation activities at the mine, and the creation of permanent or temporary impervious surfaces.

Groundwater quantity can potentially be affected by the same alteration of the infiltration of precipitation into the subsurface described above. Potential negative effects on groundwater flow regime (i.e., lowering of the water table) can affect the quantity of shallow groundwater resource available for use.

Groundwater quality can potentially be affected due to accidents and malfunctions that create spills or other discharges of hazardous materials. In addition, alterations to the groundwater flow regime (for example, the lowering of the water table) could affect the concentration of naturally occurring parameters in the groundwater. For the Kamsar area, this already occurs on a seasonal basis, with the increase in parameters such as calcium, total dissolved solids, and chloride during the dry season. There is also an interpreted seasonal seawater intrusion aspect to the water quality observed at the Kamsar Port area (Knight-Piésold, 2008).

It should be noted that there is no groundwater dewatering as part of the mine or port operations, except for during the construction of the new car dumper building at the port.

2.4.3 Existing conditions assessment

2.4.3.1 Wastewater

The processing facility at the Kamsar Port generates wastewater discharges, the volume and quality of which will be affected with the increase in bauxite production. Wastewater sampling was completed within the context of a prior study (AECOM, 2011) in January and May 2011 by an AECOM team at four locations:

- at the exit of the oil separator that treats residual liquids (primarily oily water and water contaminated by cooling liquids, Lactuca LT3000, solvents [mineral spirits and FINASOL] and degreasers) coming from gutters of the Kamsar plant or brought in from N'Dangara;
- at the exit of the oil separator in the hydrocarbon storage area;
- at the wastewater evacuation of the *Club nautique*, including according to CBG, that includes septic waste (from offices, workshops and laboratories), cooling water used for the processing facility, and steam and oily water from ditches (from the oil separator); and
- at the main gutters where wastewater from the town flow and meet.

The conclusions (AECOM, 2011) regarding these spot measurements were:

- the concentrations of suspended solids measured in the spot samples of wastewater from the oil separator and the *Club nautique* do not comply with the *EHS Guidelines* of the IFC;
- the spot measurements of wastewater from the *Club nautique*, the oil separator, the north and south Kamsar City gutters have concentrations of suspended solids that exceed some of the criteria used;
- the concentrations of oil and grease measured in spot wastewater samples from the oil separator and the *Club nautique* do not comply with the EHS Guidelines of the IFC;
- spot samples of wastewater from the oil separator show polycyclic aromatic hydrocarbons (PAH) concentrations that exceed criteria established for wastewater released to surface water (these PAHs may come from waste oil or hydrocarbons used in the power plant);
- spot wastewater from the *Club nautique*, and the north and south town gutters have phosphorus and nitrogen levels that exceed the criteria for release of wastewaters (these parameters are typically related to sanitation wastewater or chemical cleaning products such as soaps or detergents);
- the spot sample taken in the south gutter in January 2011 showed a high chloride level, probably related to the infiltration of sea water during high tide (a second sample taken at low tide in May 2011 showed a lower chloride level while other parameters remained similar to the January 2011 sample); and
- it is difficult to attribute the high heavy metal content of the *Club nautique* sample to any single source.

2.4.3.2 Surface water and sediment - methodology

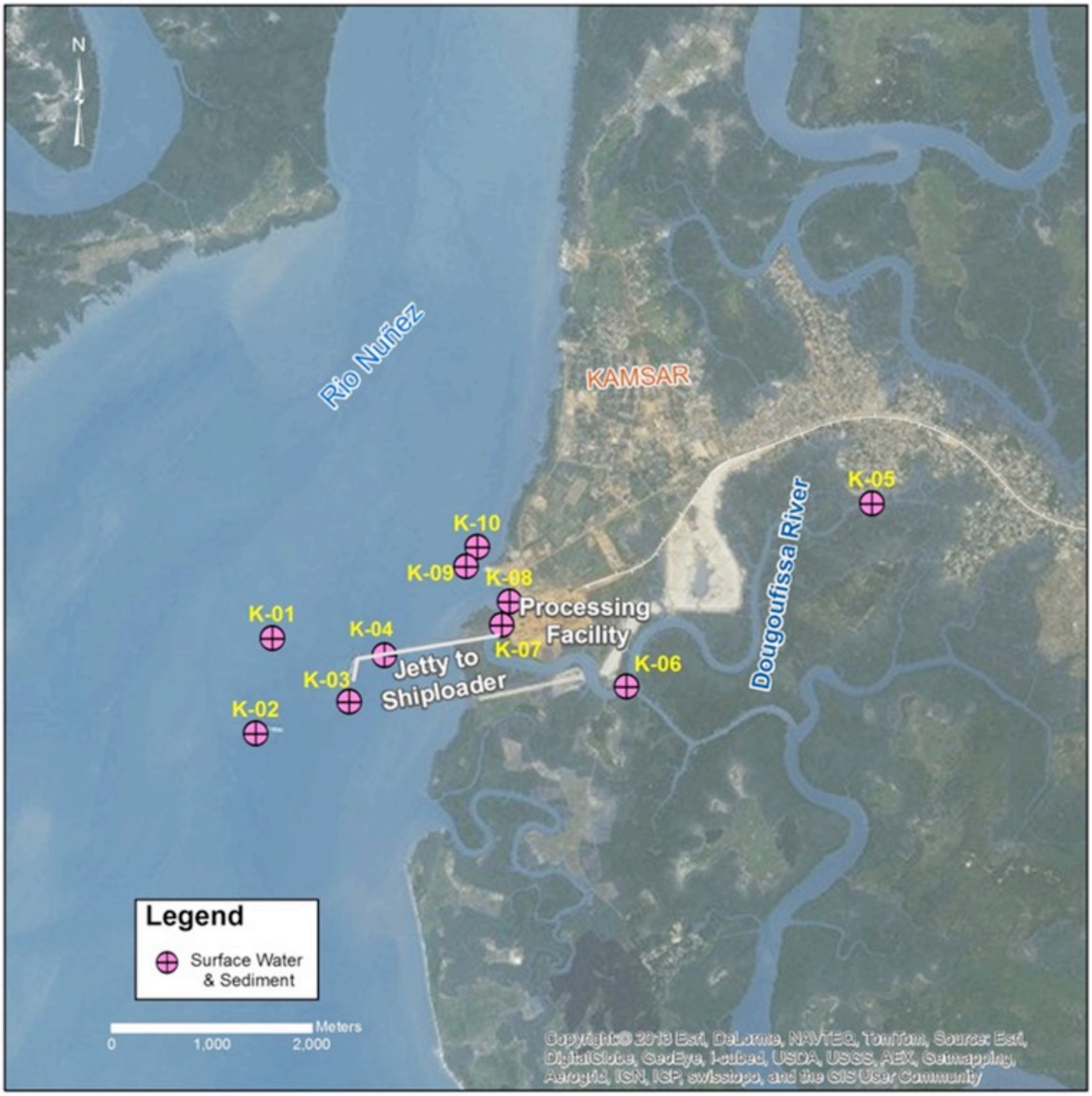
Introduction

Water quality samples had been previously collected from the Kamsar Port area where the processing plant is located (AECOM 2011). During the completion of the freshwater ecology studies (Chapter 3 of the present study), water quality measurements (e.g. pH, conductivity) were taken from the Sangarédi region where bauxite is mined. These data were augmented by surface water and sediment sampling which was carried out in April 2014 at the Kamsar Port area and in June 2014 at the Sangarédi Region

Kamsar port area

The Kamsar study area is located in the Rio Nunez Estuary, at the mouth of the Tinguilinta River where it discharges into the Atlantic Ocean. This is a large coastal river that stretches 160 km across the Boké region and drains an area of 4,858 km^2. Samples were collected from seven stations within the Rio Nunez estuary, situated along two transects; one extending progressively north from the mouth of the Dougoufissa River toward the existing loading quay (stations K-08, K-09, and K-10), and the other extending progressively west from the river mouth toward and beyond the new ship loader (stations K-01 to K-04). Station K-04 is located along the ship loader jetty, station K-03 at the south end of the ship loader, and stations K-01 and K-02 respectively northwest and southwest of the ship loader. The station locations for the Kamsar Port area are shown in Map 2-5.

Map 2-5 Sampling locations at Kamsar port area



In addition, there are many other rivers in the vicinity of Kamsar, including the Dougoufissa River, which flows in a westerly direction along the southern part of Kamsar and drains into the Rio Nunez estuary in front of the processing facility. Samples were collected from three stations along the Dougoufissa River, including one upstream of the processing facility in the eastern portion of the river (K-05), one in the lower part of the river near the processing facility (K-06), and one in the mouth of the river adjacent to the processing facility (K-07).

Sangarédi mining areas

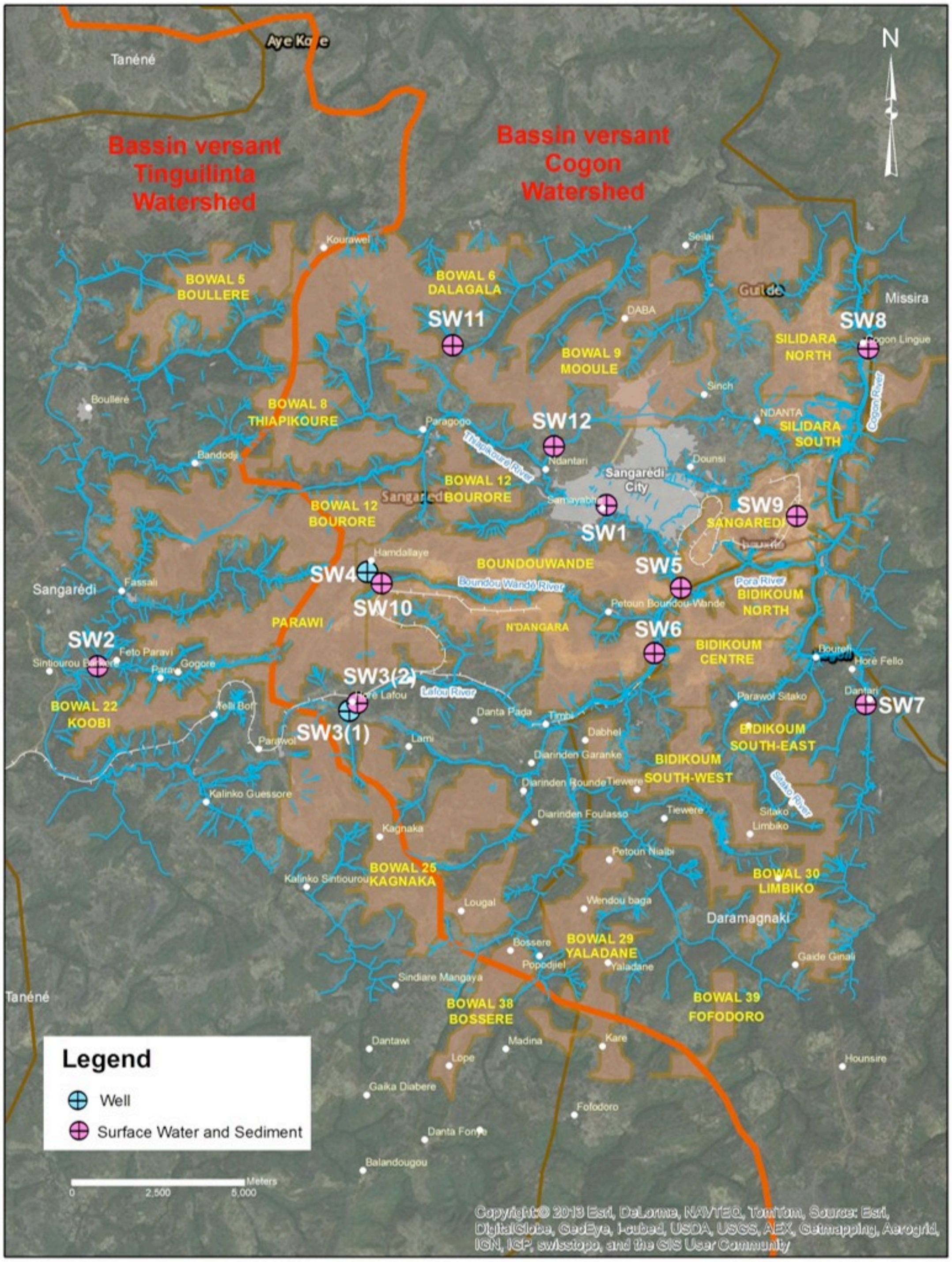
Resulting from the abundant precipitation, an extensive river network has developed within the mining area. Much of the area drains to the east and the Cogon (sometimes spelled Kogon) with rivers such as the Tiapikhouré, Boundou-Waadé, Lafou, and Pora draining eastward to the Cogon River (see Map 2-6). A part of the Study Area drains towards the Tinguilinta River watershed finally reaching the ocean by the Rio Nuñez Estuary.

The Boundou-Wandé River runs right through the middle of the current footprint of the mine operations, the Tiapikhouré River to the northwest, and the Lafou River parallel to the operations to the south. As mentioned, all three rivers drain eastward into the Pora River, which in turn flows into the Cogon River. Further south, the Sitako River also enters the Cogon River. The Cogon River flows northwest to the border with Guinea-Bissau (379 km) and then southwest until it reaches the Rio Komponi Estuary in the Atlantic Ocean.

The flow in these rivers varies greatly depending on the season. During the rainy season (July to November) it is expected that the rivers would be at the maximum flow, while during the dry season some of the small rivers may be dry.

Baseline surface water and sediment sampling in the mining area targeted locations upstream and downstream of the current mining operations along the main river systems described above, as well as some locations along streams in areas where mining operations are expected to expand (see Map 2-6).

Map 2-6 Sampling Locations at Sangarédi Mining Area



The Tiapikhouré River, which runs between the northern edge of the Boundou-Wandé plateau and Sangarédi City, was sampled on a tributary upstream of the city (station SW12) and further downstream within the southern reach of the city (station SW1). The Pora River was sampled at station SW5 at the confluence with the Tiapikhouré River. The Lafou River, which runs along the southern edge of the N'Dangara plateau, was sampled upstream at station SW3(2) near the village of Hore Lafou and further downstream at station SW6 just before the confluence with the Boundou-Wandé River. The Boundou-Wandé River was sampled far upstream at station SW10 near the village of Hamdallaye. The Cogon River was sampled upstream of the main mining operations and the confluence with the Sitako River (station SW7) and downstream of the operations and the confluence with the Pora River (station SW8).

Additional surface water and sediment samples were collected from station SW2 on a stream running along the northern edge of the Koobi (Bowal 22) plateau in the western portion of the mining area; station SW11 on a stream running along the western edge of the Mooule (Bowal 9) plateau in the northern portion of the mining area; and, station SW9 from a natural pool of water at a former mining area within Sangarédi region.

Analyses

All water and sediment samples collected from the Kamsar Port and Sangarédi mining areas were shipped to Mississauga, Ontario, Canada for laboratory analyses, which included determinations of metal constituents and general chemistry and physical parameters. In addition, in-situ measurements of pH, temperature, dissolved oxygen, conductivity, and ammonium/ammonia (freshwater only) were taken at all surface water stations during each field campaign.

The results of the field sampling are presented in Annexe 2-10 (Surface water and groundwater - SENES Consultants, 2014c). Specifically for the port of Kamsar, Table 6.2 of the report in the appendices presents the in-situ measures and Tables 6.4 and 6.5 present the concentrations in the surface waters and sediments. Specifically for Sangarédi, Table 6.6 presents the in-situ measurements and Tables 6.7 and 6.8 present the concentrations in the surface waters and sediments

In spite of all the efforts to ensure rapid transport of the samples to the laboratory, in a few cases the samples were received after the seven day limit stipulated by the laboratory for certain parameters such as TDS and TSS. This was notably the case for the samples collected on June 17 2013 at Sangarédi and that were received at the laboratory on June 27.

2.4.3.3 Surface water and sediment - description

Kamsar port area

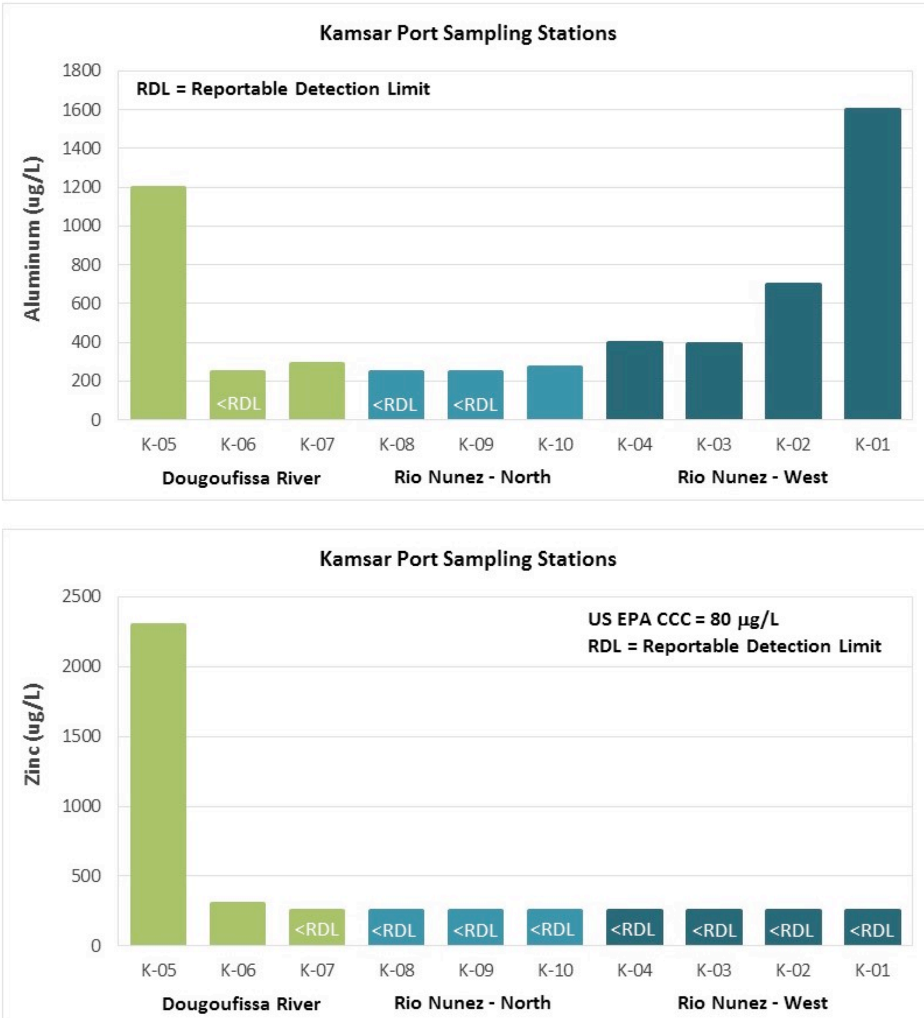
Surface water

In-situ field measurements taken in the Kamsar Port area were very similar between all of the stations sampled in both the Dougoufissa River and the Rio Nunez Estuary with only subtle dilution occurring at the river mouth upon mixing into the estuary. A slightly basic pH of 8.0 was measured in both the river and the estuary, which falls within acceptable pH levels for the protection of both freshwater and marine aquatic life. Surface waters at all stations were supersaturated with respect to dissolved oxygen, which ranged in concentration from 6.5 mg/L to 7.6 mg/L, and concentrations generally met recommended values for warm aquatic biota. The surface water temperature measured in mid-April was about 29^{o}C. The very high specific conductivity of these surface waters, ranging from 56.4 to 60.2 mS/cm, is consistent with the high levels of dissolved salts or total dissolved solids (TDS) (ranging from 34,150 to 36,900 mg/L).

Consistent with the high conductivity and TDS values, high concentrations were also reported for hardness (6,300 to 6,650 mg/L) and major ions such calcium (400 to 460 mg/L), magnesium (1,150 to 1,400 mg/L), sodium (9,800 to 11,000 mg/L), chloride (19,000 to 20,000 mg/L), and sulfate (2,600 to 2,800 mg/L). The majority of concentrations reported for total metals fell below detectable levels; however, detection limits were relatively high and typically exceeded the most conservative guideline values. Metal constituents that reported detectable levels included boron and strontium in all samples, aluminum and vanadium in most samples from both the river and estuary, and zinc in river samples only. Of these metal constituents, only zinc has a water quality criterion of 81 μg/L, which was exceeded at the most upstream stations in the Dougoufissa River (K-05 and K-06). Zinc was not detected at the remaining stations but the high detection limit of 250 μg/L also exceeds the guideline value. The concentrations of boron, strontium and vanadium were generally similar between all of the stations and between stations sampled upstream in the Dougoufissa River (K-05 to K-06) versus the Rio Nunez Estuary (K-07 to K-10) suggesting that, based on the limited data available, these constituent levels are not being affected by activities at the processing facility.

As shown in Figure 2-3, elevated concentrations of aluminum (1200 μg/L) and zinc (2300 μg/L) were measured at the most upstream station in the Dougoufissa River (K-05) but decreased below detection limits in the vicinity of the river mouth as well as throughout the estuary in the case of zinc. This suggests that aluminum and zinc are entering the river from the surrounding watershed or other sources upstream of the processing facility. As zinc levels were non-detectable in the vicinity of the river mouth and all stations within the estuary, the processing facility does not appear to be influencing zinc levels. In the case of aluminum it appears that activities at the processing facility are influencing aluminum levels in the estuary as concentrations increased moving away from the river mouth toward the ship loader to the west (K-04 to K-01).

Figure 2-3 Total concentrations of aluminum and zinc in Kamsar port surface waters



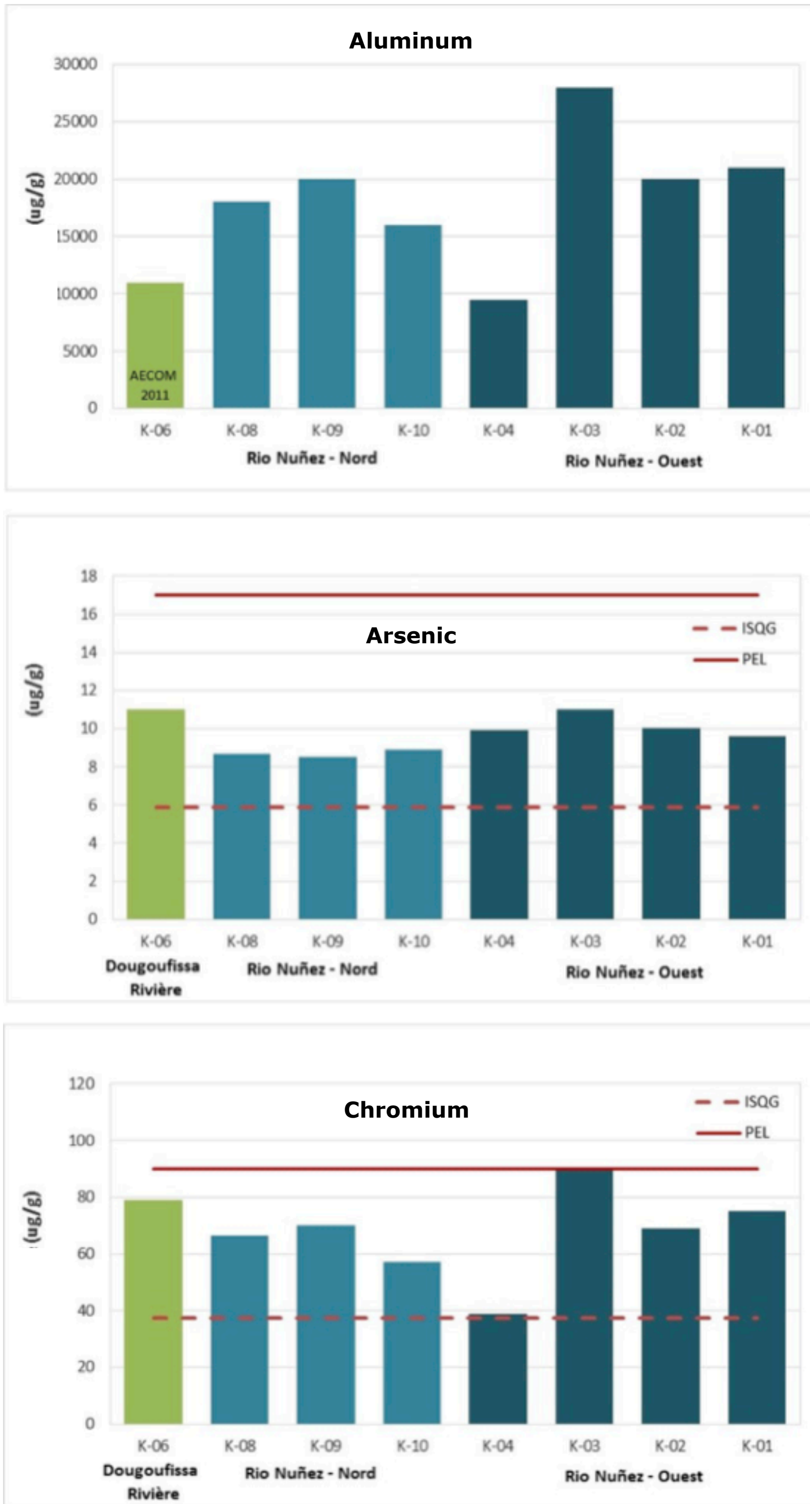
Sediments

The moisture content of all sediment samples typically ranged from about 40% to 60% and the TOC concentration ranged from 4,800 at station K-04 to 17,000 mg/kg at station K-03 in the estuary. Low concentrations falling below detection limits were generally measured for several metals including antimony, bismuth, cadmium, mercury, selenium, silver, and tin. The concentrations of arsenic and chromium exceeded the guideline value for both freshwater and marine waters on all sediment samples. The concentrations of aluminum and metal constituents exceeding CCME sediment quality guidelines in Kamsar sediment samples are shown in Figure 2-4.

Aluminum levels were previously determined by AECOM (2011) at three locations within the river mouth near the processing facility. The average aluminum concentration reported for these locations by AECOM was 11,000 μg/g, which is generally lower than what was measured in the estuary. The lowest aluminum concentration in the estuary was measured at station K-04 (9400 μg/g) along the jetty. Concentrations along the west transect ranged from 20,000 to 28,000 μg/g while concentrations along the north transect were slightly lower ranging from 16,000 to 20,000 μg/g. As seen from Figure 2-4, the same trend in concentrations was generally noted for all of the metals included in the figure with the lowest concentration measured at station K-04, the highest concentration at station K-03 and with slightly higher concentrations noted along the west transect in the vicinity of the jetty and ship loader. In addition, metal concentrations generally decreased moving from the Dougoufissa River (K-06) into the estuary along the north transect (K-08 to K-10). These metals are being influenced and assimilated into river and estuary sediments by similar processes.

It is emphasized that the existing sediment conditions were characterized based on a limited data. Sediment sampling in the Kamsar Port area was previously completed by AECOM (2011) in May 2011 when ten sediment samples were taken. The AECOM (2011) report concludes that "The analysis of the results permits to conclude that the sampled sediments have concentration below the Canadian [CCME] recommendations for sediment quality to protect aquatic life [ISQG]. Only one sample showed zinc levels exceeding the probable effects level [PEL]. The results showed elevated levels of aluminum and iron in several samples which could indicate the presence of bauxite mixed in with the sediment."

Figure 2-4 Concentrations of Metal Constituents in Kamsar Port Sediments Exceeding Guideline Values



Sangarédi mining area

Surface water

The pH in the Sangarédi surface waters was acidic ranging from 5.03 to 6.47. The pH increased moving downstream of the mining operations to the east and north along the Cogon River where the highest pH value was recorded at station SW8. The pond at the former mining area (station SW9) at the east end of the mining site was neutral. The pH measured at all river stations in the mining area fell below the acceptable range of 6.5-9.0 for the protection of freshwater aquatic life recommended by the U.S. PA and CCME. Surface waters at all river stations were undersaturated with respect to dissolved oxygen that ranged in concentration from 3.8 mg/L to 7.7 mg/L. These dissolved oxygen concentrations generally fell below acceptable levels recommended by the U.S. EPA and CCME for the protection of freshwater warm aquatic biota for all life stages. Surface water temperatures measured in the rivers in June were between 25.9 ^{o}C and 29.9 ^{o}C. The specific conductivity was orders of magnitude lower than the levels measured in surface waters at the Kamsar Port area with levels ranging from 9.6 μS/cm to 21.5 μS/cm. Concentrations of total ammonia as nitrogen ranged from 0.28 mg-N/L to 0.87 mg-N/L and were well below guidelines recommended for total ammonia in freshwater for the protection of aquatic life. Based on the limited data available, ammonia levels do not appear to be elevated in surface waters as might be expected with the use of explosives for blasting purposes during mining operations.

Low conductivity, TDS, hardness and major ions were also observed. Total dissolved solids concentrations in Sangarédi area rivers ranged from non-detectable (<10 mg/L) to 16 mg/L, hardness from 2.0 to 6.2 mg/L (as $CaCO_3$), while sulfate and chloride were not detected (<1 mg/L) at any of the stations that were sampled. The concentrations of major ions generally increased moving downstream of the mining operations; east toward the Pora River to station SW5 and north (downstream) along the Cogon River to station SW8. Concentrations of calcium ranged from 0.45 to 1.9 mg/L; magnesium from 0.23 to 0.54 mg/L; potassium from <0.20 to 0.82 mg/L; and, sodium from 0.40 to 1.5 mg/L. In addition, concentrations of boron and strontium were also several orders of magnitude lower in Sangarédi surface waters relative to the Kamsar port area with boron levels falling below the detection limit (<10 mg/L) and strontium ranging from 3.7 to 7.3 μg/L.

The majority of total metals concentrations reported in Sangarédi surface waters were below detection limits. With respect to cadmium, copper, lead and selenium, the detection limit exceeded the most conservative criterion or guideline value used in the assessment. Aluminum, barium, manganese, silicon and strontium were detected at all of the river stations including in most cases station SW9 in the stockpile area. Iron, vanadium and zinc were also detected at most stations and lead and silver at station SW5 only in the Pora River. There were no discernible trends in the available data regarding metal concentrations in Sangarédi surface waters although higher concentrations of most metals, including lead and silver, were generally measured in the Pora River (station SW5) downstream of the Tapiakhouré, Boundou-Wandé and Lafou rivers. Aluminum concentrations were highest at the upstream stations in the Lafou (SW3(2)) and Boundou-Wandé (SW10) rivers and higher along the Cogon River at the station downstream of the mining operations (SW8) relative to the upstream station (SW7), although this trend was not noted for all detectable metals.

In comparing total metal concentrations to available criteria and guideline values, exceedances were noted for iron, lead, silver and zinc concentrations at station SW5 in the Pora River. Exceedances were also noted for iron at station SW2 (1100 μg/L) near Bowal 22 (Koobi) in the west end of the mining area, station SW6 (565 μg/L) downstream in the Lafou River, and station SW8 (480 μg/L) downstream in the Cogon River. Concentrations of aluminum, iron and zinc are summarized in Figure 2.5.

Sediments

The moisture content of all sediment samples typically ranged from about 20% to 30% with the exception of sediment from the Boundou-Wandé River (SW10) which had a moisture content of 63%. The TOC content was also higher in this sample with a concentration of 140,000 mg/kg relative to a range of 6,800 to 37,000 mg/kg measured in the remaining samples.

The levels of metals in sediment were analyzed. In lieu of local standards for sediment, measured data were compared to standards developed in Canada for the protection of benthic invertebrate populations that reside in sediment. Two concentrations are provided an Interim Sediment Quality Guideline (ISQG) and a Probable Effects Level (PEL). Low concentrations were generally measured for several metals including bismuth, boron, cadmium, mercury, selenium, silver, and tin. The chromium concentration in all Sangarédi sediment samples exceeded both the ISQG and PEL. The ISQG for arsenic was exceeded in all river samples except in sediment from the Boundou-Wandé River (SW10) and the stream near Bowal 9 (Mooule) (SW11) in the north end of the mining area. In addition, the PEL for arsenic was exceeded at the downstream station (SW1) in the Tiapikhouré River and at the upstream station (SW7) in the Cogon River. Exceedances of the ISQG were also noted for copper at SW5 in the Pora River and SW11, lead at SW1 and SW5, and zinc at SW5. The greatest number of guideline exceedances were noted in the Pora River, at station SW5 which occurs downstream of the Tiapikhouré, Boundou-Wandé and Lafou rivers. At this station, arsenic, copper, lead and zinc concentrations exceeded respective ISQG values while the chromium concentration exceeded the PEL.

The concentrations of aluminum and metal constituents exceeding sediment quality guidelines in Sangarédi sediment samples are shown in Tables 2-6 and 2-7.. Aluminum concentrations ranged from 32,000 μg/g at stations SW1 downstream in the Tiapikhouré River to 76,000 μg/g at station SW11 in the stream near Bowal 9 (Mooule) in the northern portion of the mining area. Concentrations appear to decrease moving eastward towards the Pora River. It is noteworthy that the concentrations of all of the metal constituents were higher at station SW7 in the Cogon River which is upstream of the main mining operations relative to station SW8 which occurs downstream of the confluence with the Pora River and mining operations.

Figure 2-5 Concentrations of total aluminum, iron and zinc in Sangarédi surface waters

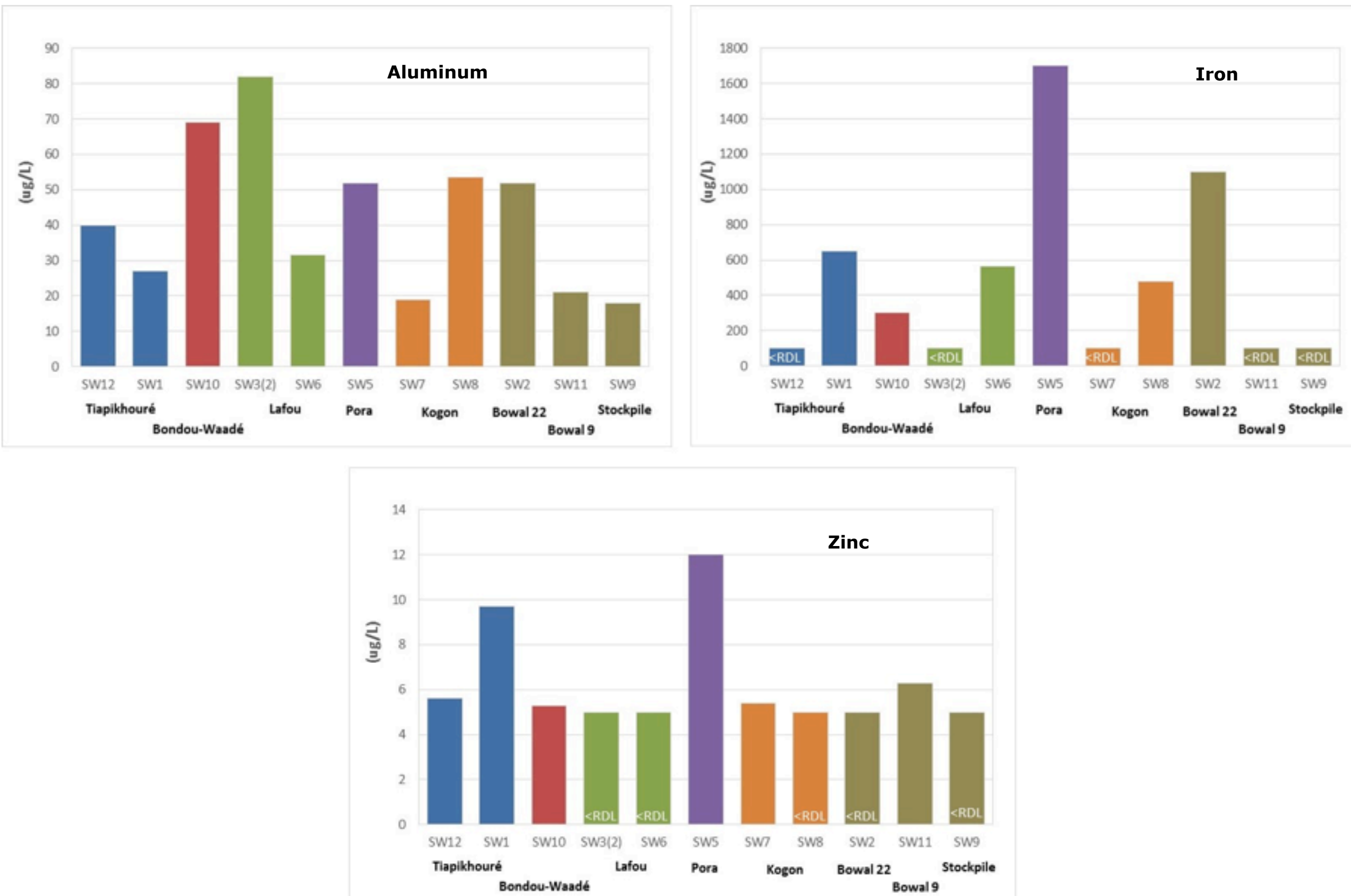


Figure 2-6 Concentrations of aluminum and metals exceeding guidelines in the sediments of Sangarédi (1/2)

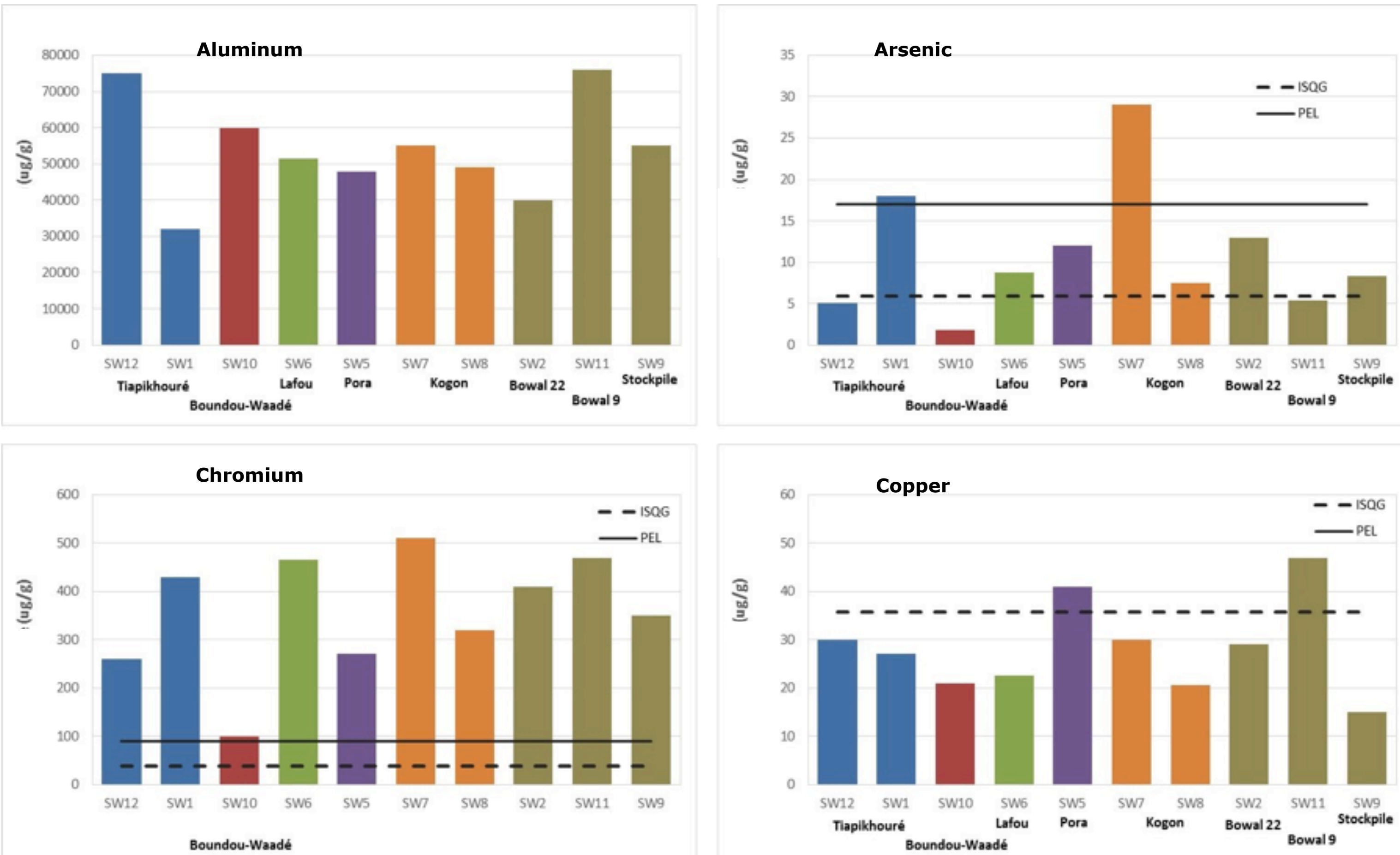
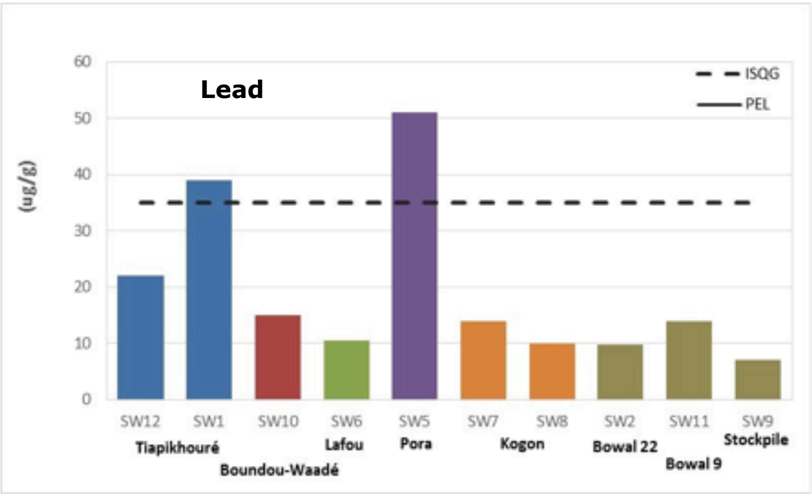
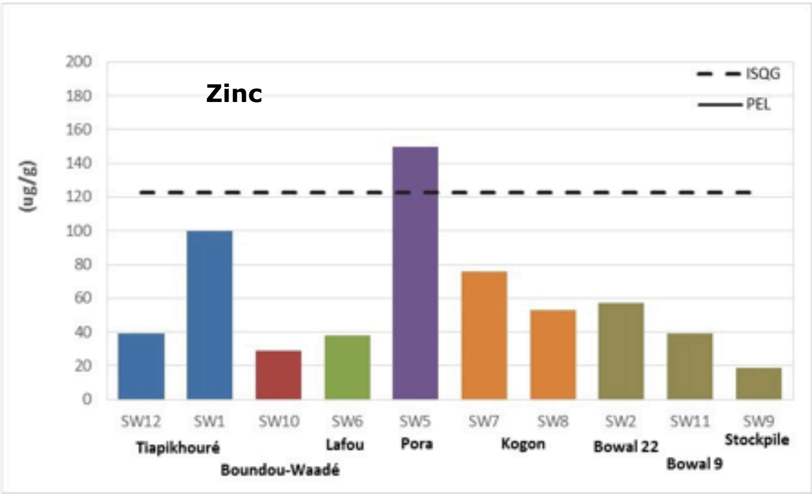


Figure 2-7 Concentrations of aluminum and metals exceeding guidelines in the sediments of Sangarédi (2/2)





2.4.3.4 Groundwater

Methodology

The primary source of data concerning the geology and hydrogeology in the Kamsar and Sangarédi Project Areas is the previous ESIA for the CBG expansion conducted by AECOM in 2011, and the ESIA for the proposed Guinea Alumina Project (GAP) conducted by Knight-Piésold in 2008, which included consideration of the port facilities, and a mine site that is adjacent to the CBG Sangarédi mine area. For both of these ESIAs, groundwater quality at Kamsar was obtained from several traditional wells, and from monitoring wells installed by others before the conducting of the EA.

For this ESIA, CBG was able to obtain two water well samples from local water well supplies within the mine site Project area, which was reviewed, where applicable, to the baseline assessment of water quality

Assessment

Kamsar

The coastal area is characterized by shallow aquifers consisting of clayey unconsolidated sediments overlying laterites that extend to over 40 m thick. The town of Kamsar has also been described as being built on a swamp of mud (Poto-Poto) subject to tidal influence.

The Knight-Piésold (2008) team sampled three traditional wells during the GAC ESIA on a periodic basis for two years, one of which was located at the CBG port facility. The chemical parameter concentrations met the WHO criteria for drinking water, except for chloride, iron and coliforms. The high concentration of chloride was interpreted as probably being related to the intrusion of salt water, and the accompanying increase in brackishness in the groundwater over the dry season. Lead concentrations exceeded the WHO guidelines at one location periodically. The presence of the bacteria was attributed to the population density in the area and poor public sanitation practices. It should be noted that the groundwater wells are not used for potable purposes, but for practical purposes on-site, such as washing or cleaning. It was stated that the villagers get their drinking water from pumps installed at several places in the village, fed by a separate network of water distribution.

AECOM (2011) sampled four wells that were located within the CBG port facility. The wells were sampled during May-June 2011, which is during the dry season. This water also exhibited exceedances of sodium and chlorine, as well as aluminum.

Sangarédi

The Sangarédi deposits are close to surface, and are accessed by direct excavation from the top or from the sides of the plateaus.

The excavations do not extend to the water table; there is no dewatering required as part of the operation, and the groundwater is not exposed to surface due to mining. Groundwater is generally encountered in a shallow aquifer located in the overburden, at the base of the bauxite deposits. Traditional shallow wells are dug into this aquifer; wells are usually dug within lands of lower elevation (i.e. not on the plateaus) to lessen the depth to access the shallow aquifer.

Twelve monitoring wells were installed within the GAC project area, which is situated immediately west of the Sangarédi mine site. Seven of these wells plus two spring samples were monitored during 2005-2006. The wells and springs contained elevated levels of aluminum, iron, and manganese, regardless of time of year, which was to be expected. Chemical parameters in the groundwater samples were generally lower than the WHO health criteria guidelines, with isolated examples of exceedances for lead, selenium, and arsenic being measured in certain wells.

Two traditional wells that were sampled in 2006 contained detectable concentrations of fecal coliform and fecal streptococci bacteria, in exceedance of the WHO biological health-based criteria for potable water. These wells were reported to be “not secure and are susceptible to runoff contaminated by human activities” (Knight-Piésold, 2008).

Two traditional wells (Horé Lafou and Hamdallaye) were sampled by CBG in the spring of 2014. Iron (1100 μg/L) and manganese (110 μg/L) concentrations in the well sample from Horé Lafou both exceeded the EU guideline values of 200 μg/L for iron and 50 μg/L for manganese. Notably, neither of the wells had elevated concentrations of aluminum, or any other dissolved metals. This may reflect the depth (source) of the well water, however, this information was not available at the time of this assessment.

2.4.4 Impact assessment

People that live in the area use surface water and groundwater for potable purposes as well as for agriculture.

The environmental impact assessment presents an analysis of how the Project will interact with its physical environment. The environmental assessment process progressed through the following steps:

- the project components were identified and selected while considering a number of key factors, including constraints related to public safety, environmental, socio-economical and terrestrial conditions and cost;
- field data about the host environment was being obtained where applicable and practical, and valued environmental components (VECs) were selected, based on a number of criteria, including public value and scientific interest;
- the Project Team collaborated to identify ways that the Project might affect the environment and the Project team then identified ways to mitigate those potential impacts;
- once the Project description was finalized, residual impacts (i.e., those that remain after mitigation) were predicted; and
- residual impacts were characterized and the significance of these impacts was determined by considering the value of the VEC and the potential importance of the impact.

Please note that the potential impacts due to accidents and malfunctions (spills, hazardous material handling, etc.) are being addressed separately.

2.4.4.1 Surface water

Methodology

CBG is currently planning to expand its bauxite production rate starting with 18.5 MTPA, to a plant capacity of 22.5 MTPA by January 2017 and a further increase of 5 MTPA to a plant capacity of 27.5 MTPA by 2022.

In the assessment of potential impacts to surface water quality, the existing condition (13.5 MTPA), and three expansion scenarios were considered:

- existing - 13.5 MTPA;
- increase to 18.5 MTPA;
- increase to 22.5 MTPA; and
- increase to 27.5 MTPA.

Kamsar

There are several project-surface water interactions identified for the Kamsar site. These include:

- wastewater released from the CBG processing facility, including release from the oil-water separator (there is also an oil-water separator at fuel storage yard);
- deposition of dust containing metals, includes deposition directly on water and deposition on land that will be transported to the port;
- physical losses of material during storage;
- deposition of SO_2 and NO_2 that may affect the water quality; and
- dredging of the turning basin.

Accidental release of substances (e.g. fuel) from spills and leakage associated with vehicles and machinery usage may also affect surface water. These potential impacts are being addressed separately.

Since the air quality assessment did indicate high levels of dust, further consideration was given to any potential changes to water quality from the facility.

Dust emissions (along with the metallic constituents) are generated by bauxite processing activities at the Kamsar port area, which include the following activities:

- rail unloading (i.e., ore handling);
- primary and secondary crushing;
- material conveyor transfers;
- drying; and,
- wind erosion of stockpiles and open areas.

Some mitigation measures have been incorporated into the current Project plans which will minimize dust emissions and/or the potential effect of project-related emissions (i.e., increased ambient concentrations of COPCs). Mitigation measures that will be applied in the future expansions include additional dust suppression systems such as dry fogging or dust collectors for the loading, transfer, and discharge of materials. These mitigation measures are detailed in the air quality assessment (Section 2.2).

Another consideration for Kamsar is that the port is regularly dredged, once every two to three years. This activity was last undertaken in 2012 and approximately 100,000 m^3 of material was removed. In addition, as the Project ramps ups, the turning basin at the existing quay will need to be enlarged for when production reaches 22.5 MTPA, while a second turning basin will be required when production reaches 27.5 MTPA. An estimated 418,000 m^3 of material will need to be dredged to implement these changes. During and for a short period of time following dredging, it is expected that elevated constituent concentrations would be observed in surface water and the sediments will be disturbed.

Sangarédi mining area

There are several Project-surface water interactions identified for the mining area. These include:

- deposition of dust containing metals that will be transported to rivers; and
- deposition of SO_2 and NO_2 that may affect the water quality.

This surface water quality study is based solely on the deposition of dust (and its metallic constituents) and gases (SO_2 and NO_2) from the operation and construction activities. Accidental release of substances (e.g. fuel) from spills and leakage associated with vehicles and machinery usage may also affect surface water. These potential impacts are being addressed separately.

Dust emissions (and its metallic constituents) are generated by bauxite mining and shipping activities at the Sangarédi, which include the following activities:

- drilling;
- blasting;
- material handling of ore;
- land clearing (i.e., dozing);
- road maintenance (i.e., grading);
- wind erosion of stockpiles and open areas; and
- haul road traffic.

Some mitigation measures have been incorporated into the current project plans which will minimize dust emissions and/or the potential effect of project-related emissions (i.e., increased ambient concentrations of COPCs). These mitigation measures are detailed in the air quality assessment.

An estimate of the water concentration was made using the dust deposition estimates. The deposition data were provided by the air quality assessment team.

Assessment

Kamsar

The predicted annual average dust deposition rates over water and land at Kamsar port area for the existing and the three future expansion scenarios are presented in Tables 2-40 and 2-41. Dust (and its metallic constituents) deposition rates for the three future expansion scenarios are either lower or similar to the existing scenario because of the mitigation measures that will be added to future expansions. The expected increase in dust emissions resulted from higher production at the processing facility at Kamsar will be offset by the addition dust suppression systems. Hence, the future expansion is not expected to result in any change to the water quality and sediment quality in the marine environment at Kamsar port area.

Table 2-40: Predicted deposition rates over water at Kamsar port area

	Average over water deposition in g/m²/s							
Scenario	**TSP**	**Al**	**Sb**	**As**	**Cd**	**Cr**	**Cu**	**Ni**
Existing	$1.2x10^{-6}$	$3.2x10^{-7}$	$4.5x10^{-12}$	$3.5x10^{-11}$	$3.0x10^{-13}$	$1.4x10^{-9}$	$1.5x10^{-10}$	$7.4x10^{-11}$
18.5 MTPA	$1.1x10^{-6}$	$2.9x10^{-7}$	$4.1x10^{-12}$	$3.2x10^{-11}$	$2.8x10^{-13}$	$1.2x10^{-9}$	$1.4x10^{-10}$	$6.7x10^{-11}$
22.5 MTPA	$6.4x10^{-7}$	$1.7x10^{-7}$	$2.6x10^{-12}$	$1.9x10^{-11}$	$1.8x10^{-13}$	$7.1x10^{-10}$	$8.0x10^{-11}$	$4.2x10^{-11}$
27.5 MTPA	$1.2x10^{-6}$	$3.3x10^{-7}$	$4.7x10^{-12}$	$3.6x10^{-11}$	$3.2x10^{-13}$	$1.4x10^{-9}$	$1.6x10^{-10}$	$7.7x10^{-11}$

Table 2-41: Predicted deposition rates over land at Kamsar port area

	Average over land deposition in g/m²/s							
Scenario	**TSP**	**Al**	**Sb**	**As**	**Cd**	**Cr**	**Cu**	**Ni**
Existing	$2.4x10^{-6}$	$6.3x10^{-7}$	$1.0x10^{-11}$	$7.0x10^{-11}$	$7.2x10^{-13}$	$2.6x10^{-9}$	$3.0x10^{-10}$	$1.7x10^{-10}$
18.5 MTPA	$2.0x10^{-6}$	$5.4x10^{-7}$	$9.3x10^{-12}$	$5.9x10^{-11}$	$6.5x10^{-13}$	$2.2x10^{-9}$	$2.6x10^{-10}$	$1.5x10^{-10}$
22.5 MTPA	$1.1x10^{-6}$	$2.9x10^{-7}$	$6.4x10^{-12}$	$3.3x10^{-11}$	$4.6x10^{-13}$	$1.2x10^{-9}$	$1.4x10^{-10}$	$1.1x10^{-10}$
27.5 MTPA	$1.6x10^{-6}$	$4.1x10^{-7}$	$8.8x10^{-12}$	$4.6x10^{-11}$	$6.3x10^{-13}$	$1.7x10^{-9}$	$2.0x10^{-10}$	$1.4x10^{-10}$

Potential acidification of surface water due to deposition of sulfur (S) and nitrogen (N) from gases produced by machinery was also considered. Although the air quality assessment showed that concentrations will increase with production, the prevailing wind direction indicated that deposition will occur mainly on land and it is not expected that the operation would have an effect on the pH of the surface waters.

As discussed previously, the port is dredged on a periodic basis for navigational purposes and the turning basin will have to be enlarged. As the Rio Nuñez Estuary is relatively shallow in depth, regular dredging is necessary to maintain an access channel to allow ships to reach the existing loading quay. This activity results in a physical disturbance to sediment causing sediment suspension which in turn increases water turbidity and degrades water quality.

Water for Kamsar currently comes from deep wells at Sogolon (30 km to the northeast of Kamsar) and from the Tinguilinta River via a pumping station near

Boké (Batafong). Of the daily received volume of 11,000 m^3, CBG distributes approximately 5,000 m^3 to Kamsar City. No increase in pumping at Sogolon is planned under the Extension Project. For the 27.5 MTPA scenario, an additional consumption of 1,381 m^3 is predicted, to come exclusively from the Batafong pumping station. As the Tinguilinta watershed upstream from Boké is 3,750 km^2, no change of current conditions is anticipated.

Sangarédi mining area

The predicted annual average dust deposition rates over land at Sangarédi for the existing and the three future expansion scenarios are presented in Table 2-43. Deposition rates go up as production increases with the exception of the 27.5 MTPA scenario. Mining activities in that scenario would be in a different area and the locations where there is extraction are closer together. The haul road is also direct to the shipping area. Thus, although the predicted concentrations are higher in the 27.5 MTPA scenario, the area of impact is smaller and thus the average value is lower than the other scenarios. It is acknowledged that there is the potential for a larger impact on some of the smaller rivers, this risk is expected to be highest in the 27.5 MTPA due to the higher concentrations.

The results shown in Table 2-42 show that the deposition of dust and metals can increase by almost 60%. See the air quality assessment (Section 2.2) for details regarding the different assumptions used for each scenario.

Table 2-42: Predicted deposition rates over land at Sangarédi

	Average over land deposition in g/m²/s							
Scenario	**TSP**	**Al**	**Sb**	**As**	**Cd**	**Cr**	**Cu**	**Ni**
Existing	$3.5x10^{-7}$	$2.4x10^{-8}$	$3.1x10^{-13}$	$2.6x10^{-12}$	$2.0x10^{-14}$	$1.0x10^{-10}$	$1.1x10^{-11}$	$5.0x10^{-12}$
18.5 MTPA	$5.2x10^{-7}$	$3.4x10^{-8}$	$4.3x10^{-13}$	$3.7x10^{-12}$	$2.9x10^{-14}$	$1.4x10^{-10}$	$1.6x10^{-11}$	$7.0x10^{-12}$
22.5 MTPA	$6.1x10^{-7}$	$3.8x10^{-8}$	$4.8x10^{-13}$	$4.1x10^{-12}$	$3.2x10^{-14}$	$1.6x10^{-10}$	$1.8x10^{-11}$	$7.9x10^{-12}$
27.5 MTPA	$5.1x10^{-7}$	$2.7x10^{-8}$	$3.4x10^{-13}$	$3.0x10^{-12}$	$2.3x10^{-14}$	$1.1x10^{-10}$	$1.3x10^{-11}$	$5.6x10^{-12}$

A (quasi) mass balance approach was used to assess the impacts of the increased dust deposition (and its metallic constituents) to the surface water quality of the water bodies in the Sangarédi mine area. Since not much information on the watershed in the Sangarédi mine area is available, the assessment was conducted only for the Cogon River where flow statistics are available from the Guinea Alumina Project (Knight Piésold, 2008). This screening-level assessment indicated that it is possible that the project will have an influence on water quality in the area, particularly for aluminum. It is noted that impacts may be more significant to smaller rivers and streams due to lower flow rates; however, these effects would be localized.

The predicted surface water concentrations in the Cogon River resulting from air deposition are presented in Table 2-43. The concentrations are predicted to remain low with the possible exception of aluminum. Aluminum surface water concentrations in the Sangarédi mine area may potentially be impacted.

Table 2-43: Predicted surface water concentrations resulting from air deposition (Sangarédi)

	Incremental Concentrations (µg/L) in Cogon River due to air deposition						
Scenario	**Al**	**Sb**	**As**	**Cd**	**Cr**	**Cu**	**Ni**
Existing	65	0.001	0.007	0.00006	0.28	0.031	0.014
18.5 MTPA	91	0.001	0.010	0.00008	0.38	0.044	0.019
22.5 MTPA	102	0.001	0.011	0.00009	0.43	0.049	0.021
27.5 MTPA	73	0.001	0.008	0.00006	0.31	0.035	0.015
Maximum Measured	54	<0.5	<1.0	<0.1	<5.0	<1.0	<1.0

The water quality guideline for aluminum used in the assessment is 87 µg/L from the U.S. EPA. This value is based on toxicity test with the striped bass in water with pH 6.5–6.6 and hardness <10 mg/L. There is potential for this value to be approached or exceeded in the expansion scenarios, particularly the 22.5 MTPA scenario. The mobility and availability (therefore toxicity) of aluminum is highly influenced by pH and presence of dissolved organic carbon. There is generally more inorganic and organic Al as water pH decreases, and there is generally more organic Al as the concentration of DOC increases (Gensemer and Playle 1999). The pH in surface waters in the area ranges from 5 to 6.5, which is somewhat acidic. There is uncertainty in the pH as measured by the laboratory were higher (in the range of

6.2-6.7) and the measurements taken by the freshwater ecology team showed neutral pH (6.6-9.6) in local streams. DOC in the samples collected from the area is in the range of 1 to 2 mg/L. It is also noted that temperature can have an effect, at low temperature (2°C) aluminum species are expected to remain in their most toxic form compared to that which would occur at higher temperature (20°C).

Currently aluminum concentrations in sediment range from 32,000 μg/g to 76,000 μg/g without any obvious spatial distribution. These concentrations are within the range of values measured worldwide (WHO, 1997). If there are changes to the water quality, this could also influence sediment quality, particularly in areas where there may be deposition. Considering that this is an active mining area and, although data are limited, there is no obvious indication of impacts on sediment to date, it is not expected that there would be widespread changes to the aluminum levels in sediment as the project progresses; however, localized areas of increased aluminum in sediment may occur.

Potential acidification of surface water due to deposition of sulfur (S) and nitrogen (N) from gases produced by machinery was also considered. Although the air quality assessment showed that there are short-periods of high concentrations, the annual average concentrations are low. Hence it is not expected that the operation would have an effect on the pH of the water.

CBG has a water treatment plant at Sangarédi to supply the mining operations and part of the town. The pumping station is on the Cogon River downstream from the dam to ensure supply even during the dry season. There will be an increase in water need during the Extension Project, notably an increase in water required for dust control on roads. For the 27.5 MTPA scenario the predicted increase in water use is 496 m^3 per day. Given the importance of the water volume in the Cogon and the presence of the dam, the impact is considered to be low. There is also predicted to be an increase in water in shallow aquifers following the increase in infiltration when new pits are opened.

2.4.4.2 Groundwater

Methodology

A review of the Extension Project port and mining operations was used to qualitatively evaluate the potential impacts on the groundwater resource from the proposed activities.

In the case of groundwater, the scope of field studies was limited to sampling of a couple of traditional wells in the Sangaredi mine site region. There was previous information on groundwater quality that was available from previous studies, briefly summarized above. The assessment relied to a great extent on professional judgment based on knowledge of the scale of proposed new construction at the Kamsar site, the method and scale of extraction at the mine site, and geological and hydrogeological information.

Kamsar

The Extension Project requires the installation of a new car dumper along with associated rail yard modifications. This decision was based on the fact that the forty year old existing unloading facility requires high maintenance and that the new car dumper will provide a safer unloading operation. The unloading will produce dust especially during the dry season. A dust control system will be provided in order to maintain a clean working environment in the car dumper vault.

The magnitude of the effects is classified as medium, due to the high relative score that was accorded the VECs related to the physical environment. The potential effects of dewatering at the new car dumper construction is considered to have the largest potential effect of any construction activity; most of the other activities do not entail dewatering, and the port site itself has already been affected by continuing operations with respect to presence of impervious surface, increased run-off etc. Note that the potential effect from dewatering is of short duration, restricted to the length of time that the excavations related to the car dumper construction are open.

The magnitude of the potential impacts from the increased rate of extraction and area in operation does not change under the 18.5 MTPA, 22.5 MTPA, or 27.5 MTPA scenarios.

Sangarédi

At present, there is a paucity of groundwater monitoring at the Sangaredi mine site, where CBG has been operating for several decades. There is on-going extraction, and there may be impacts to groundwater from spills and/or related to day-today operations (e.g. residues from blasting).

Limited groundwater monitoring of local water wells has not indicated adverse impacts related to general chemistry or metals parameters.

2.4.5 Mitigation measures

If there is a need to have an additional source of wastewater discharge, the effluent must meet IFC discharge criteria.

Some mitigation measures have been incorporated into the current project plans which will minimize dust emissions and/or the potential effect of project-related emissions (i.e., increased ambient concentrations of COPCs). These measures have been described in further detail in the air quality assessment.

2.4.5.1 Kamsar

The impact sources are related to construction of the new facilities at the Kamsar port and plant, specifically the dewatering associated with construction of the new car dumper. The mitigation efforts for groundwater quantity and flow are related to discharging the water to the Dougoufissa River or ocean. The effects of dewatering on the water levels in the shallow aquifer are localized (expected radius of influence <100 meters) and of short duration, due to the clayey nature of the near-0surface soils and the shallow penetration of the water table. With respect to groundwater quality due to dewatering, the implementation of reasonable best management practices in the vicinity of the dewatered excavations should adequately protect against producing an adverse effect on the local shallow aquifer water quality. Measures should be undertaken to provide filtration to minimize the amount of total dissolved and total suspended solids that are discharged during dewatering.

2.4.5.2 Sangarédi

There are potential positive effects on groundwater flow and quantity due to the potential for increased infiltration of precipitation into the subsurface due to the exposure of subsurface soil from mine excavation activities. Blasting activities can also increase infiltration by creating surficial fractures in the soils/laterites. In the absence of a vegetated surface, infiltration directly into the subsurface can be expected to be greater under the post-extraction scenario.

Despite the above, re-vegetation of the excavation surfaces is still recommended, in that it helps prevent soil erosion, fixates nutrients to the soils, and promotes habitat for flora and fauna. Under a scenario of progressive rehabilitation of the excavation surfaces, the change in the infiltration compared to the pre-extraction condition is expected to be negligible.

The groundwater quality could be affected by the current mining activities through infiltration of precipitation into the soil, facilitated by the creation of soil fractures from the blasting. Explosive residues could therefore more easily lead to groundwater contamination by infiltration after a rainfall. The Project will increase the frequency of the blasting. Although this could represent an additional risk for groundwater contamination, blasting activities have been occurring throughout the mine site area since the onset of operations. Since there is no baseline (pre-mining) groundwater quality data for the region, especially proximal to the mined plateaus, and no groundwater monitoring regime has been in place since mining first commenced, it is impossible to judge if groundwater has been already been affected by mining activities through this interaction. Without this information, the impact magnitude is assessed as of low magnitude as originally indicated in an environmental impact study performed in 2011 (AECOM, 2011, p. 5-65).

2.4.6 Monitoring measures

2.4.6.1 Surface water

An environmental monitoring program must be developed that includes any wastewater discharges to the environment to ensure that the quality of the releases complied with the applicable guidelines.

Routine monitoring of surface water and sediment in the Kamsar port and Sangaredi mining areas is needed in order to augment the limited database currently in existence and to help establish spatial and temporal trends of constituents in each area. At a minimum, the "baseline" monitoring program will have to be repeated but should be expanded over time to encompass new areas of operation with additional upstream and downstream stations being established to help assess the impacts of mining activities on surface water and sediment quality. It is also important to gather information on the seasonal variability.

2.4.6.2 Groundwater

Kamsar

Measures will be undertaken to provide filtration to minimize the amount of total dissolved solids (TDS) and total suspended solids (TSS) that are discharged during dewatering. On-site monitoring of the discharge using portable monitoring equipment will be implemented during the dewatering phase of the car dumper construction.

Sangarédi

Limited groundwater monitoring of local water wells has not indicated adverse impacts related to general chemistry or metals parameters. However, there are parameter suites that have not been tested (petroleum hydrocarbons, blasting residue compounds).

A shallow groundwater monitoring network will be established in proximity to plateaus that have already been completely extracted and plateaus that are currently still being exploited to establish baseline (i.e., current conditions).

The network could be employed to provide a basic characterization of the groundwater quality regime in the vicinity of the mine operations. Monitoring wells must also be installed in the vicinity of several plateaus that have not been extracted, and ideally, that are distant enough, and upgradient or cross-gradient from, other extracted plateaus, so that they may be considered to provide relative "baseline" groundwater quality information. This could be conducted in concert with monitoring of the discharge from springs that may provide potable water to residents, or merely discharge to surface watercourses. Groundwater samples must be analyzed for general chemistry, metals as well as petroleum hydrocarbons, blasting residue compounds where appropriate.

2.5 Landscape, geology, soils and seismicity

This section is largely based on the AECOM ESIA for a CBG increase in production project in 2011 (AECOM, 2011), with some additional data and field analyses, notably the landscape study. ÉEM mandated Sylvatrop Consulting to produce a landscape analysis.

2.5.1 Regulatory framework

Guinean regulations concerning the protection of soils are mainly found in the *Code de l'environnement* (Ordonnance N° 045/PRG/87) of 1987. This text puts into context the protection of soils but does not present specific standards for soil quality. *Titre 2* of the *Code de l'environnement* considers the protection and enhancement of receptor environments including the soil and subsoil. It should be noted that there is no Guinean requirement or legal standard for the assessment of landscapes or visual resources.

The *Environmental, Health, and Safety Guidelines for Mining* of the World Bank and the IFC (2007b) give specific guidance to the industry for mining projects in regards to environment, worker health and safety, community health and safety and the closure and restoration of mining sites. The guidelines apply to different mining techniques. They define target levels of performance for waste, hazardous materials, land use, biodiversity, air quality, noise and vibration, energy use and visual impacts. The *EHS Guidelines* contain performance levels that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the *EHS Guidelines* to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

In this ESIA, the soil analysis results are compared to the level C described in the *Guide d'échantillonnage à des fins d'analyses environnementales* of the ministère du Développement durable, de l'Environnement et des Parcs du Québec (MDDEP, 2009) concerning land used for industry.

2.5.2 Baseline

2.5.2.1 Landscape

Introduction

This section presents the visual landscape in the area where the Project is to be implemented. It targets three principal areas into which the different components of the Project will integrate themselves. In the first place, it is the site of the treatment plant in Kamsar, where the principal infrastructure needed for the increase in production will be built. In the second place, it is the port. In the third place, is the bauxite mining area in Sangarédi.

There is no site within the Study Area that is on the UNESCO world heritage list, a list that includes 981 sites that make up the cultural and natural heritage deemed to have exceptional and universal value. Only one site in Guinea is on that list: the integral nature reserve of Mount Kimba. This reserve includes a large number of animal species on the IUCN red list.

The analysis of a landscape is a difficult thing:

> The perception of a landscape being largely influenced by the subjectivity of the observer and his or her background, culture, geographic origin, etc., it is always necessary to take into account the difficult to quantify emotional side of the observer.
>
> The perception that an observer has of a landscape opening or closing generally varies from one observer to another. However, what varies remarkably is the effect that this sensation has on the observer.
>
> A person native to the area will be sensitive to elements that are nearly indescribable, such as odors, sounds, a particular human activity (agriculture, forestry, hunting, fishing), the presence of animals, the effects of the wind and warning signs of weather.
>
> (http://www.ecosociosystemes.fr/paysages.html).

Methodology

The approach used in the context of the visual environment is the one generally used in the classical approach to landscape analysis.

The approach is on the one hand search for valued elements of the landscape such as national parks, listed forests and heritage sites, and, on the other hand search for those that might be modified by the elements of the Project. Finally one determines what these elements represent for observers whether they are local communities or visitors.

The approach of course includes an inventory of the landscape elements or the landscape units that enable later the identification of the most vulnerable elements within the context of the Project implantation.

The landscape resources that contribute to the visual environment are varied and cumulative. They comprise, among other, the topographical relief, the geology and the natural resources (woodlands, watercourses, fauna, fauna and their diversity).

The landscapes can be divided into three categories based on their tolerance to change: natural landscapes, modified landscapes and built landscapes.

A natural landscape, which has not been modified by human activities, is very sensitive to changes since any human modification to this landscape would be the first.

A modified landscape (such as a harvested forest, a forest transformed into agricultural land, slash and burn agriculture or a mined environment) has a greater tolerance to visual changes.

The built environment (towns, villages and associated infrastructure) has the greatest tolerance to change because it is entirely, or nearly so, modified by human activities.

Kamsar plant

The site of the plant in Kamsar does not include any valued landscape elements. It is an industrial landscape greatly modified by humans that has a great tolerance to visual changes.

Outside the walls of the plant, the plant chimney and its plume are very visible to observers from the national road at the entrance to Kamsar or from the sea. In the town itself, because of buildings and the vegetation that act as visual barriers, the plant site is not very visible.

The local communities, townspeople and people associated with fishing activities, are permanently confronted by this landscape and are probably used to it, to the extent that they may no longer perceive it as an artifact in their landscape but as an element in their daily lives. For a visitor, the chimney and its plume constitute a visual feature that automatically captures one's attention.

The new infrastructure elements within the plant enclosure related to the increase in the treatment and export of bauxite (conveyors, drying station, railroad car unloading area, etc.) are much lower in terms of height and will practically only be visible to workers within the plant enclosure.

Photo 2-1 CBG plant at Kamsar

Kamsar port

The port of Kamsar is visible only from the sea. It is composed primarily of a jetty (supporting a conveyor and an access road) and a bauxite-loading quay at the end of the jetty.

The port is in between the coastal plain landscape unit and the marine landscape unit. These units developed from the geological evolution of the environment over time. They are composed of various forms including large marine expanses, islands and islets, mangrove forests, tidal channels, mud flats, sand banks and beaches (sandy, muddy or rocky), all elements composing the visual aspect of the neighboring environment.

At sea the views are vast, open and deep most of the time, depending on weather conditions and the position of the observer in relation to the coast (the perception of a landscape depends on the distance to the observed landscape or the framing the observer uses). These two landscape units are common along the Guinean coast.

The marine landscape unit may be considered as quasi-natural because it has few evident anthropic modifications. It is frequented by what appears to be an established population of Atlantic humpback dolphin, a threatened and little known species (see Section 3-5), which makes the site of particular interest for the region of Kamsar. Even if locally this does not mean this unit is of special status, any intervention in the marine environment should take this species into account.

As to the coastal plain landscape unit, it is composed of a modified landscape having lost its initial characteristics due to anthropic interventions such as harvesting the mangrove stands for fire wood and using the land for agriculture, the construction of ports such as the Quai français, the Quai italien, Port Néné and the CBG mineral port, elements making up the biggest visual artifacts of the unit along with the chimney of the industrial complex for a visiting observer. For the local fishing communities (the main local observers), the CBG mineral quay and the industrial complex have formed part of their daily visual environment since the end of the 1950s.

The coastal landscape unit in the region of Kamsar does not present sufficient biodiversity or heritage characteristics to make it a particular valued landscape element when compared to the southeast of the Island of Binari that has a very high ecological value in view of its use by migratory birds and nesting turtles and is considered a Ramsar site, or the nature reserve of the Tristao Islands, a marine reserve and Ramsar site. A Ramsar site is one recognized by the Convention on Wetlands, also called the Ramsar Convention.

Sangarédi

The Sangarédi Study Area includes three main landscape units: the mining unit, the urban unit and the agro-pastoral forest unit. These units are within a slightly rolling topography, without sharp features. They are traversed by a relatively well developed drainage system with principal watersheds, namely that of the Cogon (sometimes written Kogon) River on the east and the Tinguilinta (sometimes written Tinguilita) River towards the west. None of these units have sufficient environmental or heritage characteristics to give them a particular landscape value at a large scale.

The urban unit, of the built category, is considered to be very tolerant to visual change. Only new housing constructions are planned for in this unit to house new workers for the CBG Extension Project.

The area around Sangarédi

The mining unit, previously natural and then agro-pastoral before mining, is primarily composed of bare soil. It includes the plateaus of Sangarédi, Silidara Nord, Bidikoum Nord, N'Dangara and Boundou Wandé. It is a unit that has been strongly modified by anthropic activities, tolerant to visual change. From the top of these plateaus, depending on locations, the views are vast and open on the bare areas and farther on the agro-pastoral unit. The access to these plateaus however is restricted to CBG workers and therefore the visibility of this unit is restricted. Some villages are however located on the border of this unit. Given the vegetation cover (fruit trees, fallow fields, gallery forests, etc.) and the buildings, the visual accessibility of this unit for the local communities is nearly inexistent except in a few areas when villagers go to their field fields or into town. It should be noted that these mining landscapes have been part of their daily lives for a long time.

For visitors or citizens of Sangarédi, the main visual access to this unit is from the national road joining Boké to Sangarédi. However, this road passes outside and to the north of the mined area and given the vegetation cover, the rising relief to the south and the speed of travel of observers, the visibility is rare and of short duration, as was observed during the fieldwork.

> The perception of a landscape depends on the time one gives to its observation. This is especially true when one is dealing with static observation. When a landscape is perceived while travelling, the speed of travel determines the duration of the observation.
>
> (http://www.ecosociosystemes.fr/paysages.html).

Photo 2-2 Agro-pastoral landscape unit at Sangarédi -

© L. Chirio

The agro-pastoral unit is situated around the urban and mining units. It is this unit that will bear the main landscape modifications from the Project because of the mining developed that is planned.

It is an anthropic unit, the result of agricultural practices that have modified the original natural conditions. Nearly 80% of the Guinean population is rural and lives off agriculture. This unit, developed over rolling terrain with laterite plateaus, mainly includes villages and hamlets, fields and fallow lands, bowé (eroded laterite plateaus whose formation is often accelerated by deforestation and the drying of soils following it) and remnants of forests, particularly along the watercourses. The agricultural practices (slash and burn, fallow fields, clearing of vegetation) associated with hunting practices, mainly of a subsistence type, have resulted in a unit with limited floristic and biological diversity. According to the field studies (see chapters on fauna, flora and heritage) this landscape unit, at the scale of the territory being studied, does not present fundamental characteristics permitting it to be valued within the landscape assessment as a national park, classed forest or in terms of natural heritage.

In this landscape unit, the visual field is generally restricted given the presence of vegetation (often fallow land or young secondary forest) along the access roads to villages and hamlets, except for the bowé, where, at least during the dry season (in the rainy season the grasses can reach two meters in height) the views are wider and deeper.

These vast and deep views are available to observers solely on the bowé because on the edges of these laterite plateaus, vegetation is always present in the form of fallow land, secondary forest or gallery forests.

The laterite plateaus that will be mined can be found on either side of national road 22 joining Boké to Sangarédi. In order to mine these areas, access roads for heavy machinery (including ore transport trucks) will have to be built. These roads will not be usable by local communities or visitors but only by CBG workers.

To be used efficiently these access roads will have to have fairly gentle grades. Consequently, in low areas (in particular where there is a watercourse), the amount of backfilling may be significant and the wide access roads will be like scars on the landscape for potential observers.

Currently a single section of national road 22 in the area of the laterite plateaus to be mined offers wide and deep views of confirmed esthetic value, at least for a visitor. This area with accessible views lies between Hamdallaye and Sangarédi and the views exist because of the nearby relief. To the north of the road is a depression due to a watercourse bordering the road and this allows short visual access for about a kilometer along the road to the village of Paragogo and beyond to the Mooule and Dalagaba bowé (plateaus to be mined as part of the Project). Wide access roads with significant backfilling passing through the Paragogo Valley will be visible from the national road.

Also, the N'Dangara west plateau and the Koobi bowal will be mined on either side of the national road. The modified landscape will be visible from national road 22 unless visual barriers are put up and maintained.

The villages and hamlets in the plateaus to be mined or close to the access roads (Paragogo and Hamdallaye, among others) will be displaced. Not knowing where the villages will be re-built, the visibility of the mined plateaus and access roads to these villages is not known.

This agro-pastoral landscape unit is of a more rural nature and is less able to absorb the visual modifications than the two preceding units.

2.5.2.2 Geology

Introduction

The geology of the region is subdivided in two main structures (Knight-Piésold, 2008 p 159):

- Bedrock, consisting of Paleozoic-aged sedimentary rocks, faulted and intruded by Mesozoic-era diabase/dolerite sills and dikes; and
- Surficial alluvial formations, consisting of geologically recent deposits dating from the Tertiary (Miocene) and Quaternary (Pleistocene) eras, including the bauxite ore bodies, clays, and lateritic duricrusts.

Kamsar

The Kamsar Study Area, situated in a natural region of mangroves on a coastal plain is influenced by a marine coastal climate and saline conditions. Different trees grow along the saline fine sediments along the coast. The mangrove zone is regularly submerged by tides that sometimes come inland as much as 50 m along the river shores where the watercourses are under tidal influence.

The area around Kamsar is part of a geomorphological coastal zone known as the Guinea basin, dating from the Quaternary and Tertiary. This basin is situated on the continental plateau whose total surface area is 430,000 km2, the largest plateau of the West African coast. Its topography is flat with a maximum elevation only 100 m above sea level.

Kamsar is located on the Rio Nuñez Estuary, an area of complex geological stratification that presents numerous faults oriented northwest to southwest and northeast to southwest. The surficial alluvial formations are mainly composed of coastal and marine sediments. The faulted Lower Paleozoic bedrock of the coastal area is found in boreholes at more than 40 m below the bottom of the estuary. A superficial laterite layer, normally 1 to 2 m thick, but no thicker than 3 m, overlies the bedrock, and is in turn covered by littoral sediments up to 40 thick of varying degrees of compression, including loose laterite gravels, hard laterite slabs, and slightly consolidated sand and clay (Knight Piésold, 2008).

Sangarédi

The principal topographic feature of the Sangarédi region are high plateaus or “bowals”, deeply cut by numerous river valleys forming a dense hydrographic network trending slightly to the northeast and heading ultimately to the Atlantic Ocean. These bowals are characterized by a vast iron-rich duricrust called bowé. The topography of the Study Area is principally composed of two plateaus, those of and N’Dangara, separated by the Boundou Wandé River. These plateaus have the shape of a leaf attached to an oval branch, the base formed by the meeting of the Thiapikouré and Pora Rivers, the main vein being the Boundou Wandé River and the stem by the Pora River. Together the two plateaus cover an area of 2,602.59 ha with 1,111.59 ha for the Boundou Wandé Plateau and 1,491.31 ha for the N’Dangara Plateau (BERCA-Baara/Berd, 2003).

At their highest point, the plateaus of Boundou Wandé and N’Dangara reach between 220 and 240 m above sea level whereas in the piedmont their elevation varies from 150 to 160 m. These plateaus thus have a maximum difference in elevation of only 70 m. Although the tops of the plateaus have been leveled by erosion, their slopes are abrupt, with grades of 8 to 10%. Within the Sangarédi region these plateaus are mainly underlain by metamorphic bedrock (BERCA-Baara/Berd, 2003).

The alluvial formations of the region lie upon Paleozoic rocks from the Ordovician, Silurian and Devonian eras, of a depth of at least 800 m (Knight Piésold, 2008). In the Boké region the sedimentary rocks are characterized by alternating layers of sandstone and shale. In Sangarédi, Bidikoum and the plateaus of Boundou Wandé/N'Dangara the sedimentary series from the Devonian is made up of grey-blue shale, trending towards black and accompanied by rare layers of sandstone.

The following description of the Sangarédi plateau is from an article by Bah et Sayed (Bah et Sayed, 1987):

> The Sangarédi deposit is formed essentially from detritic sediments that accumulated in a small fluvio-lacustrine basin during the Tertiary in an environment of Silurian and Devonian shales. The bauxite rests directly on a base of kaolinic clay derived from these shales. The contact is generally conformable and a lateritic transition is visible on the flanks.
>
> Mineralogically, the deposit is essentially gibbsite but boehmite is present in significant proportions: 2 to 6% in the upper layers, 10 to 30% in lower layers of the deposit.
>
> The original texture of the sediments (gravels, conglomerates, sands, silts and clays) can still be distinguished. Three principal units were recognized in the structure of the deposit:
>
> 1. A gravelly bauxite in the upper zone, made up of cemented detritic gravels, consolidated and very hard. Sometimes within these massive hard zones there are unconsolidated gravel pockets and lenses of psammitic bauxite. This unit usually has lower levels of monohydrate (1 to 5%) and lower TiO_2 levels (2 to 6%). Generally, bauxite with low monohydrate and bauxite to be burned are mined in this unit.
>
> 2. An intermediate conglomeratic unit with gradual transformations. The conglomeratic bauxite is made up of polygenic stones varying in size from 2 to 8 cm. This unit always has very high levels of monohydrate. The thickness of this layer is quite variable, from a few centimeters to more than 25 m. Psammitic layers are more frequent and are generally thin. Significant silty and clayey lenses

of very fine material are present in this unit, especially at the top of the unit.

3. A sandy-gravelly bauxite at the base of the profile, lying directly on the clay base. This bauxite is often less consolidated and less hard. Sometimes at this level one observes the presence of a hard brechic bauxite.

There are very numerous discontinuities in the distribution of the various facies, often linked to tectonic activity from the time of sedimentation to the last phases of bauxite formation. The regional tectonic directions are found in the deposit.

The base clay has a bedded texture (or sometime ribbon-like). Contact with the bauxite above is frank and net. The interlaid clayey-silty lenses usually have low concentration of monohydrate.

The issue of the clogging bauxite is particularly important because it creates a serious problem during mining.

The clogging character results from the combination of several factors:

- the silty bauxite is very fine, saturated in water and with a more or less pronounced plastic behavior;
- the clayey bauxites, bauxitic clays and clays with a humidity that is over 15% and may attain 35%; and
- the altered bauxite that crumbles with contact with water – this is the case of white bauxite and pisolithic bauxite, derived from the lower layers.

2.5.2.3 Soils

Kamsar

In the region of Kamsar, there are two major soil associations. The most common soils are hydromorphic Planosols lying on fluvio-marine alluvium but there are also deep ferralithic soils in certain area (Rossi et al., 2000). FAO defines Planosols as soils having bleached, temporarily water-saturated topsoil on slowly permeable subsoil.

Recent fluvio-marine sediment deposits along the river and along the coast characterize the coastal mangrove swamps. The city of Kamsar itself was built on a mud (poto-poto) wetland subject to tidal influence (Knight Piésold, 2008).

At several areas on the CBG industrial site, the upper soil layer is made up of bauxite deposits from bauxite maintenance operations.

The analysis of the drill holes of the Golder Associates geotechnical study in May and June 2011 (AECOM, 2011) allowed identification of the type of sol found on the CBG industrial site. In general, silty sand or silty clay covers the surface. These become compact and dense with very hard layers at depth. Starting at 30 to 50 m in depth, argillite of from good to bad quality depending on the layers is present.

The AECOM ESIA (AECOM, 2011) stated that there were visual inductions that soils contaminated with hydrocarbons might be present at various places on the industrial site. Following are the places where there were indications of contamination:

- near the hydrocarbon storage place;
- near the fuel loading and unloading areas;
- near the locomotive workshop (central workshop);
- near the railroad;
- near the future decontamination site ("site de rédemption"); and
- along the sides of the ditch leaving the oil separator.

The register of incidents involving the spill of hydrocarbons at the Kamsar plant from 1993 to 2011 show that a total of 33 spills were reported in 17 years, suggesting an average of nearly two spills per year (AECOM, 2011). A large part of the soils contaminated by these spills were transported for storage to a pile at the extremity of the industrial zone of CBG, a site referred to as the "site de rédemption". This temporary storage may contaminate soils underneath. A bioremediation cell has been constructed to receive and treat contaminated soil.

A preliminary soil characterization survey has been undertaken for the AECOM ESIA (AECOM, 2011). This was carried out in January and May 2011 from samples taken in sites that were identified as potentially contaminated and sites close to areas potentially affected by construction work. The three places where samples were taken were:

1. the drying bed (SI2) where material may be stored during construction;
2. the spill contaminated soil storage area, commonly known as the *site de rédemption* (composite sample taken from several piles); and
3. an area south of the reservoirs where soil contaminated during a spill in the hydrocarbon storage area is stored (SI1).

Sampling conducted according to the requirements of the *Guide d'échantillonnage à des fins d'analyses environnementales : échantillonnage des sols (cahier 5)* (MDDEP, 2009). Each sample was composed of five sub-samples, taken randomly from the site. Sampling was done by scraping the first five centimeters of the soil and using it to fill a fifth of a 250 g sterile bag with a trowel. A new trowel was used at each sampling area.

The samples taken were sent to an accredited Canadian laboratory for analysis. Table 2-44 presents the results of the analyses and compares them with the level C criteria for industrial land of the MDDEP guide (MDDEP, 2009). Concentrations that do not meet the criteria are highlighted. Additional samples were taken during the May and June Golder Associate geotechnical study and these results are also presented on Table 2-44 and the sampling locations are shown on Map 2-7 (B02, B16 and B18). Drilling was done by two PBU2 drill units on trucks. The samples were collected with a split spoon of 51 mm internal diameter. Samples were taken in the first 1.5 m.

The results of the analyses show that the concentrations measured in the piles near the hydrocarbon storage area are above the Quebec criteria for industrial lands (C level criteria). The concentration in petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) clearly indicate the presence of fuel oil. Two samples were taken in the *site de rédemption*. The January sample respects the criteria whereas the May one shows that petroleum hydrocarbons and certain PAHs are above the MDDEP criteria for industrial land. The samples taken in the drying bed contained a high concentration of aluminum, typical of bauxite.

Table 2-44: CBG Kamsar soil sample analyses (from sites likely to be contaminated) (AECOM, 2011)

Parameters	Units	Level C MDDEP criteria	Concentrations						
			SI1 – near hydrocarbon storage	SI2 – drying bed	SI3 – redemption site		B-02 – railcar dumper	B-16 – drying building	B-18 - dispensary
			Jan. 2011	Jan 2011	Jan. 2011	May 2011	May 2011	May 2011	May 2011
Petroleum hydrocarbons (C_{10}-C_{50})	mg/kg	3,500	120,000	--	130	48,000	BDL	BDL	BDL
Fluoride (F)	mg/kg	2,000	NA	NA	NA	NA	6	39	14
pH	mg/kg	NA	NA	NA	NA	NA	8.05	8.51	7.59
Chloride (Cl)	mg/kg	NA	NA	NA	NA	NA	3	7	31
Phosphorus (total) (P)	mg/kg	NA	NA	NA	NA	NA	120	400	140
Sulfate (SO_4)	mg/kg	NA	NA	NA	NA	NA	8	99	64
Metals									
Aluminum (Al)	mg/kg	NC	17,000	40 000	15 000	--	4,600	4,600	2,300
Arsenic (As)	mg/kg	50	6	BDL	BDL	--	NA	NA	NA
Silver (Ag)	mg/kg	40	BDL	BDL	BDL	--	NA	NA	NA
Barium (Ba)	mg/kg	2,000	14	BDL	BDL	--	BDL	BDL	BDL
Cadmium (Cd)	mg/kg	20	BDL	BDL	BDL	--	BDL	BDL	BDL
Chromium (Cr)	mg/kg	800	130	230	59	--	NA	NA	NA
Cobalt (Co)	mg/kg	300	3	BDL	BDL	--	NA	NA	NA
Copper (Cu)	mg/kg	500	27	4	2	--	--		
Lead (Pb)	mg/kg	1,000	19	BDL	6	--	--		
Iron (Fe)	mg/kg	NC	79,000	63,000	13 000	--	--		
Mercury (Hg)	mg/kg	10	NA	NA	NA	NA	NA	NA	NA
Manganese (Mn)	mg/kg	2,200	120	65	27	--	--		
Molybdenum (Mo)	mg/kg	40	1	BDL	BDL	--	--		2
Sodium (Na)	mg/kg	NA	NA	NA	NA	NA	BDL	360	250
Nickel (Ni)	mg/kg	500	5	5	BDL	--	1	4	2
Vanadium (V)	mg/kg	NC	170	190	56	--	NA	NA	NA
Tin (Sn)	mg/kg	300	BDL	BDL	BDL	--	BDL	BDL	BDL
Zinc (Zn)	mg/kg	1,500	90	BDL	BDL	--	BDL	BDL	BDL
Polycyclic aromatic hydrocarbons (PAHs)									
Naphthalene	mg/kg	50	32	--	BDL	4	BDL	BDL	BDL
Acenaphthylene	mg/kg	100	5	--	BDL	BDL	BDL	BDL	BDL
Acenaphthene	mg/kg	100	9	--	BDL	5	BDL	BDL	BDL
Fluorene	mg/kg	100	24	--	BDL	6	BDL	BDL	BDL
Phenanthrene	mg/kg	50	56	--	BDL	26	BDL	BDL	BDL
Anthracene	mg/kg	100	4	--	BDL	5	BDL	BDL	BDL
Fluoranthene	mg/kg	100	2	--	BDL	3	BDL	BDL	BDL
Pyrene	mg/kg	100	10	--	BDL	19	BDL	BDL	BDL
Benzo[c]phenanthrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
Benzo[a]anthracene	mg/kg	10	BDL	--	BDL	11	BDL	BDL	BDL
Chrysene	mg/kg	10	1	--	BDL	12	BDL	BDL	BDL
7-12-dimethylbenzo[a] anthracene	mg/kg	10	0.6	--	BDL	BDL	BDL	BDL	BDL
Benzo[b,j, k]fluoranthene	mg/kg	10	0.2	--	BDL	3	BDL	BDL	BDL
Benzo[a]pyrene	mg/kg	10	BDL	--	BDL	5	BDL	BDL	BDL
3-methylcholanthrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
Indeno[1,2, 3-cd]pyrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
Dibenzo[a h]anthracene	mg/kg	10	BDL	--	BDL	1	BDL	BDL	BDL
Benzo[g,h, i]perylene	mg/kg	10	BDL	--	BDL	4	BDL	BDL	BDL

Parameters	Units	Level C MDDEP criteria	Concentrations						
			SI1 – near hydrocarbon storage	SI2 – drying bed	SI3 – redemption site		B-02 – railcar dumper	B-16 – drying building	B-18 - dispensary
			Jan. 2011	Jan 2011	Jan. 2011	May 2011	May 2011	May 2011	May 2011
Dibenzo[a l]pyrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
Dibenzo[a i]pyrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
Dibenzo[a h]pyrene	mg/kg	10	BDL	--	BDL	BDL	BDL	BDL	BDL
2-methylnaphtalene	mg/kg	10	170	--	BDL	30	BDL	BDL	BDL
1-mehylnaphtalene	mg/kg	10	110	--	BDL	22	BDL	BDL	BDL
1, 3-dimethylnaphtalene	mg/kg	10	190	--	BDL	43	BDL	BDL	BDL
2,3, 5-trimethylnaphtalene	mg/kg	10	91	--	BDL	23	BDL	BDL	BDL

BDL = below detection limits, NA = not applicable, NC = no criteria

Map 2-7 Soil sampling points at Kamsar (2011)

As for the soil samples collected during the geotechnical study and documented in AECOM (2011) all the analysis results are below the MDDEP criteria for industrial soils.

To study the risk of contamination to groundwater from the activities related to drying of the bauxite (drying beds) and the *site de rédemption*, soil samples were subjected to leaching tests. These results are presented on Table 2-45.

Table 2-45: Results of the leaching tests (AECOM, 2011)

Parameter	Unit	Concentration			
		SI2 (drying bed)		SI3 (decontamination area)	
		Jan. 2011	May 2011	Jan. 2011	May 2011
Aluminum (Al)	mg/l	2.5	2.4	0.42	2.2
Arsenic (As)	mg/l	BDL	BDL	BDL	BDL
Barium (Ba)	mg/l	0.073	0.072	0.058	0.082
Boron (B)	mg/l	BDL	BDL	BDL	BDL
Cadmium (Cd)	mg/l	BDL	BDL	BDL	BDL
Calcium (Ca)	mg/l	29	9	34	500
Chromium (Cr)	mg/l	BDL	BDL	BDL	0.048
Cobalt (Co)	mg/l	BDL	BDL	BDL	BDL
Copper (Cu)	mg/l	BDL	BDL	BDL	BDL
Iron (Fe)	mg/l	BDL	BDL	BDL	BDL
Lead (Pb)	mg/l	BDL	BDL	BDL	0.01
Molybdenum (Mo)	mg/l	BDL	BDL	BDL	BDL
Nickel (Ni)	mg/l	0.03	0.011	BDL	0.038
Selenium (Se)	mg/l	BDL	BDL	BDL	BDL
Silver (Ag)	mg/l	BDL	BDL	BDL	BDL
Tin (Sn)	mg/l	BDL	BDL	BDL	BDL
Vanadium (V)	mg/l	BDL	BDL	BDL	BDL
Uranium (U)	mg/l	0.0032	BDL	0.0013	BDL
Zinc (Zn)	mg/l	BDL	BDL	BDL	BDL

BDL = below detection limits

Based on the analysis of the results, leaching of the soils could lead to an increase in concentration of aluminum in the groundwater, especially under the drying bed, where bauxite mud coming from the basin dry directly on the soil. As for other heavy metals, their potential for leaching likely to have an impact on groundwater is very low.

To prevent soil contamination by wastes, CBG has developed waste management procedure that includes the collection, the storage and the elimination of household waste, biomedical waste and dangerous and non-dangerous wastes. Following this procedure the CBG and Kamsar City household wastes and the CBG non-dangerous wastes are collected and taken to a landfill with a geomembrane. The procedure for dangerous wastes is presented on Table 2-46.

Table 2-46: Management of the CBG dangerous wastes (AECOM, 2011)

Hazardous waste	Management approach
Used batteries	Each service collects the used batteries, takes them to the garage and empties them of their acid.
Biomedical wastes	Medical wastes are collected, wrapped and then incinerated. The ashes are taken to the landfill.
Used oil	Waste oil is collected and taken to the pumping station at THF4 to be burned in the drying ovens.

Photo 2-3 shows two photographs that illustrate the official landfill site at Kamsar. The household waste from Kamsar City and the CBG plant are taken to the site twice a week. The wastes are then covered with laterite to prevent the local population from taking the waste. Twice a week, CBG collects the piles of garbage that accumulate in various places in Kamsar City, mainly along the railroad line.

Photo 2-3 Official landfill site at Kamsar (the first photo is from April 13, 2011 and the second from May 11, 2011) (AECOM, 2011)

Sangarédi

The soils of the Sangarédi region can be divided into two groups – those on the plateaus (bowals) and those in the valleys. The soils on the bowals are typically poor, with high iron content, called skeleton ferralithic soils. These soils are generally thin, with a thickness of a few centimeters and easily erodible in some areas. They are often formed in slight depressions in the Sangarédi bauxite plateaus, where vegetation has a low density (Knight Piésold, 2008).

These ferralithic soils are characterized by

- a deep alteration of the primary minerals except for quartz;
- a removal of silicium and basic elements such as calcium and magnesium through groundwater movement; and
- an accumulation of iron and aluminum sesquioxydes due to the changing seasons (rainy season and dry season) leading to a duricrust of bauxite.

In the valleys, the soils (also ferralithic) are generally rich and their thickness increases toward the bottom of the valleys and downstream. Precipitation and associated seasonal flooding combine to bring new alluvial deposits to the river valley (Knight Piésold, 2008).

In the Study Area, the mining activates have had a direct impact on the soil composition in certain areas. Currently, CBG is mining in the N'Dangara, Sangarédi, Boundou Wandé 2 (occasionally), Boundou Wandé 3, Boundou Wandé 4 and Boundou Wandé 5 areas and these are areas where the organic layer has been removed and the bauxite removed. Old mining sites, especially near Sangarédi, have been rehabilitated by adding organic matter removed during the stripping and plants. The Parawi-South plateau remains intact and un-mined. Within the Study Area there are stockpiles of bauxite to be loaded onto rail cars, near the N’Dangara mining site.

Waste produced by the CBG mine sites and the urban activities of Sangarédi are taken to a landfill located about a kilometer east of the town boundary.

Indications of soil contamination by hydrocarbons has been noted in some places in the AECOM (2011) ESIA, notably near the CBG garages and the fuel loading and unloading areas. During the AECOM (2011) ESIA a composite soil sample was taken in January 2011 in the train fuel unloading area, close to the administration building of CBG. The results of the analysis, by an accredited Canadian laboratory, is presented on Table 2-47. The values that do not meet the MDDEP level C criteria for industrial lands are shown in bold. The sampling methods were the same as used by AECOM in Kamsar (AECOM, 2011).

The results of the analysis of the composite sample show some petroleum hydrocarbon and PAH concentrations above the Quebec criteria for industrial lands (level C criteria). The concentrations of petroleum hydrocarbons and certain PAHs indicate the contamination of the soil by petroleum products (fuel oil).

In 2014, CBG under the direction of ÉEM, undertook soil sampling on typical bowals and in the technical zone, using the same procedures as in the AECOM (2011) ESIA. The localities are shown on Table 2-48 and Map 2-8. The results of the analyses are presented on Table 2-49. Sample S2 was contaminated during transport and was not analyzed.

Table 2-47: Soil sample analyses from potentially contaminated area of N'Dangara (SI1)

Parameters	Units	Level C MDDEP criteria	SI1 – near fueling area
Petroleum hydrocarbons (C_{10}-C_{50})	mg/kg	3,500	40,000
Fluoride (F)	mg/kg	2,000	NA
pH	mg/kg	NA	NA
Chloride (Cl)	mg/kg	NA	NA
Phosphorus (total) (P)	mg/kg	NA	NA
Sulfate (SO_4)	mg/kg	NA	NA
Metals			
Aluminum (Al)	mg/kg	NC	6,200
Arsenic (As)	mg/kg	50	10
Silver (Ag)	mg/kg	40	BDL
Barium (Ba)	mg/kg	2,000	9
Cadmium (Cd)	mg/kg	20	BDL
Chromium (Cr)	mg/kg	800	49
Cobalt (Co)	mg/kg	300	BDL
Copper (Cu)	mg/kg	500	8
Lead (Pb)	mg/kg	1,000	BDL
Iron (Fe)	mg/kg	NC	33,000
Mercury (Hg)	mg/kg	10	NA
Manganese (Mn)	mg/kg	2,200	93
Molybdenum (Mo)	mg/kg	40	2
Sodium (Na)	mg/kg	NA	NA
Nickel (Ni)	mg/kg	500	9
Vanadium (V)	mg/kg	NC	65
Tin (Sn)	mg/kg	300	BDL
Zinc (Zn)	mg/kg	1,500	43
Polycyclic aromatic hydrocarbons (PAHs)			
Naphthalene	mg/kg	50	7.1
Acenaphthylene	mg/kg	100	1
Acenaphthene	mg/kg	100	4.8
Fluorene	mg/kg	100	7.2
Phenanthrene	mg/kg	50	34
Anthracene	mg/kg	100	5.9
Fluoranthene	mg/kg	100	2.7
Pyrene	mg/kg	100	14
Benzo[c]phenanthrene	mg/kg	10	0.9
Benzo[a]anthracene	mg/kg	10	13
Chrysene	mg/kg	10	11
7-12-dimethylbenzo[a] anthracene	mg/kg	10	5.2
Benzo[b,j, k]fluoranthene	mg/kg	10	2.8
Benzo[a]pyrene	mg/kg	10	4.8
3-methylcholanthrene	mg/kg	10	5.0
Indeno[1,2, 3-cd]pyrene	mg/kg	10	0.9
Dibenzo[a h]anthracene	mg/kg	10	1
Benzo[g,h, i]perylene	mg/kg	10	3.2
Dibenzo[a l]pyrene	mg/kg	10	BDL
Dibenzo[a i]pyrene	mg/kg	10	BDL
Dibenzo[a h]pyrene	mg/kg	10	BDL
2-methylnaphtalene	mg/kg	10	52
1-mehylnaphtalene	mg/kg	10	27
1, 3-dimethylnaphtalene	mg/kg	10	48
2,3, 5-trimethylnaphtalene	mg/kg	10	15

BDL = below detection limits, NA = not applicable, NC = no criteria

Table 2-48: Soil samples taken in the Sangarédi area in 2014 (CBG/ÉEM)

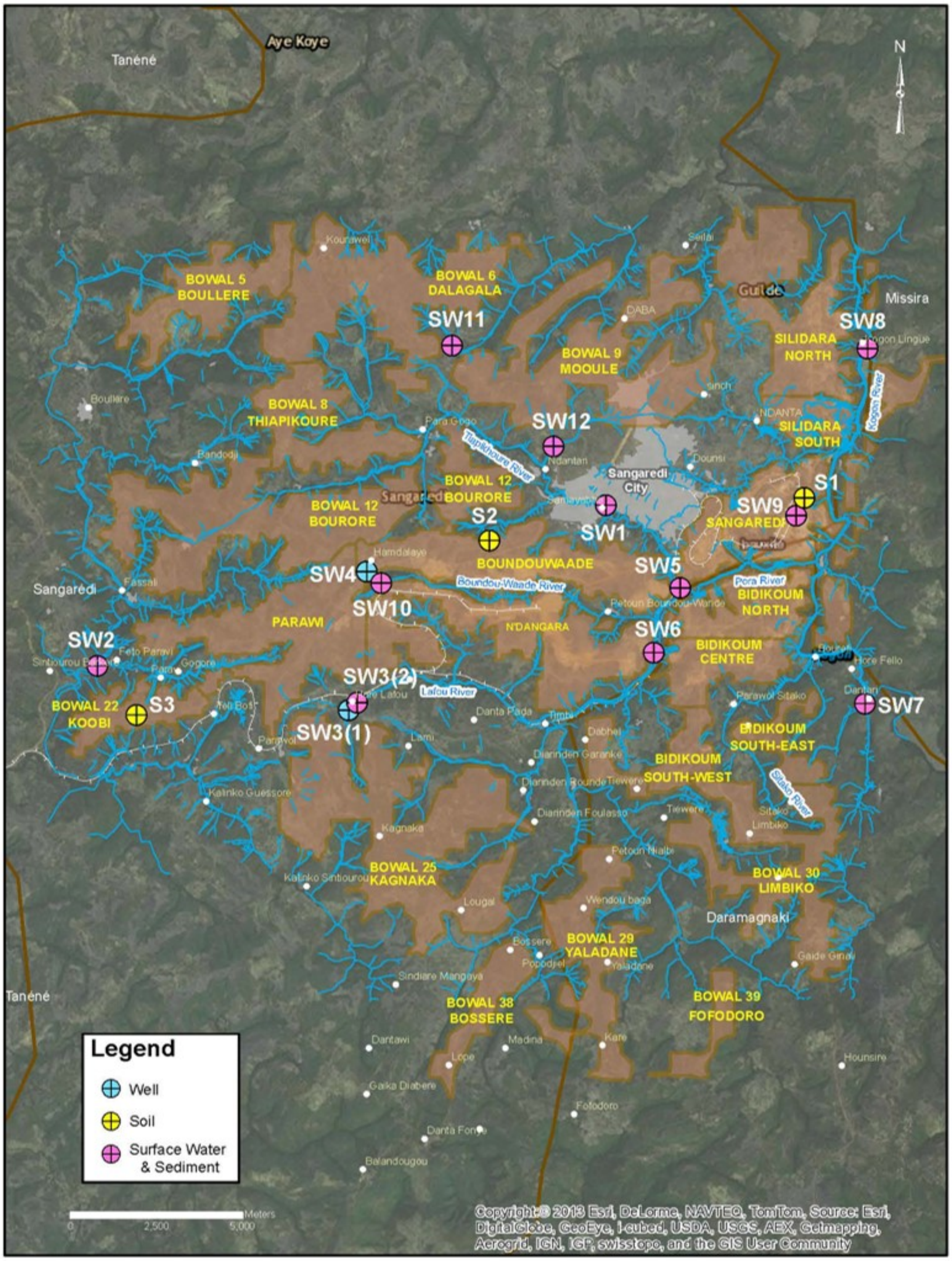
Station	Date	Location	Latitude	Longitude
S1	17-Jun-14	Sangarédi fueling station	11.10093	-13.76712
S2	17-Jun-14	Hamdallaye Bowal	11.09002	-13.85108
S3	17-Jun-14	Koobi (Bowal 22)	11.04445	-13.94532

Table 2-49: Analyses of soil sampling Sangarédi (2014)

Constituent	Units	Reportable detection limit (RDL)	Sangarédi fueling station	Bowal 22
			S1	S3
Inorganics				
Chloride	µg/g	20	21	21
Fluoride	µg/g	5	<5	<5
pH (available $CaCl_2$)	pH	N/A	6.76	5.43
Sulfate (Soluble)	µg/g	20	<20	<20
Metals				
Aluminum	µg/g	250	67000	52000
Antimony	µg/g	0.2	0.78	0.72
Arsenic	µg/g	1	6.1	6.7
Barium	µg/g	0.5	13	71
Beryllium	µg/g	0.2	0.41	0.83
Bismuth	µg/g	1	<1.0	<1.0
Boron	µg/g	5	<5.0	<5.0
Cadmium	µg/g	0.1	<0.10	<0.10

Constituent	Units	Reportable detection	Sangarédi fueling station	Bowal 22
Calcium	µg/g	50	1800	880
Chromium	µg/g	5	270	230
Cobalt	µg/g	0.1	4.7	5.8
Copper	µg/g	0.5	34	23
Iron	µg/g	250	81000	100000
Lead	µg/g	1	7.3	16
Lithium	µg/g	1	4.7	5.5
Magnesium	µg/g	50	1000	1100
Manganese	µg/g	1	140	170
Mercury	µg/g	0.05	<0.050	<0.50
Molybdenum	µg/g	0.5	2.6	2.0
Nickel	µg/g	0.5	10	14
Phosphorous	µg/g	50	500	800
Potassium	µg/g	200	380	570
Selenium	µg/g	0.5	<0.50	<0.50
Silver	µg/g	0.2	<0.20	<0.20
Sodium	µg/g	100	250	<100
Strontium	µg/g	1	11	14
Thallium	µg/g	0.05	0.06	0.082
Tin	µg/g	5	<5.0	<5.0
Titanium	µg/g	25	N/A	490
Uranium	µg/g	0.05	2.3	1.8
Vanadium	µg/g	25	270	260
Zinc	µg/g	5	28	31

Map 2-8 Soil sampling points Sangarédi (2014)



2.5.2.4 Seismicity

The West African plate that lies beneath the Study Area is a very old and very stable geological unit, substantially decreasing the potential for significant seismic activity in the Project area. In the surrounding region of Boké, however, there are several earthquake epicenters associated with fault lines. The largest earthquake that impacted the prefecture of Boké occurred December 22, 1983, and had a measured surface magnitude of 6.4 Ms. Table 2-50 lists the major earthquakes in Guinea since 1795 (Knight Piésold, 2008).

Table 2-50: Major earthquakes in Guinea (Knight Piésold, 2008)

Date	Hour	Epicenter	MF1
1795-05-20	22 h	9.3 N. 134 W	5.2
1818-01	-	12.1 N. 12.4 W	5.9
1887	-	10.9 N. 14.5 W	-
1892-11-03	22 h	9.5 N. 13.7 W	-
1911-01-02	7 h 45	9.5 N. 13.8 W	-
1914-02-08	-	10.2 N. 14.0 W	-
1927-07-11	11 h 30	9.8 N. 13.4 W	4.0
1928-04-05	8 h 02	9.8 N. 13.3 W	4.8
1928-04-19	0h	9.6 N. 13.2 W	-
1930-03-26	2 h 30	10.2 N. 14.1 W	4.5

Date	Hour	Epicenter	MF1
1935-07-17	15 h 35	10.3 N. 14.3 W	4.0
1939-05-26	7h	9.6 N. 13.2 W	4.1
1983-12-22	4 h 11	11.85 N. 13.51 W	6.4
1987-11-02	19 h 07	11.44 N. 13.44 W	4.2

Note: The MF unit designates the magnitude equivalent to the surface shock wave. Source: Met-Chem Canada inc. 1997.

2.5.3 VEC identification

Valued ecosystem components (VECs) are features of the environment selected to be the focus of the EIA because of their ecological, social, cultural or economic value and their potential vulnerability to effects of the Project. In the case of the soil study there are two sub-components. The first is the soil itself as a resource. This VEC is mainly applicable in the context of the new mining area in Sangarédi where important quantities of soil will be stripped from the mine sites. Soil is an important resource, as much for the local natural vegetation as for potential agricultural activities. Soils take a long time to form and it is not easy to replace it after it is destroyed. In addition, soil in place contains the seeds of plant species adapted to local conditions. This future vegetation bank must be considered a valuable entity. This VEC is therefore considered of High value.

The second is the quality of the soil in place. Soils close to operations have the potential to be affected by the deposition of particulates or gases coming from atmospheric releases from Project activities or by accidental releases during activities. This pollution can affect the use of the soil by natural vegetation or farmers. However, this potential pollution is considered less critical than the complete elimination of the soil and this VEC is therefore judged to be of Medium value.

There is no VEC for geology. No protected geological area is known from the region.

2.5.4 Impact assessment

2.5.4.1 Identification of impacts

There are four types of impacts to soil to consider:

- the stripping of the soil on the site of new mining areas and access roads;
- the erosion of soils on the site of new mining areas and access roads;
- the deposition from dust and gases in areas close to the construction and operation areas; and
- accidental pollution linked to releases from equipment (considered a technological risk).

2.5.4.2 Stripping

Stripping in the new mining sites will remove the soil from an area of about 3,200 ha, to which must be added a still unknown surface for the access roads. There will also be a small area affected by the construction of the railroad sidings and the new sorting yard.

2.5.4.3 Erosion

Soil erosion is a problem for the soil stockpiles, the surroundings of the mining areas and the access roads. It is impossible to quantify the erosion problem at this stage but given the surface areas in question it is potentially major.

2.5.4.4 Deposition

Deposition comes from two sources: dust and gases.

The deposition of dust is not a problem in itself to soil but the presence of toxic substances could cause a problem. Analyses for air quality (Section 2.2) suggest that only aluminum may be present in sufficient quantities to have an impact. The soils of the region tend to already have a high aluminum concentration and the percentage increase would be small.

The impact of aluminum on plants is discussed in chapter 4.

The deposition of nitrogen (N) and sulfur (S) from gases emitted during the operations of machinery does not seem sufficient to impact the acidity of soils or water.

2.5.4.5 Accidental pollution

The main impact on soils by accidental pollution is the risk of contamination from spills of hazardous substances (especially fuels). This is more of a technological risk and therefore outside the purview of this section but data from the AECOM (2011) ESIA allow for a brief discussion here.

The sources of impact are associated with the following activities:

- construction - modifications to the rail yard (Kamsar plant);
- installation of the new unloading station (Kamsar plant);
- installation of the new crushing stations (Kamsar plant);
- modification to the dryer feeding facilities and combustion chambers (Kamsar plant);
- conveyor addition and modifications (Kamsar plant);
- construction of new sidings and sorting yard (railroad);
- opening of new mining areas (Sangarédi);
- construction of new access roads (Sangarédi);
- general increase in the amount of ore being handled (mining, transport, stopping of trains on sidings, loading, unloading, crushing, drying, shipping and energy production) (everywhere);
- management of hazardous substances (Sangarédi); and
- additional workforce (everywhere).

Spill or leakage of petroleum products from machinery and equipment can contaminate the soil as well as potentially the surface waters and the groundwater.

These risks are present during machinery refueling, equipment breakage and vehicles oil changing or maintenance. Increasing activities means increasing the risk of soil contamination. Despite the constant efforts by the CBG to implement procedures to reduce soil contamination, oil and fuel spills occur at least once a year. The increase of ore processing will certainly lead to more spill events, simply by increasing the frequency of hydrocarbon transfer operations (loading, unloading, transportation).

The wastes produced by the demolition and construction as well as those associated with the presence of a larger workforce also represent potential additional source of soil contamination. However, since most of these wastes will be sent to a landfill, these are of low impact in terms of soil contamination.

The addition of manpower also increases the risk of contamination. Once the ore production is operational, the additional needed manpower will also bring their families and attract people in general, to come and establish themselves in the area. Therefore, the newly arrived residents will also produce domestic wastes, generating additional sources of soil contamination. However, the magnitude of the impact associated to this type of contamination is negligible since the population increase related to the Project is relatively limited and most of the waste they will generate is not hazardous.

2.5.5 Mitigation measures

The following mitigation measures include some measures for preventing pollution.

2.5.5.1 Kamsar

Construction phase

A program will be put in place to evaluate the contamination of all soils excavated during the Project. More details on this program are provided in the ESMP, presented in Chapter 10. Contaminated soils removed during the project or produced during the works will be sent to the redemption site cell to be confined. No excavated industrial soils, even the one considered not contaminated, shall be sent outside plant for agricultural use. Farming will not be permitted anymore in the CBG industrial area.

Project waste will be sent to landfill sites only after ensuring that the landfill site is adequate for receiving the waste without generating any other contamination problems. CBG will put in place recommendations, resulting from the evaluation, to upgrade the landfill site and its management. No hazardous waste shall be sent to the landfill site, knowing that it was initially designed to receive only domestic and vegetal waste.

The soil contamination from spills of hazardous material (mainly oil and fuel) or bad management of waste is an environmental risk that will be minimized by ensuring the following practices:

- review and update the CBG hazardous material management plan to make sure that all sources of potential contamination are addressed and controlled.
- control the machinery in order to avoid leakage and spilling of hazardous materials (hydrocarbons, etc.);
- complete the machinery and mobile equipment maintenance work inside the CBG workshop (garages) (used oils shall be collected according to CBG procedures for hazardous waste and send to the THF4 tank, for being burned in the bauxite dryers);
- complete the mobile equipment and machinery refueling on the specifically designated CBG site or according to safe practices if done directly onsite;
- apply precautionary measures during transportation, handling and installation of equipment containing oil;
- avoid the accumulation of any type of wastes on the working site - recycle all scrap metal and other recyclable materials (scrap metal could be sent by boat to a recycling plant out of the country) and transport all final wastes to the CBG landfill site located east of Kamsar City;
- contaminated soils resulting from construction activities or from hydrocarbon spills must be sent to the redemption site;
- materials and equipment will be stored in a dedicated temporary storage area built for the project (this area will be enclosed with a fence and be guarded by security personnel to avoid vandalism and stealing which could result in soil contamination);
- when possible, use vacant industrial sites for building temporary storage area and for storing the excavated soils;
- all contractors must be liable to CBG environmental practices;

- maintain effective containment barriers for preventing spills of hazardous material from reaching the environment; and
- respect the environmental follow-up program established according to requirements stated in Section 10.

Operation phase

The contamination of soils close to the site by deposition of atmospheric dust and gases is possible. These impacts will be minimized by applying the mitigation measures recommended in the air quality study (Section 2.2).

The soil contamination by hazardous material (mainly oil and fuel) spills is an environmental risk that can be minimized by ensuring that the following practices are applied:

- review and update the CBG hazardous material management plan to make sure that all sources of potential contamination are addressed and controlled;
- ensure that the procedures on management of hazardous materials are truly put into practice, and not only in theoretical documents;
- improve the fuel and oil handling operations done in Kamsar site, especially at the terminal wharf, the wagon and locomotive fill-up station, the used oil pumping station to THF4 and by storage tanks i.e. at locations where spills occurred;
- confinement structures for hazmat (includes fuel and oil) storage must all be 100% tight. (openings in tank farm must be sealed);
- control the new equipment (crushers, conveyors, etc.) in order to avoid leakage and spilling of hazardous materials (hydrocarbons, etc.);
- complete the vehicle maintenance work inside the CBG workshop (garages) - used oils shall be collected according the CBG procedure on hazardous waste and send to the THF4 tank, for burning in the bauxite dryers;
- complete vehicle refueling on the specifically designated CBG site; and
- contaminated soils resulting from hydrocarbon spills must be sent to the redemption site.

2.5.5.2 Railroad corridor

Construction phase

The soil contamination by hazardous material (mainly oil and fuel) spills is an environmental risk that can be minimized by applying the measures specified for construction at Kamsar.

As soil stripping for the new sidings is relatively minor and the sites are not planned for rehabilitation in the predictable future, the question of soil storage is not critical. The possibility of a previous contamination because of their presence close to the railroad line suggests that they should not be employed in agriculture.

Operation phase

The contamination of soils close to the site by deposition of atmospheric dust and gases is possible. These impacts will be minimized by applying the mitigation measures recommended in the air quality study (Section 2.2).

The soil contamination by hazardous material (mainly oil and fuel) spills is an environmental risk that can be minimized by applying the following measures:

- control the engine leaks and maintain the engine in good condition, in order to avoid leakage and spilling of hazardous materials (oils and cooling liquids);
- ensure a careful watch of the fuel wagon to prevent any fuel stealing; and
- have appropriate absorptive materials available on board the train, so that in the event of a spill or accidental discharge, the spill can be contained and cleaned up immediately.

2.5.5.3 Sangarédi

Construction phase

Generally in the ESIA there is no distinct construction phase for the mining operations in Sangarédi, but for the soil there are three aspects that relate specifically to construction: protection of the stripped soils; protection against erosion; and access road construction.

The main impact of the mining operations on soil will be the stripping of the existing soil on the mine sites. These soils are critical for the restoration of the vegetation or for future agricultural uses. The stripped soils constitute a veritable bank of seeds of native species already adapted to the local environment. It is a precious resource to conserve with care. In addition to standard measures against erosion it will be necessary to:

- educate the persons responsible for the stripping operations on the importance of the soil and its protection;
- evaluate the situation carefully so that the soil is stored in a safe area that will not be affected by subsequent operations; and
- use normal measures to ensure that the soil is stored under good conditions (determine a maximum slope angle, encourage vegetation growth to reduce wind erosion).

The opening of mining areas and the construction of access roads will increase the risks of erosion. Erosion leads to the loss of soils (an important resource) and the potential pollution of nearby watercourses.

Standard protection measures against erosion must be used such as those in:

- Hénensal, Pierre. 1996. *La lutte contre l'érosion sur l'emprise routière – une contribution à la protection de l'environnement. Bulletin des laboratoires des Ponts et Chaussées*, 201, janvier-février 1996 ; et
- Nova Scotia Department of the Environment, Environmental Assessment Division. 1988. *Erosion and sedimentation control – Handbook for construction sites.*

The measures described below for the operation phase are of course also applicable to the construction phase.

In view of the importance of the protection of soils during construction activities, an environmental inspector will have to be on-site to ensure that the measures are well respected.

Operation phase

The contamination of soils close to the site by deposition of atmospheric dust and gases is possible. These impacts will be minimized by applying the mitigation measures recommended in the air quality study (Section 2.2).

The soil contamination by hazardous material (mainly oil and fuel) spills is an environmental risk that can be minimized by applying the following measures:

- review and update the CBG hazardous material management plan to make sure that all sources of potential contamination are addressed and controlled;
- all waste potentially contaminating the environment must not be sent to the CBG dumpsite near Sangaredi, because it has not been designed to protect groundwater and surface water integrity - these wastes will then be sent to Kamsar by train and be discharged in Kamsar confined landfill site;
- improve the fuel handling operations done on the mine site, especially at the fuel unloading station and at the oil handling operation site, i.e. at locations where spills occurred;
- control the machinery and mobile equipment in order to avoid leakage and spilling of hazardous materials (hydrocarbons, etc.);
- complete the machinery and mobile equipment maintenance work inside the CBG workshop (garages) - used oils shall be collected according to the CBG procedure on hazardous waste and send to the THF4 tank, for being burned in the bauxite dryers;
- complete the mobile equipment and machinery refueling on the specifically designated CBG site or according to safe practices if done directly onsite;
- contaminated soils resulting from construction activities or from hydrocarbon spills must be sent to the Kamsar redemption site; and
- all contractors must be liable to CBG environmental practices.

2.5.6 Monitoring measures

No regular monitoring measure is recommended at this stage.

2.6 Summary of the assessments

Table 2-51 gives a summary of the potential and residual impacts by component and subcomponent. The methodology is the one described in Chapter 1. The impacts are described in more detail in Sections 2.2 to 2.5 and the base for the calculation of impacts in Table 2-52. It is important to note that, after the application of mitigation measures, the degree of disturbance decreases but the numerical scores often fall in the same range that defines the significance of the impact (Table 0-11). This does not mean that there is no improvement.

The potential impact levels of the Extension Project have been reassessed in this section, assuming the application of all the mitigation measures described in Sections 2.2 to 2.5, and that are summarized in the ESMP (Chapter 10) according to an aggressive and sustained schedule supported by the appropriate resources. In particular, the mitigation measures for noise and vibration in the mining zone often require considerable setbacks, and the residual impacts consider that these setbacks have been applied. The residual impact levels under these conditions are presented below.

Impacts of a positive nature:

High	**Medium**	**Low**	**Does not apply (n/a)**

Impacts of a negative nature:

High	**Medium**	**Low**	**Does not apply (n/a)**

Other impacts:

None = no predicted impact

Neutral = positive and negative predicted impacts counterbalance n/a = Does not apply

Table 2-51: Summary of the impacts on the physical environment

VEC/impacts by subcomponent	Construction phase			Operation phase		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Air quality						
Particulates and metals	n/a	n/a	n/a	High	Medium	Medium
Residual impacts	n/a	n/a	n/a	High	Medium	Medium
Gases (NO_2, SO_2)	n/a	n/a	n/a	High	High	Medium
Residual impacts	n/a	n/a	n/a	High	High	Medium
Noise and vibrations						
Noise from mining operations	n/a	n/a	n/a	High	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a
Noise from explosives	n/a	n/a	n/a	High	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a

VEC/impacts by subcomponent	Construction phase			Operation phase		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Noise from trains	n/a	n/a	n/a	n/a	n/a	Medium
Residual impacts	n/a	n/a	n/a	n/a	n/a	Medium
Noise from railroad sidings	n/a	n/a	n/a	n/a	n/a	Medium
Residual impacts	n/a	n/a	n/a	n/a	n/a	Medium
Noise from the plant	n/a	n/a	n/a	n/a	Medium	n/a
Residual impacts	n/a	n/a	n/a	n/a	Medium	n/a
Vibrations (explosives)	n/a	n/a	n/a	High	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a
Marine waters						
Wastewater	n/a	n/a	n/a	n/a	Medium	n/a
Residual impacts	n/a	n/a	n/a	n/a	None	n/a
Water – aerial deposition	n/a	n/a	n/a	n/a	None	n/a

VEC/impacts by subcomponent	Construction phase			Operation phase		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Residual impacts	n/a	n/a	n/a	n/a	None	n/a
Water – dredging	n/a	Medium	n/a	n/a	Medium	n/a
Residual impacts	n/a	Medium	n/a	n/a	Medium	n/a
Sediments – aerial deposition	n/a	n/a	n/a	n/a	None	n/a
Residual impacts	n/a	n/a	n/a	n/a	None	n/a
Sediments – dredging	n/a	n/a	n/a	n/a	High	n/a
Residual impacts	n/a	n/a	n/a	n/a	High	n/a
Freshwater						
Water – aerial deposition	n/a	n/a	n/a	Medium	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a
Sediments – aerial deposition	n/a	n/a	n/a	Medium	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a

VEC/impacts by subcomponent	Construction phase			Operation phase		
	Zone 1	**Zone 2**	**Zone 3**	**Zone 1**	**Zone 2**	**Zone 3**
Groundwater						
Flow	n/a	Low	n/a	High	n/a	n/a
Residual impacts	n/a	Low	n/a	Medium	n/a	n/a
Quantity	n/a	Low	n/a	High	n/a	n/a
Residual impacts	n/a	Low	n/a	Medium	n/a	n/a
Quality	n/a	Low	n/a	High	n/a	n/a
Residual impacts	n/a	Low	n/a	Medium	n/a	n/a
Soils						
Quantity – stripping	n/a	n/a	n/a	High	n/a	n/a
Residual impacts	n/a	n/a	n/a	Medium	n/a	n/a
Quantity – erosion	n/a	n/a	Medium	Medium	n/a	n/a
Residual impacts	n/a	n/a	Low	Low	n/a	n/a
Quality – aerial deposition	n/a	n/a	n/a	Medium	Medium	Medium

VEC/impacts by subcomponent	Construction phase			Operation phase		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Residual impacts	n/a	n/a	n/a	Medium	Medium	Medium

EEM

Table 2-52: Calculations for the determination of impact

QUALIFICATION OF THE IMPACT				Zone			Phas		POTENTIAL IMPACT					RESIDUAL IMPACT			
Valued ecosystem component (VEC)	Subcomponent	Description of impact	Positive / negative	Mine	Plant and port	Rail	Construction	Operation	VEC value	Magnitude of distubance	Spatial extent	Duration	Importance of impact	Magnitude of distubance	Spatial extent	Duration	Importance of impact
Air quality	Particulates, metals	Zone 1	Negative	x				x	High	High	Local	Long	High	Medium	Local	Long	High
Air quality	Particulates, metals	Zone 2	Positive		x			x	High	Low	Local	Long	Medium	Low	Local	Long	Medium
Air quality	Particulates, metals	Zone 3	Negative			x		x	High	Low	Site	Long	Medium	Low	Site	Long	Medium
Air quality	Gases (NO2, SO2)	Zone 1	Negative	x				x	High	High	Local	Long	High	High	Local	Long	High
Air quality	Gases (NO2, SO2)	Zone 2	Negative		x			x	High	Medium	Local	Long	High	Medium	Local	Long	High
Air quality	Gases (NO2, SO2)	Zone 3	Negative			x		x	High	Low	Site	Long	Medium	Low	Site	Long	Medium
Noise and vibration	Noise	Operation noise	Negative	x				x	High	Medium	Local	Long	High	Low	Local	Long	Medium
Noise and vibration	Noise	Blasting noise	Negative	x				x	High	Medium	Local	Long	High	Low	Local	Long	Medium
Noise and vibration	Noise	Frequency of trains	Negative			x		x	High	Low	Local	Long	Medium	Low	Local	Long	Medium
Noise and vibration	Noise	Rail siding noise	Negative			x		x	High	Low	Local	Long	Medium	Low	Site	Long	Medium
Noise and vibration	Noise	Plant noise	Negative		x			x	High	Low	Local	Long	Medium	Low	Local	Long	Medium
Noise and vibration	Vibrations	Blasting	Negative	x					High	Medium	Local	Long	High	Low	Local	Long	Medium
Marine waters	Water quality	Release of polluted water	Negative		x				High	Low	Local	Long	Medium	None	Local	Long	0
Marine waters	Water quality	Deposition of gases and particulates	Negative		x				High	None	Local	Long	0	None	Local	Long	0
Marine waters	Water quality	Dredging	Negative		x				High	Low	Local	Short	Medium	Low	Local	Short	Medium
Marine waters	Sediment quality	Deposition of gases and particulates	Negative		x				High	None	Local	Long	0	None	Local	Long	0
Marine waters	Sediment quality	Dredging	Negative		x			x	High	High	Local	Short	High	Medium	Local	Long	High
Freshwater	Water quality	Deposition of gases and particulates	Negative	x			x		High	Low	Local	Long	Medium	Low	Local	Short	Medium
Freshwater	Sediment quality	Deposition of gases and particulates	Negative	x					High	Low	Local	Long	Medium	Low	Local	Long	Medium
Groundwater	Groundwater flux	Zone 1	Positive	x				x	High	Medium	Local	Long	High	Low	Local	Long	Medium
Groundwater	Groundwater flux	Zone 2	Negative		x		x		High	Low	Site	Short	Low	Low	Site	Short	Low
Groundwater	Groundwater quantity	Zone 1	Positive	x					High	Medium	Local	Long	High	Low	Local	Long	Medium

QUALIFICATION OF THE IMPACT				Zone			Phas		POTENTIAL IMPACT					RESIDUAL IMPACT			
Valued ecosystem component (VEC)	Subcomponent	Description of impact	Positive / negative	Mine	Plant and port	Rail	Construction	Operation	VEC value	Magnitude of distubance	Spatial extent	Duration	Importance of impact	Magnitude of distubance	Spatial extent	Duration	Importance of impact
Groundwater	Groundwater quantity	Zone 2	Negative		x		x	x	High	Low	Site	Short	Low	Low	Site	Short	Low
Groundwater	Groundwater quality	Zone 1	Negative	x					High	High	Local	Long	High	Low	Local	Long	Medium
Groundwater	Groundwater quality	Zone 2	Negative		x		x	x	High	Low	Site	Short	Low	Low	Site	Short	Low
Soil	Soil quantity	Stripping of mine areas	Negative	x					High	High	Site	Short	High	Medium	Site	Short	Medium
Soil	Soil quantity	Erosion	Negative	x		x			High	Medium	Site	Short	Medium	Low	Site	Short	Low
Soil	Soil quality	Deposition of gases and particulates	Negative	x		x			Medium	Medium	Site	Long	Medium	Medium	Site	Long	Medium
Soil	Soil quality	Pollution through accidental releases	Negative	x	x	x			Medium	High	Site	Short	Medium	Medium	Site	Short	Low

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