1.0 INTRODUCTION

1.1 Project Context

Cameroon Alumina Limited (CAL), incorporated and registered in Cameroon, is a 100% subsidiary of Hidromine Global Mineral GMBH Ltd (HGM). HGM is a joint venture company of Hindalco Industries Ltd, India, Dubai Aluminium Company (DUBAL), UAE and Hidromine Inc, USA with 45%, 45% and 10% shareholding respectively.

CAL proposes to establish a bauxite mining and alumina refinery project in the Republic of Cameroon. The alumina project will be based on the bauxite reserves of Minim-Martap and Ngaoundal deposits located in the Adamawa region in the northern Cameroon. CAL holds the exploration permit No. 0022 and 0023/MINIMIDT/SG/DMG/SDAM for these bauxite deposits. The total exploration permit area of Minim-Martap and Ngaoundal deposits are 948 km² and 416 km² respectively.

This Environmental and Social Impact Assessment (ESIA) report has been prepared for the bauxite mining part of the project.

1.1.1 Current Status of the Project

CAL has completed the feasibility study for the bauxite mining project. Based on the exploration work carried out on 14 major plateaus, the estimated bauxite resource is 554 Million Tonnes.

CAL has submitted the above study reports to the Ministry of Industry, Mines and Technological Development and has applied for the Mining Permit for the two deposits vide Letter No. 2009/11/24/01 dated 24th November 2009.

CAL has obtained approval of Terms of Reference (TOR) for ESIA studies from Ministry of Environment and Protection of Nature (MINEP) vide letter No. TR/00000023/L/MINEP/CAB/CIE dated 22nd March 2010.

Based on the TOR, this ESIA report has been prepared using the baseline data collected during April 2009 to March 2010. In accordance with the TOR, Public consultations have been carried out during March – April 2010 and the public concerns are addressed in this report.

1.1.2 Objectives of the Project

The proposed bauxite mining project will supply 7.5 Million Tonnes per Annum (MTPA) bauxite to the proposed alumina refinery and will be implemented in two phases of 3.75 MTPA each. Initially, the bauxite mining will be carried out at Danielle plateau (Minim-Martap) and Simone plateau (Ngaoundal) and will be progressively extended to other plateaus of the two deposits.
1.1.3 Description of the Exploration Permit Leases

The Minim-Martap and Ngaoundal deposits are located in the Adamawa province, which are about 350 km (average aerial) northwest from the capital Yaoundé. The centre of the Minim-Martap deposit area is about 50 km (aerial) northwest of the Ngaoundal area. The more southerly deposits of Ngaoundal are located 462 km (aerial) northeast of Douala, the main port of Cameroon on the Bight of Biafra. The index map and 10 km radius map around the permit areas are given in **Figure-1** and **Figure-2** respectively.

- **Minim-Martap Deposit**

  The bauxite deposit of Minim-Martap occurs on a barren plateau separated by shallow valleys. The slopes around the Minim-Martap plateaus are gentle and allow a reasonably easy access to the bauxite. The Minim-Martap bauxite deposit form a significant part of the Adamawa plateau. They occur as a circle shaped cluster of plateaus covering about 1000 km² centered at 06°50'N and 12°55'E.

  Minim-Martap can be accessed from Ngaoundal by the Ngaoundal-Tibati paved road (N-6) and from Ngaoundere by the road (D-19) to Tibati that passes through the northern part of the permit area. The distance between Minim and Ngaoundere is approximately 73 km (aerial). A secondary road (N-15A) follows the eastern limit of the bauxite deposit. This road connects Martap to Tekel, Bekoko and finally Sebadi on the paved road (N-6) between Ngaoundal-Tibati.

- **Ngaoundal Deposit**

  The Ngaoundal bauxite deposit forms a high, isolated and dissected plateau overlooking the Djerem plain centered at 06°24' N and 13°15' E with a peak altitude of about 1410 m aMSL. There is a fairly steep escarpment surrounding most of the deposit, but there are also ridges which run down to the plain and down. The deposits of Ngaoundal are on the plateaus which are elevated about 300 m above the surrounding valley side.

  Generally, both the deposit tops are virtually uninhabited. The seasonal vegetation is grazed by local cattle.

1.2 Need and Justification of the Project

Bauxite is the basic raw material required for aluminium production. It is estimated that the demand for aluminium is expected to grow by 5-7% per annum and reach over 60 million tonnes per annum by 2020 from the present level of 40 million tonnes per annum.

The world’s largest bauxite deposits are located in Guinea, Australia and Brazil. In 2008, the annual world production of bauxite was 205 million tonnes (US Geological Survey 2009). Out of this, most of the bauxite was produced in Australia (31%), followed by China (16%), Brazil (12%), India (10%), Guinea (9%) and Jamaica (7%).
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FIGURE-2
10 KM RADIUS MAP AROUND THE PERMIT AREAS

VIMTA Labs Limited, India
Rainbow Environment Consult, Cameroon
1.2.1 Importance of the Project to the Country and Region

The bauxite mining project is an essential part of the proposed integrated Greenfield alumina refinery project, which is critical for meeting the country's domestic requirement and to earn foreign exchange through export. The estimated capital cost of the integrated project is expected to be above USD 4 Billion, which will provide significant impetus to Cameroon's economy. The proposed project will result in further industrialization through development of ancillary industries and boost the country's GDP growth.

The proposed project will also boost the socio-economic development of Cameroon through development of human resources and creation of direct & indirect employment opportunities. The peripheral development is expected to result in improvement in facilities with regard to health care, education, transport, communication, potable water, sanitation etc.

2.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 CAL Environmental and Social Policies and Programs

CAL is committed to meet the spirit and intent of various international, national and regional policies, guidelines, laws and regulations relevant to Cameroon. These include:

- Internal corporate mandates, policies and best practice commitments;
- Cameroon Government strategies, legislation, permits and approvals;
- International Finance Corporation (IFC) Performance Standards; and
- Good International Industry Practices (GIIP).

2.2 Cameroon Policy on Environment

In harmony with the international context, several laws and actions came after the conference of United Nations on Environment and Development, which was held in June, 1992 in Rio de Janeiro in Brazil. Cameroon worked out a National Environmental Management Plan (NEMP) which allowed defining the policies for the protection of environment and rational management of natural resources.

2.3 Administrative Aspects Related to Environmental Assessment

The Cameroon regulatory authority responsible for environmental management collectively is referred to as Ministry of Environment and Protection of Nature (MINEP) in spite of various references to environmental protection made in the Mining Code and other related regulations.

Presidential Decree Nº 2005/0577 of 23rd February, 2005 defines the process for conducting an EIA as required by the EIA Conduct Decree for installations classified for the protection of the environment. These projects must complete a full-fledged Environmental and Social Impact Assessment (ESIA) study and submit to MINEP for grant of Environment Compliance Certificate.
2.4 Institutional Framework for Environmental Management

MINEP and Ministry of Forestry and Wildlife (MINOF) are the nodal agencies which are primarily responsible for protection of environment in Cameroon. They set national environment policy and standards for the protection of environment and forests. Further, other ministries are also governed by the law of protection of environment in the activities concerning their ministries.

2.5 International Protocol and Environmental Agreements of Cameroon

Cameroon is party to many international treaties aimed at preserving global environment. This testifies the commitment of Cameroon government towards a sustainable development.

3.0 ENVIRONMENTAL BASELINE STATUS OF THE PROJECT AREA

3.1 Introduction and Delimitation of Study Area

The report includes the baseline environmental data generated in the study area during April 2009 to March 2010 for various environmental attributes. Secondary data collected from MINEP, Yaoundé and various other Government, Semi-Government and Non-Government sources with respect to the project study areas is also incorporated in the report.

The study area considered for the Environmental and Social Impact Assessment is the entire 10 km radius area around both exploratory permit areas located at Minim-Martap and Ngaoundal. The exploratory permit area is considered as core zone while the 10 km radius around the exploratory permit area is considered as the buffer zone.

3.2 General Approach to the Baseline Study

The baseline environmental setting, monitoring and data collection includes ground truth data for land environment including soil quality and land use / land cover, site specific climatic conditions, ambient air quality, hydro-geological aspects including water flow and water quality, noise levels, traffic density, vegetation pattern, biological environment, socio-economic and demographic profile with reference to the study area and historical background data from secondary sources.

3.3 Physical Environment

3.3.1 Geography

The Adamawa Province is a mountainous area and forms the barrier between Cameroon’s forested south and Savannah north. Adamawa is the fourth largest province among the ten provinces with geographical area of 63,691 km² (24,591 square miles). The surface features of the region are generally rugged.
Geographically, the exploratory permit areas of Minim-Martap and Ngaoundal occupy areas of 948 km² and 416 km² respectively. The Minim-Martap plateau has about 100 to 200 m relief above the surrounding valleys while the Ngaoundal plateau has a more gradual rise of about 300 m above the surrounding plain.

3.3.2 Climatic Conditions

Cameroon has a wide range of climatic types, from the wet southern regions near the equator to the dry northern ones around the Lake Chad basin. It is crossed diagonally by the Cameroon Volcanic Line (an unbroken chain of volcanic hills).

3.3.2.1 Climate of Adamawa Region

The climate of Adamawa Plateau is classified as tropical Sudan type. It has only two seasons namely the dry and wet. The year may broadly be divided into two seasons namely dry season (November to April) and wet season (May to October).

Generally, rainfall in the region averages 900 mm to 1500 mm per annum and decreases further north. August records the rainfall peak. May and June are normally wet. Temperatures dip from November to January and reflect winter conditions. Temperatures rise from January onwards and reach a high in April. The rains in May and June again bring the temperatures down.

3.3.2.2 Project Onsite Meteorology

Minim-Martap Permit Study Area

An automatic weather monitoring station has been installed at Martap village in the house of village chief at a height of about 10 m from the ground. The meteorological station at Martap village is located at 06° 53’ 30.7” N and 13°02’ 30.3” E and is located at an altitude of 1144 m above mean sea level.

The temperatures observed to range from 13.0°C to 41.6°C. The rainfall recorded during April 2009 to March 2010 was 1128 mm. The relative humidity ranged from 10.2-99.9%. Similarly, during the monitoring period, the predominant wind directions were observed to be from west of northwest, west and east of northeast.

Ngaoundal Permit Study Area

An automatic weather monitoring station has been installed at the guest house near Ngaoundal railway station at a height of about 10 m from the ground. The meteorological station at Ngaoundal is located at 06°26’ 44.5” N and 13° 16’ 10.7” E and is located at an altitude of about 955 m above mean sea level.

The temperatures observed to range from 10.1°C to 37.4°C. The rainfall recorded during April 2009 to March 2010 was 1776.8 mm. The relative humidity ranged from 10.8-99.9%. Similarly, during the monitoring period, the predominant wind directions were observed to be from southwest and north of northeast.
3.3.3 **Ambient Air Quality**

The prime objective of the baseline air quality study is to assess the existing air quality of the area and to compare with national and international norms. Ambient Air Quality Monitoring (AAQM) stations were set-up at eight locations in each permit study area (Minim-Martap and Ngaoundal).

**Minim-Martap Permit Study Area**

The TSPM was observed to range between 20.6 µg/m³ and 132.7 µg/m³. The PM₁₀ was observed to range between 8.1 µg/m³ and 36.2 µg/m³ during the study period.

The SO₂ was observed to range between <4.0 µg/m³ and 8.3 µg/m³. The NOₓ was observed to range between <6.0 µg/m³ and 9.1 µg/m³ during the study period.

The CO was observed to range between 0.01 ppm and 0.51 ppm during the study period.

The concentration of lead and ozone concentration was observed to be <0.1 µg/m³ and <0.01 ppm respectively at all the locations during the study period.

**Ngaoundal Permit Study Area**

The TSPM was observed to range between 20.6 µg/m³ and 96.9 µg/m³. The PM₁₀ was observed to range between 6.7 µg/m³ and 32.6 µg/m³ during the study period.

The SO₂ was observed to range between <4 µg/m³ to 6.5 µg/m³. The NOₓ was observed to range between <6 µg/m³ to 9.2 µg/m³ during the study period.

The CO was observed to range between 0.01 ppm and 0.31 ppm during the study period.

The concentration of lead and ozone concentration was observed to be <0.1 µg/m³ and <0.01 ppm respectively at all the locations during the study period.

The ambient air quality of the study areas indicates very low concentrations of the pollutants due to absence of any pollution generating anthropogenic activities like urbanization, industrial/major commercial activities, major coal or any other fossil fuel burning etc.

Major part of the study area is covered with vegetation with about six months of wet season. The occurrence of continuous rainfall acts as a great moderator of pollution. The only pollution sources in both the study areas are domestic firewood burning, forest fires, burning of vegetation for clearing the bushes.

Overall, it can be concluded that the ambient air quality of the region is well within the permissible national and international standards and can support major future industrial activity and has adequate buffer capacity.
3.3.4 Geology and Soils

The geology of the project area is mainly composed of thin alluvial cover, belonging to Sub-Recent to Recent of Quaternary period followed by laterite and bauxite belonging to Tertiary-Quaternary basalt followed by Neo-proterozoic Pan-African granites. The Pan-African granites commonly cross-cut both the schist belts and the Paleoproterozoic high-grade metamorphic complexes.

The soils of Adamawa region are mostly made up of brown or brownish red laterites as a result of annual shift between dry and wet conditions and soil wash on the mountains. The iron and aluminium content is generally high, which causes hardpans, duracrust or cuirasses to form near the surface due to oxidation. The soil of the Lom valley is a lightly evolved composition of raw materials as is that directly north-west of the Mbakaou Reservoir and directly west of the Faro River. The extreme northwest of the province has ferruginous soil instead, and many of the province’s mountains including the Gotels and Mambilas contain mixtures of several soil types.

- Soil Quality of the Study Area

Land environment with respect to the soil quality in the region has been assessed in the study areas of both the permit areas. The soil samples were collected and analysed for various physical and chemical parameters at eight locations each for Minim-Martap and Ngaoundal permit study area.

Overall, the soils have been observed to be affected by physical activities such as erosion, tillage etc. There is no sign of any contamination due to any individual activities. Further, it is observed that there is no practice of application of any chemical fertilizers and pesticides in the agricultural fields.

3.3.5 Water Resources, Hydrology, Hydrogeology and Water Quality

3.3.5.1 Water Resources & Hydrology

The Adamawa region is generally known as the ‘Water Tower’ of Cameroon as large number of rivers rise in the region. All of these fall into tropical regime, with a period of high water from May to September during the rainy season and a period of low water from October to April. Some of these are subject to seasonal flooding, such as the Djerem River in the area of Mbakaou reservoir.

Ngaoundal and Minim-Martap deposits lie in the Atlantic basin. The Atlantic basin is dominated by the Sanaga river system which covers almost the entire length of the southern plateaus, especially the region to the north of latitude 4° N. The major tributaries of Sanaga river system are the Lom, Djerem, Mbam and Noun. Other major rivers within the Atlantic basin are the Ntem, Nyong, Wouri and Mungo. The major rivers from Cameroon which flow into the River Congo are the Sanaga and Ngoko, with tributaries almost entirely from the southern low plateau.
3.3.5.2 Hydrogeology

Ground water occurs in the Pliocene to Recent formations, under water table conditions. Alluvium / laterite of Ngaoundal and Minim-Martap region form the principal aquifer in the area.

The water bearing formations in the core (lease area excluding plateau area having bauxite) and buffer (10 km radius area) zones is mostly composed of laterite. Bauxite mineralization is restricted to the elevated plateau areas. The depth to water table in core (plateau region-deposit areas) ranges from 25 to 30 m below land surface during post monsoon period and 28 to 35 m during pre-monsoon period.

The depth to water table in core (non-plateau region-deposit areas) ranges from 2 to 9 m below land surface during post monsoon period and 4 to 13 m during pre-monsoon period. The depth to water in buffer zone ranges from 2.00 to 6.00 m below ground level during post-monsoon period while it is deeper ranging from 5.00 to 9.00 m below ground level during pre-monsoon period. However, the water levels are shallow near streams, ponds and low lying areas in buffer zone where it ranges from 0.5 to 2.00 m.

Hydro-Geological Assessment

- Minim-Martap Deposit

The present study reveals that against the total ground water recharge of 129.91 mcm in the buffer zone, the ground water discharge is 0.14 mcm indicating the status of ground water development of buffer zone as 0.11%. The buffer zone therefore is hardly exploited. Similarly, against 0.02 mcm ground water discharge in the core zone, the area receives ground water recharge of 195.90 mcm (including plateau area) indicating status of ground water development as 0.01%. The core zone therefore has surplus exploitable ground water potential.

- Ngaoundal Deposit

The present study reveals that against the total ground water recharge of 241.58 mcm in the buffer zone, the ground water discharge is 0.15 mcm indicating the status of ground water development of buffer zone as 0.06%. The buffer zone therefore appears to be safe. Similarly, against 0.04 mcm ground water discharge in the core zone, the area receives ground water recharge of 86.15 mcm (including plateau area) indicating status of ground water development as 0.05%. The core zone therefore is safe.

3.3.5.3 Water Quality

Water sampling was carried out representing dry and wet seasons. Five surface and seven ground water locations are selected for water quality measurement for each of permit study area. The analysis of surface and ground water samples from Minim-Martap and Ngaoundal permit study areas revealed the following general observations:
The microbial contaminants such as cryptosporidium, giardia lamblia, total coliform and heterotrophic plate count have been detected in few surface water locations indicating the contamination due to human or animal activity.

According to published literature, even in areas with little human activity significant levels of bacteria and viruses can be detected originating from fish, aquatic mammals and from animals grazing near rivers such as deer. Hence, the microbial contaminants may be attributed to these activities.

Inorganic constituents like fluoride and nitrates are present in all the samples; however, these concentrations are within the specified drinking water standards.

Aluminium and iron are found in high concentration at some locations, higher than the prescribed drinking water limits. Manganese is found in high concentration at few locations. According to literature, a wide range of metals may be found in rivers from natural sources where metal ores are present in the rocks over which the river flows or in the aquifers feeding water into the river. Iron, usually as Fe$^{3+}$ is a common constituent of river waters at very low levels. This might be the reason for higher concentrations of aluminium and iron in the water samples.

pH was found to be slightly acidic in all the water samples. pH in rivers generally is affected by the geology of the water source, atmospheric inputs and a range of other organic and chemical contaminants.

Based on the water quality assessment, it can be concluded that both the surface water and ground water of the study areas are found suitable for drinking after conventional treatment followed by disinfection as all of the basic soluble salts are well within the limits of drinking water standards. However, treatment for removal of aluminium and iron is required for water fit for drinking. No industrial pollution is observed in the water quality of the study area.

3.3.5.4 Water Table and Stream/River Water Flow

- **Water Table Fluctuation in the Study Area**

About 22 wells in both the permit study areas and surroundings were monitored twice during study period for measurement of groundwater table.

The groundwater levels in the Minim-Martap permit study area were observed to range from 8.1 m to 14.6 m below ground level (806.1 aMSL to 1129.8 aMSL). Similarly, the groundwater levels in the Ngaoundal permit study area were observed to range from 1.4 m to 10.8 m below ground level (850 aMSL to 949.9 aMSL).

Many variations have been observed in water table levels in both the study areas. This may be due to the undulated plateaus, water lines, springs and local geology.
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- **River/Stream Water Flow Measurements**

  All major streams and Djerem River have been monitored for their water flow. Less water flow was observed during April, May and June, owing to less rainfall. High water flows were observed during July due to high rainfall. There is a gradual increase in the water flow from May to June, but flow decreases slowly by mid of June. The flow increased by mid of July due to heavy rains.

  The Djerem river flow was observed in the range of 631,584 m³/hr to 791,532 m³/hr during the observation period. Anam stream is another major water body for which flow was observed in the range of 4,288 m³/hr to 10,638 m³/hr during the observation period.

3.3.6 **Landforms**

  In the Adamawa plateau, Minim-Martap and Ngaoundal areas are traversed by a network of several seasonal and perennial streams draining the storm water, which flows from the plateaus from NE direction into the low lying areas where the drainage is controlled by Djerem River and its tributary system in the southern side of Minim-Martap and western side of Ngaoundal areas.

3.3.6.1 **Land Use Studies**

  Land use in and around the 10 km radius area of the permit has been studied by analyzing remote sensing satellite imagery data and by analyzing data from secondary sources.

  - **Land Use/Land Cover – Core Zone (Permit Area)**

    - **Savannah Vegetation**

      This is the major portion of the core zone area. About 54,564 ha area of Minim-Martap permit area and about 22,203 ha area of Ngaoundal permit area is covered under savannah vegetation. This works out to about 54.9% and 53.5% of the Minim-Martap and Ngaoundal permit areas respectively.

    - **Forest Land**

      There is no notified forest area in the core zone of permit areas. However, highly dense vegetation of gallery forest exists on the stream course areas of the core zone areas. An area of 13,244 ha area (13.3%) and 51,16 ha area (12.3%) comes under gallery forest category in Minim-Martap and Ngaoundal permit areas respectively. This shows that gallery forest is the other major type of land under permit areas of both the deposits.

    - **Waste Land/ Barren Land**

      Grass lands and rocky, barren land is classified as waste land. A total of about 30,430 ha area (30.6%) and 12,922 ha area (31.1%) comes under waste land category in Minim-Martap and Ngaoundal permit areas respectively.
• **Built-Up-Land/Settlements**

The built-up land (settlement area) in Minim-Martap and Ngaoundal permit areas is only about 79 ha (0.08%) and 534 ha (1.29%) respectively. This shows that human habitations exist to a bare minimum area in the total deposit areas.

• **Agricultural Land**

Cultivated land including orchards and plantations in Minim-Martap permit area is about 1050 ha (1.1%) and in Ngaoundal permit area it is about 650 ha (1.56%) of the total deposit areas.

• **Water Bodies**

No major water bodies exist in Minim-Martap permit area. About 107 ha land in the Ngaoundal permit area is covered under water bodies, which work out to about 0.26% of the total deposit area. This may be due to the fact that, the stream courses are densely vegetated and are classified under gallery forest areas.

➤ **Land Use/Land Cover – Buffer Zone**

The land use based on remote sensing satellite data revealed that about 49% and 56.8% area of Minim-Martap and Ngaoundal study areas (buffer zones) respectively is covered under savannah vegetation area. This shows that majority of the land in buffer zone comes under savannah vegetation.

Grass lands and rocky, barren land is classified as waste land. A total of about 33.7% and 26.5% of Minim-Martap study area and Ngaoundal study areas (buffer zones) respectively come under waste land category. This shows that waste land is the second major type of land under study areas of both the permit areas.

There is no notified forest area in the buffer zone of permit areas. However, highly dense vegetation of gallery forest exists on the stream course areas of the buffer zone areas. The gallery forest of about 15.9% and 12.99% exists in Minim-Martap permit and Ngaoundal study areas (buffer zones) respectively. This shows that gallery forest is the other major type of land under study areas of both the permit areas.

3.3.7 **Noise Environment**

Noise monitoring has been carried out at different zones of land use viz rural/residential and commercial zones in the study area. There are no identified industrial zones in the study area.

Both daytime and night time noise levels in both of the study areas were observed to be well within the specified international guidelines for respective landuse, showing that study area is generally calm. This may be attributed to rural environmental settings, absence of any major commercial and industrial activities.
3.3.8 Traffic Density

The traffic studies have been conducted to discern the prevailing traffic volumes on major roads in the vicinity of the permit area. Traffic survey was undertaken along national highways N6 and N15A.

National highway, N6 (Yaoundé to Meiganga via Tibati) runs in south direction of the Minim-Martap permit area. After crossing the Sebadi junction, National highway, N6 runs through the Ngaoundal permit area. National highway, N15A (Sebadi to Ngaoundere) runs in eastern direction of the Minim-Martap permit area. Sebadi is the junction point of national highways N6 and N15A.

The traffic survey conducted in the study area revealed that the highest traffic is observed at Sebadi junction (along Sebadi to Ngaoundere road). The major volume of traffic comprises of trucks, buses and light motor vehicles. However, the 2-wheeler traffic is more at Ngaoundal junction owing to proximity to market area and residential zone.

For the increased traffic volumes, the existing road network requires to be strengthened and also needs widening for smooth laminar flow of the traffic. It can be concluded that the existing roads, if properly strengthened, can take additional traffic many folds of existing traffic.

3.4 Biological Environment

A general ecological survey was conducted covering the permit area and an area of 10 km radius from permit area boundary.

Majority of the land in the study area is covered by Guinean forest-savannah mosaic vegetation. *Daniellia oliveri, Lophira lanceolata, Terminalia species* and *Mangifera indica* (Mango) are the main trees and shrubs like *Combretum* and *Annona genera* are generally observed in the area.

The study area contains sparse distribution of medicinal plants. The common medicinal plants found in the study area are *Azadirachta indica, Terminalia avicennoides, Combretum molle, Milicia excelsa, Nauclea diderrichii, Bridelia ferruginea* etc. No threatened plant species were observed in both the permit areas.

Cassava and maize are the main agricultural crops in this region. Rainwater is the main source for irrigation and drinking water in the region.

Animals like hippopotamus, duikers, wild donkeys, patas and baboons are reported in the study area. Birds like cattle egret, sparrow, pigeon, sunbirds, bee-eater, babbler, paradise flycatcher, African quail, African pied crow (white bellied crow), dove, quail etc are recorded. In reptiles, crocodiles (*Crocodylus niloticus*) and monitor lizard (*Varanus niloticus*) are reported in the study area.

Out of the total animals in the 10 km area, mandrill, panther, hippopotamus, African golden cat are vulnerable species as per IUCN, 2004.
3.5 Socio-Economic Baseline Conditions

3.5.1 History

Adamawa province was created during 1980s. Recently, all the provinces are renamed as regions. The Adamawa region is divided into 5 large divisions. Ngaoundéré is the head quarter of the region.

The 10 km buffer zones of Minim-Martap and Ngaoundal permit areas fall under following three divisions and four sub-divisions in the Adamawa Region:

- **Djerem Division - Tibati and Ngaoundal sub-divisions**;
- **Vina Division - Martap sub-division**; and
- **Mbere Division - Dir sub-division**.

➤ **Tibati Sub-division**

Tibati is a very old sub-division, created just after Cameroon independence and was occupied during the 19th century by Foulbé. The first residents of Tibati are Mbam, Vuté (Babouté) and later came G’baya, Haussa and Kolé people. Tibati is the traditional headquarter of the division. The population of Tibati is estimated at 65,000 while 22,000 residents live in Tibati urban area.

Located between Banyo and Ngaoundal Sub-divisions, the borders of Tibati are shared with the centre region, as well as the Martap Sub-division with Minim at the northwest of the Sub-division.

➤ **Ngaoundal Sub-division**

The Ngaoundal is one of the sub-divisions of the Djérem division. This Sub-division covers 4,500 km² for 68,612 inhabitants. The Ngaoundal urban area exists since 1969 with the construction of the railway and later followed by the creation of the Military camp in early 1980s after the departure of COGEFAR, the enterprise in charge of building the railway and the Tibati-Meïdougou road. The name Ngaoundal originally comes from the Mbum dialect which means mountain in view of the Ngaoundal hill. On 29th November, 1970, the former Regifercam (newly called Camrail) decided to name current railway station ‘Ngaoundal’ which was previously called Bagodo. The Ngaoundal sub division was officially created by presidential decree in 1981.

➤ **Martap Sub-division**

Martap sub-division was created by the presidential decree N° 2007/115 of 23rd April, 2007 dividing the former Ngaoundéré sub division into 6 different entities. This sub division as well as Sub-division covers 3,125 km² with a population of 39,000 residents.

➤ **Dir Sub-division**

The sub-division of Dir was created by the decree N°93/322 of November 1993. This is one of the three councils of the Mbéré division and covers 4,300 km² with
a population of 40,000 inhabitants. According to the Dir sub-division development plan, the local population is divided as follows: G’bayas 70%, Bororos 15%, Mbum 7%, Peuhls 5%, and others 3%. Dir sub-division covers all the villages along the road between Ngaoundal and Meiganga.

### 3.5.2 Demography

Primary household survey was carried out in the 10 km radius study area of both the permit areas to establish the baseline data for socio-economics. This is supported with the help of secondary data collected from various government and non-government organizations.

#### Social Survey Profile within Core and Buffer Zones

There are three villages in the core zone and thirty six villages come under the buffer zone of Minim-Martap permit area. They fall under the administrative divisions of Tibati sub-division, Martap sub-division and Ngaoundal sub-division. The total population of the villages under core area is 8,899 and buffer zone is 34,893.

The Ngaoundal deposit covers 29 villages and hamlets. The deposit includes both Ngaoundal and Dir sub-divisions with the Bagodo and surrounding communities. The total population of the Ngaoundal permit study area is 34,193.

#### Ethnic Groups

According to the definition giving by the fundamental law of Cameroon, Bororo are a marginalized ethnic group. The Bororo community exist in the area of Ngaoundal. They are more or less a sub group of the Foulbé community and structured traditionally on the bases of their culture.

### 3.5.3 Education

The study areas of Minim Martap and Ngaoundal Permit Areas experience a literacy rate of 10.8% and 9.7% respectively. In general, the education system in the study area is understaffed and overcrowded and these conditions prevail from Ngaoundal to Martap.

### 3.5.4 Public Health

The health condition of the population of the study zone is not the best. Most of the residents are occasionally affected by malaria, diarrhoeic diseases (dysentery as well as constipation). Among the more vulnerable population (children and the elderly), respiratory infections are common.

The main causes of mortality and morbidity of the hospital and health centre patients are malaria, diarrhoeal diseases, parasites, acute respiratory infections and STDs/HIV infections.
3.5.5 **Economic Activities**

Farming community and livestock workers are the main workers of the study area. As there is no industrialisation, no industrial or related workers exist in the area. As per the estimates, about 18,274 people (41.7% of total population of study area) and about 8,674 people (25.4% of total population of study area) are farmers in Minim Martap and Ngaoundal permit areas respectively. Livestock workers of about 15,939 (36.4%) and 2,434 (7.1%) exist in the Minim Martap and Ngaoundal permit study areas respectively.

3.5.6 **Community Infrastructure**

A study of the existing public infrastructure in the Minim-Martap and Ngaoundal area reveals a significant deficit in the minimum requirements for basic needs as potable water and adequate sanitation. Access to electricity is severely limited and poorly regulated. The area also suffers from a lack of sufficient social services, notably with regard to health and education services, although there has been some improvement in recent years. Majority of the rural population experience significant isolation. In general, road facilities are generally inadequate and in urgent need of rehabilitation and with insufficient transportation facilities for residents.

There is no public transport in the region. In the urban zone and its surroundings, travel is almost entirely by private motor taxis, while private cars maintain links between the cities, for example between Ngaoundal and Tibati, Ngaoundéré and Tibati etc.

The Makor station (17.5 km, E) is the nearest railway station to the Minim-Martap permit, whereas Ngaoundal Railway station is located inside the Ngaoundal permit area. The nearest airport is Yaoundé, 364 km (aerial) from the Minim-Martap permit, and 327 km (aerial) from the Ngaoundal permit area.

There is no electricity in Minim and Martap. In Minim, installation has been recently set-up and it was promised that a generator will be provided soon. Beka Gotto and Danfili recently received generators for very low capacity, insufficient for commercial use.

**4.0 PROJECT DESCRIPTION**

The proposed bauxite mining project will supply 7.5 Million Tonnes Per Annum (MTPA) bauxite to the proposed alumina refinery and will be implemented in two phases of 3.75 MTPA each. Initially, the bauxite mining will be carried out at Danielle plateau (Minim-Martap) and Simone plateau (Ngaoundal) and will be progressively extended to other plateaus of the two deposits.

**4.1 Project Site**

The proposed bauxite mining project will be based on the bauxite deposits of Minim-Martap and Ngaoundal located in the Adamawa region in the north-central part of the Republic of Cameroon.
4.1.1 Location of the Project Sites

The Minim-Martap permit area falls under latitudes N 06° 39’ 40” to N 06° 58’ 42” and longitudes E 12° 47’ 30” to E 13° 05’ 53.3” covering a total area of 948 km².

The Ngaoundal permit area falls under latitudes N 06° 21’ 53.3” to N 06° 33’ 00” and longitudes E 13° 08’ 46.6” to E 13° 19’ 46.7” covering a total area of 416 km².

4.1.2 Description of Actual State of Project Site

4.1.2.1 Site Topography

The elevations of plateaus are about 100 m to 200 m above surroundings. The deposits of Ngaoundal are also on plateau but elevated about 300 m above the surrounding countryside. As a result, the bauxite bearing area in both the deposits is virtually uninhabited. Seasonal grass is grazed by local cattle.

The slopes around the Minim Martap plateaus allow easy access and especially the Danielle plateau at an altitude of above 1292 m aMSL in the northeast portion and sloping generally in gentle way towards southwest. Plateau top is fairly flat and broad with minor undulations and gentle slope. Presently, about 8 m wide un-metalled road is available to access the plateau top.

4.1.2.2 Physiography and Drainage Pattern

The Minim-Martap plateau has about 100 to 200 m relief above the surrounding valleys while the Ngaoundal plateau has a more gradual rise of about 300 m above the surrounding plain. A smaller plateau, Ngaoundourou (~1260 m aMSL) is located to the north of the Ngaoundal group of plateaus.

4.1.2.3 Geology of Permit Area

The Minim-Martap and Ngaoundal bauxite deposits occur as dissected flow basalt landscapes that form relatively flat plateau rising steeply from the surrounding granitic planes. The bauxites comprise the indurated caps covering virtually the entire surfaces of the plateau. Erosional ramps and benches provide reasonable vehicle access to all the plateaus. Many bauxite-bearing plateaus are known within the permit area.

4.1.2.4 Hydro-Geology

The significant elevations of the bauxite plateaus aid the drainage. The water table level in the area is under monitoring at presently. However, in Daniel plateau ground water table can safely be taken as 1070 m aMSL. Similarly, in Simone Plateau water table can be safely taken around 1312 m aMSL, as observed in recent field studies.
4.2 Details of Exploration

Exploratory drilling at Minim Martap and Ngaoundal was carried out under the guidance of SRK Consulting (Australasia) Pty Ltd during January to June 2009 on 14 plateaus (11 in Minim-Martap and 3 in Ngaoundal).

4.2.1 Nature of Mineralisation

The bauxite comprises the upper horizon of the laterite alteration profile. It is composed of oxides and hydroxides of aluminium and iron with lesser amounts of titanium and silica. Trace levels of phosphorus and vanadium are ubiquitous. Bauxite is developed where the Al₂O₃ content exceeds the Fe₂O₃ content and the silica in the form of reactive silica, quartz, kaolinite and illinite do not occur at deleterious levels. Aluminium dominance is widespread in the Minim-Martap and Ngaoundal bauxite plateaus tested in the 2009 drilling campaign. Main mineral from samples of boreholes is Gibbsite. Iron bearing phases are believed to be Goethite and Hematite.

4.2.2 Elemental Composition of Ore

The bauxite horizon typically varies in thickness from 3 m to over 30 m and is usually hard near the surface. Purple, white and variegated mottled clays are commonly observed although the high iron content through the deposit can disguise the transition.

4.2.3 Nature and Behaviour of Ore Body

Average bauxite thickness varies between the plateaus ranging from 7 m to 11 m across Minim-Martap permit. Danielle average thickness is 8.6 m. At Ngaoundal permit, the bauxite is commonly much thicker with the average at Simone being 15.5 m.

4.3 Geological Reserves and Quality

Based on the data generated through the exploration program, SRK prepared an independent evaluation of the bauxite resources of the Minim-Martap and Ngaoundal deposits. The following table gives the summary of the resource evaluation.

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Plateaus</th>
<th>Resource Class</th>
<th>Tonnage ( Million T)</th>
<th>Projected Grade (% w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>T. Al₂O₃</td>
<td>T. SiO₂</td>
</tr>
<tr>
<td>Ngaoundal</td>
<td>3</td>
<td>Indicated</td>
<td>88</td>
<td>41.79</td>
</tr>
<tr>
<td>Minim-Martap</td>
<td>11</td>
<td>Inferred</td>
<td>466</td>
<td>46.15</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td></td>
<td>554</td>
<td>45.50</td>
</tr>
</tbody>
</table>

Notes:
1. Abbreviations: T.Al₂O₃—Total Alumina, T.SiO₂—Total Silica, Fe₂O₃—Iron Oxide, TiO₂—Titanium Oxide, LoI—Loss on Ignition
2. Dry density of 1.8 t/m³ was used for resource estimation
3. Following cut-offs were applied to the overburden and floor:
   3% T.SiO₂ and 30% T.Al₂O₃; 4% T.SiO₂ and 40% T.Al₂O₃; 5% T.SiO₂ and 50% T.Al₂O₃
4.4 Mine Plan Design Basis

- As the Danielle Plateau is the largest deposit and more accessible than other Minim-Martap plateaus, it would be mined early in the schedule; and

- Ngaoundal plateaus, which have very low silica content, can be mined continuously throughout the project life at a lower rate of production to support the Minim-Martap deposits.

- Open cast mining is considered for the project as deposits are plateaus.

- Trunk conveyor system is considered for Minim-Martap permit area whereas rail transportation will be utilised for Ngaoundal permit area.

4.5 Mining Operations

4.5.1 Proposed Method of Working

Most of the bauxite could be mined with ripping and dozing method. Some of bauxite may require drilling and blasting for which suitable provision has been made. The vertical grade profile observed during the exploration work shows reasonably consistent layering in some areas which indicates that multi-benching may not be required. In any case, single layer mining will promote vertical blending.

4.5.2 Mine Development and Production

It is proposed to produce 7.5 MTPA of bauxite ROM from both Minim-Martap and Ngaoundal deposits together in two phases of 3.75 MTPA each.

4.5.3 Mine Plan

It is proposed to carry out mining operations in one 11 hours shift per day based on 353 effective working days. However, for providing continuous bauxite supply to the alumina refinery, the ROM stockpile reclaimer, crusher and mine-plant conveyor will work in two 11 hours shifts.

An un-mined selvedge of bauxite all around the plateau will be preserved to prevent soil erosion due to uncontrolled run-off and allow the run-off to drain from predetermined engineered overflow.

The mine plan has been prepared for 25 years of mine operation based on the following criteria.
Executive Summary

- It is proposed to blend the bauxite from Ngaoundal with that of Minim-Martap at 1:4 ratios to achieve a sustainable bauxite quality;

- As Danielle plateau is the largest deposit in Minim-Martap and is more accessible than other plateaus, it is proposed to commence mining from Danielle and move to other plateaus after Danielle is exhausted or as grade control requires;

- The target bauxite quality is 41.5% Av. Al₂O₃ (min.) and 1.2% R.SiO₂ (max.); and

- The production target from the mines will commensurate with the proposed Phase-I and Phase-II production capacities of 3.75 MTPA and 7.50 MTPA respectively.

Summary of the first 25 year production schedule is as follows:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Production ('000 Dry MT)</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PP</td>
<td>1</td>
</tr>
<tr>
<td>Refinery Requirement</td>
<td>-</td>
<td>2428</td>
</tr>
<tr>
<td>Ngaoundal</td>
<td>-</td>
<td>453</td>
</tr>
<tr>
<td>Danielle</td>
<td>476</td>
<td>1975</td>
</tr>
<tr>
<td>Other Plateaus (MM)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Minim-Martap</td>
<td>476</td>
<td>1975</td>
</tr>
<tr>
<td>Total Production (less PP)</td>
<td>476</td>
<td>2428</td>
</tr>
</tbody>
</table>

Note: PP: Pre-Production

After 25 years of operations, south Martap plateaus will be worked out with the Danielle crusher moved to the new location and a new conveyor will be constructed. The south Martap crusher will be moved to crush ore from Gilberte and Eulalie after Alice plateau.

4.5.4 Mine Life

Based on the explorations results, the mineral resources are 554 million tonnes and corresponding mineable reserves are 458 million tonnes. At the proposed rate of extraction, the expected life of the mine will be minimum 60 years.

4.6 Drilling and Blasting

4.6.1 Drilling Method

It is assumed that the ore will be drilled by single pass rigs and blasted. It is assumed that the drilling will be of the full depth of the bauxite up to a maximum of 10 m in single bench system such as Danielle Plateau [average bauxite thickness being 8.32 m after giving allowance to about 0.3 m bauxite thickness probable loss during scraping operations] and multi bench system at Simone Plateau where first bench proposal is for 10 m depth and second bench depth of remaining thickness, say 5.6 m average, 102 mm diameter vertical holes at 4 m
by 4 m centres and subsequent rows being in staggered pattern rather than straight line to give better fragmentation of the rocks.

4.6.2 Blasting

In general, powder factors of 0.31 kg explosive per m$^3$ rock were allowed for. All blasting will be dry using ANFO and will be initiated using nonel detonators. ANFO will be made on site; a mixing station is allowed for. Holes will be gravity loaded from pre-weighed reusable bags and stemmed with drill cuttings. Plastic liners may have to be used in the holes on occasion.

4.7 Surface Subsidence

The proposed mining site is on two plateaus and the working method is open cast [Open Pit] mechanized mining extraction and depth of excavation will be as per the thickness of the bauxite mineral. There will be no subsidence of surrounding area as the activity is proposed on the surface only while the plateau slopes in almost entire area, considered in first 5 years span, will remain in original shape and unaffected by mining. However, the top of the plateau will be at a slightly lower height, sloping uniformly towards southwest direction in the first phase of two targeted plateaus namely Danielle and Simone plateaus.

4.8 Mine Drainage

Water precipitation in the working pits during rainy/wet season will be channelled to the de-silting tank having 3 compartments each of 10 m wide x 10 m long x 6 m depth constructed on both the Danielle plateau and Simone plateaus through well placed 3 m wide x 3 m deep drains after each year of mining activity. From the de-silting tanks, surplus water will reach the original drainage streams/river. To cater to the very heavy rain fall which may be more than the water channel capacity, standby pumping arrangement shall be provided to the de-silting tanks.

4.9 Disposal of Overburden

During first 3 years of mining activity, soil and overburden are proposed to be temporarily stored near to the working areas for Danielle plateau and Simone plateau. After third year of mining activities, concurrent backfilling has been proposed. The soil and overburden dumps of first 3 years of operation will be re-handled for backfilling and no permanent dumps are required to be provided.

4.10 Crushing and Transport

The ROM bauxite needs primary crushing at the mine before transportation to the alumina plant. Primary crushers will be provided at the plateau top for size reduction from +1000 mm to 150 mm. Conveying the ROM bauxite up to primary crushers will be by 90 tonne dumpers.

It is proposed to have covered conveyor transport for Minim-Martap bauxite deposits. From Simone plateau, it is proposed to use 25 Tonne highway-legal rear
dump trucks to transport the crushed ore to a train loading siding at Ngaoundal. From there, the ore will be sent to the refinery site using rail network.

4.11 Site Services

4.11.1 Water Supply

The water requirement for the proposed mine will be 1140 m³/day for mine operation and haul road sprinkling. This requirement will be met from the water accumulated due to direct precipitation in the mining pits, diverted through proposed de-silting tanks. Drinking water requirement will be met through drinking water tankers.

4.11.2 Power Supply

The electric power required for mines Danielle plateau and Simone plateaus is 5.4 MW and 2.4 MW respectively.

The power requirement for the Danielle plateau will be supplied from the proposed alumina refinery. For Ngaoundal, it is proposed to provide 2 numbers of 1.25 MVA diesel generating sets.

4.12 Employment Potential

The total manpower requirement for phase-I and phase-II will be about 212 and 282 respectively.

5.0 PUBLIC CONSULTATION

Public consultations were organized during 18th to 30th March 2010 in and around the bauxite mining site at Ngaoundal and Minim-Martap. These public consultations were intended to explain the salient features of the project to the stakeholders and to understand their concerns and expectations regarding the proposed project.

Stakeholders consulted comprised of administrative and traditional authorities, local representatives of ministry departments (MINEP, MINIMIDT, MINEE, MINEPIA, MINADER, MINDAF and MINEPAT), local communities, NGOs and other organizations of the civil society from the project area.

The public consultations were organized in the form of individual meetings, community meetings and informal interaction with eminent members of the community. The key outcomes of the Public consultations are:

- Strong support of various stakeholders for the project; and
- High expectations from the project.

The local population and local authorities want the project to start as soon as possible because they hope it will become a vehicle for development in the area. As a result, lot of expectations have been generated without necessarily taking
into account CAL’s ability and responsibility to fulfil the same. The greatest expectations are related to employment opportunities and development of social and economic infrastructure. Keeping in view the low literacy rate in the project area, training programs for the local community aimed at developing the necessary skills for the project would have to be organized well in advance.

Concerns were also raised about the risks of air and water pollution, the possibility of eviction of certain population, influx of people in the area and its impacts such as reduction of farming and grazing land.

The local administration and NGOs have advised compliance to the applicable environmental regulations and preservation of the rights of the local community.

6.0 IMPACT ASSESSMENT AND MITIGATION MEASURES

Mitigation measures at the source level for the negative impacts and improvement measures for the positive impacts are elicited so as to improve the supportive capacity of the study area and also to preserve the assimilative capacity of the receiving bodies.

6.1 Methodological Approach

Mining has the potential to affect biodiversity and the environment throughout the life cycle of a project, both directly and indirectly. Direct impacts are usually readily identifiable. Direct impacts from mining can result from any activity that involves land clearance (such as access road construction, exploration drilling, overburden stripping) or direct discharges to water bodies or the air (such as dusts). Indirect impacts can result from social or environmental changes induced by mining operations and are often harder to identify immediately. There are no other industrial projects in these areas; hence, there is no possibility of any cumulative adverse impacts due to the proposed mining project.

Environmental and Social Impact Assessment is an important tool for ensuring that sustainability and biodiversity are integrated into project planning and decision-making and that relevant environmental and social interfaces are considered. The ESIA process provides a structured approach to considering the environmental, economic and social consequences of options and alternatives when developing a mining project.

6.2 Analysis of Potential Project Impacts

6.2.1 Identification of Environmental Aspects

Project activities have been identified through the review of project design document and consultation with project proponents and their mining consultant. After identification of all project related activities, environmental and socio-economic receptors have been established.
6.2.2 Impacts Identification

All surface mining methods produce some irreversible impacts. The environmental and social impacts due to the proposed opencast mining could be broadly classified into the following categories:

- Air pollution;
- Land degradation;
- Solid waste/overburden;
- Water pollution (resources and quality);
- Noise pollution and ground vibrations; and
- Socio-economic development.

6.2.3 Impacts and Mitigation Measures

6.2.3.1 Construction Phase

The construction phase will involve land clearance, construction of access roads and construction of mining facilities and infrastructure. These activities will have impact on land use, topography, soil quality, air quality, noise levels, flora-fauna and socio-economic aspects.

Mitigation measures suggested are:

- Preservation of topsoil for future use;
- Minimize area extent of site clearance;
- Avoid uprooting trees or removing undergrowth where possible;
- Water sprinkling;
- Personal protection equipment to workers;
- Regular maintenance of vehicles and covered transport;
- DG set maintenance to meet stipulated standards;
- Plantation on safety zone; and
- Provision of drinking and sanitation facilities to construction labour.

6.2.3.2 Operational Phase

**Land Environment**

- **Topography**

The original elevation of the mining area on the plateaus will be reduced due to bauxite removal. Thus, the impact on the topography of the plateaus will be irreversible. However, no other impact on topography is envisaged.

After third year mining activity, concurrent backfilling of excavated overburden is proposed. With mining excavations, the plateau top height will be reduced giving a smooth slope towards southwest of the plateau. However, around the top periphery of the plateau, a 20 m wide selvage / containment belt will be provided, which will serve as a safety barrier and greenbelt will be developed.
• **Drainage Pattern**

Natural drainage pattern will be maintained as much as possible on the plateau. Drainage modifications in the mining area, if required, will only be done through garland drains. As the mining activity will not disturb the surface drainage pattern significantly, no appreciable irreversible impact is envisaged due to the proposed mining activity on the surface drainage of the both plateaus.

There is almost no evidence of the development of drainage system on the plateau top as there are only few eroded gullies running off the plateaus.

During the course of mining, the precipitated rainwater in the mining pits will be channelized through drains of size 3 m wide x 3 m deep, which are proposed from bottom of mining pit to proposed de-silting tank. The clear water is proposed to be used in mining operations after adequate sedimentation. Surplus water, if any, from the de-silting tanks will be channelised to the nearest natural drainage streams.

• **Land Use Pattern**

The impacts on land use will be limited as the mining will be confined to plateau top only. Typically, the bauxite bearing plateaus are barren due to presence of hard and compact laterite with very thin or no soil cover. Such barren plateau tops are called bauxitic desert. This has also been observed on the plateau tops of Minim-Martap and Ngaoundal where most of the land is barren with only small patches of vegetation. Due to the mining operation, the hard lateritic layer is broken, which promotes natural vegetation after mine closure.

During the mining operations, this barren land will be used for industrial purpose and subsequently, rehabilitated and returned to public domain after mine closure in a phased manner.

Backfilling and rehabilitation of mined out pit area will be done by overburden and attempt will be made to spread over the topsoil generated from fourth year onwards. The backfilled area will be vegetated using native species compatible with the climatic condition and the surroundings.

The mining operations will have a positive impact on the land use pattern by converting large patches of barren land to vegetated area.

• **Overburden Dumps**

The overburden excavated during the mining operations is proposed to be stored temporarily in an earmarked area for future backfilling purposes. However, during rain, there is a possibility of wash-off of loose materials from the storage along the plateau slopes, which may result in loss of overburden material and silting of natural drainage channels. To prevent this, following precautionary measures are proposed:
• Provision of garland drains surrounding the overburden dump areas;
• Overburden dumps will be properly levelled and compacted;
• Dump slopes will be stabilised by stone pitching and growing grass; and
• Water collected in garland drains will be sent to the de-silting tanks constructed at lower contours.

• Landslides and Soil Erosion

The mining operations may cause landslides and heavy soil erosion if mining is carried out up to the plateau edges. To prevent this, 20 m wide un-mined selvedge all along the plateau boundary is proposed, which will be developed as a greenbelt.

During the mining operations, the topsoil will be removed, which may result in erosion during rainy season. Therefore, it is proposed to preserve the excavated topsoil for future rehabilitation of the mined out areas.

The plateau slopes are thickly vegetated and the topsoil thickness generally varies from 0.3 m to 0.5 m. Hence, the possibility of soil erosion is generally very less.

• Mine Closure Plan

The mining operations will be commenced on Danielle and Simone plateaus and will progressively move to other plateaus after exhausting the plateau deposits. The mine closure will be planned in a phased manner to rehabilitate the mined out plateaus. The mine closure and rehabilitation will be done in following steps:

• Stored overburden shall be used for back filling of mines from fourth year onwards;

• Topsoil will be spread over the backfilled overburden for about 30 cm depth on the backfilled area. As far as possible, excavated top soil shall be re-used. If sufficient top soil is not adequate from the mined out areas, it will be sourced from nearby burrows;

• If required, inoculation of soil with beneficial microbes (nitrogen fixing and phosphorus solubilizing) shall be done before spreading on the backfilled area;

• Ploughing of top soil will be done before planting seeds to break up compacted soil layers and improve aeration, water infiltration and root penetration;

• If required, the top soil will be supplemented with fertilizers such as bio solids, compost, manure etc for promoting vegetation;

• Vegetation species will be selected based on nativity, tolerance to local conditions and which can establish quickly and have fast growth;
• Regular watering, monitoring and protection of the rehabilitated mined area will be done until vegetation is sufficiently stabilised; and

• Appropriate measures such as reseeding, fertilisation will be taken to address evidence of invasive species or poorly established vegetation during monitoring and protection period.

**Disposal of Domestic Solid Waste**

Domestic solid waste of about 30 tonnes per year is expected to be generated, which will be disposed off as follows:

• Bio degradable material will be collected separately in farm yard manure pits;

• Paper and plastic waste will be collected separately and sent to recycling facility;

• Other domestic waste will be sent to a common disposal site.

**Air Environment**

The major anticipated pollutant from the proposed mining activities is dust, which is likely to be generated during ripping, dozing, drilling, loading, unloading, transportation, crushing and stockpiling.

The impact of the mining activities on air quality has been assessed by using USEPA approved area source model namely Fugitive Dust Model (FDM). It is predicted that the maximum incremental concentrations of dust (Particulate Matter less than 10 microns) due to various mining operations will be 6.8 µg/m³ and 3.3 µg/m³ will occur within the plateau boundary for Minim-Martap and Ngaoundal permit areas respectively. The difference in incremental dust concentrations is due to the difference in production capacities. Major mitigation measures for reducing air pollution are as follows:

• Ripping and dozing technique shall be practiced to the maximum extent and usage of blasting will be minimized as far as possible;

• Drilling units will have in-built vacuum cyclone dust collector;

• Controlled blasting techniques with pre-line drilling and buffer blasting will be adopted;

• Bag filter/cyclones will be provided to the crusher unit and transfer points of belt conveyor;

• Transportation of ore to the proposed refinery site will be through covered conveyor belt;

• Water sprinkling will be used during handling, storage, transportation to suppress dust;
Plantation will be carried in and around the mining area, permanent haul roads;

The dust respirators will be provided to workmen;

**Noise and Vibrations**

Major noise sources are mobile equipment, ripping, drilling, blasting, handling, transportation and crushing. For estimation of dispersion of noise in the ambient from the source point, in-house mathematical model (Dhwani) is used. According to modelling results, high noise levels will be confined to work zone areas only. The predicted noise levels beyond 500 m from the mining area will be less than 45 dB (A), which is within the permissible international norms.

The following control measures shall be adopted to keep the ambient noise levels well below the permissible limits:

- Use of hydraulic drills;
- Controlled blasting with proper spacing, burden and stemming;
- Crusher units will be completely enclosed;
- Silencers will be provided to the mining machinery;
- A thick greenbelt will be provided around the plateau boundary;
- Provision of protective devices like earmuffs/earplugs to workmen; and
- Provision of sound insulated chambers for the workers in high noise zones.

**Water Environment**

The major water pollutant from mining operations will be suspended solids of topsoil, overburden and bauxite. Other pollutants include oil, grease and sanitary waste. No groundwater contamination is expected as the groundwater table on the plateaus is below the economic bauxite floor level and as a result excavations will not puncture the groundwater table. The water pollution is due to:

- Rainwater run-off from temporary dumps/stock piling area/mining area, haul road and drainage of excess sprinkled water;
- Wastewater from workshop and crushing plant; and
- Discharge of sanitary waste.

Mitigation measures for water pollution are as follows:

- Garland drains will be provided around the overburden dumps and mining areas;
- De-silting tanks will be provided on the drainage points of the plateaus being mined;
- Two numbers of check dams will be constructed across the Manbal and Mbui streams;
- Wastewater Treatment Plant will be provided for treatment of wastewater from workshop/service centre; and
- Sewage Treatment Plant will be provided for treatment of sanitary waste.
Biological Environment

Bauxite bearing plateaus in Ngaoundal and Minim-Martap are largely barren with only small patches of vegetation and no endangered flora species. Therefore, the proposed mining operations are not likely to cause any significant loss of vegetation. On the contrary, the barren land will be converted to vegetated area after mine closure, which is a positive impact on the biological environment.

The impact on fauna may be due to the human activities, noise, vibration and fragmentation of land. However, the plateaus have no endangered fauna species and wildlife except for few small animals like squirrel, hare and duikers, which are commonly found in the entire Adamawa region. These small animals are likely to migrate to nearby areas after commencement of mining activities. Hence, no significant loss of fauna is expected. The proposed progressive plantation over a period of time shall create conditions favourable for fauna habitat.

Socio-Economic Environment

People in the region generally depend for their livelihood on the agriculture and grazing of cattle. Plateau tops where mining is proposed are devoid of any agriculture and major vegetation. No earmarked cattle grazing areas exist on the plateau top. Hence, no disturbance to livelihood is envisaged.

No impacts on community health are envisaged due to the proposed project. However, the site health care centre shall also provide medical assistance to the surrounding villagers through its rural welfare schemes.

The proposed mining project will result in infrastructure development of the area such as construction of roads, schools, hospitals and communication facilities etc which will improve the quality of life of the local community.

The unemployment rate in Ngaoundal and Minim-Martap area is quite high due to lack of any major industrial and commercial establishments. The mining project will create direct and indirect employment opportunities for the local community. Indirect employment will results from peripheral developments such as restaurant business, hotel industries, transport companies and road construction etc. CAL proposes to establish a vocational training facility for the local community for development of skills required by direct and indirect employment as well as for self employment.

There are no ancient monuments and sensitive habitats like historical, cultural and ecological importance places within 15 km radius of both the permit lease areas. Hence, no impact on such features is envisaged.
7.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN AND POST PROJECT MONITORING

7.1 Salient Features

- Health, Safety, Environment and Community (HSEC) Policy to be formulated during the development phase of the project;
- Complete compliance with all applicable laws, regulations, standards and permits, govt policies, procedures, specifications, rules, standards and guidelines;
- Development of Environment Management System and ISO 14001 certification;
- Preparation of annual environmental statement;
- Constitution of environmental monitoring cell for implementation of ESMP and coordination with MINEP;
- Regular environmental audits; and
- Establishment of environmental monitoring laboratory.

7.2 Environmental Cost Estimates

In addition to the built-in features in mining equipment and facilities, estimated capital cost for dedicated environmental protection facilities is USD 278,000 and their corresponding recurring cost is USD 126,000 per annum.

8.0 RISK ASSESSMENT AND DISASTER MANAGEMENT PLAN

8.1 Risk Assessment for Hazards

8.1.1 Hazards in Mining Activity

Surface mining operations are defined as activities undertaken during mining / winning, transporting and processing of minerals mined from the surface.

The hazards during mining include accidents during using large earth moving equipment during land clearance, drilling, blasting, excavation, loading and transportation.

The main hazards arising from the use of large earth moving vehicles are incompetent drivers, brake failure, lack of all around visibility from the drivers position, access to the cab, vehicle movements particularly reversing, roll over and maintenance. Those most at risk are the driver and pedestrians likely to be struck by the vehicle, and drivers of smaller vehicles, which cannot be seen from the cabs of large vehicles. Accidents often occur when vehicles break down.
The hazards associated with belt conveyors are mainly in running nips between the belts and driven and direction change rollers and falls from heights. The hazard from the conveying system puts the people at either the feed or delivery ends of the system at great risk.

8.2 Hazard Identification & Assessment

8.2.1 Accident Location

There are many locations within a mine site where a fatality can occur. A combination of poor safe work procedures, equipment movement and operation and unexpected ground movements, can be the result in many fatalities.

According to International Mining Fatality Database, 2008, at the Mine working area, about 41% of the incidents and 82% of the fatalities occur. This high number is due to the multiple fatality incidents, which more frequently transpire in the mining area. Transportation is the next place where a mining fatality is most likely to occur, with 13% of the incidents, but only 4% of the fatalities. These incidents however are usually only single or double fatalities and cause a higher percentage of incidents than fatalities. Because transport is of high importance in mining operations, roads and roadways are susceptible to the occurrence of fatalities.

8.2.2 Accident Investigation

It has been observed that about 88% of accidents were caused by unsafe acts, 10% by unsafe conditions and 2% were unavoidable. It can be understood that majority of the accidents take place due to the actions of the workers.

A large percentage of mining time is spent on production activities and it is the most risky activity being performed throughout the mine life. Production activities account for about 23% of all mining incidents, but 70% of mining fatalities.

The main cause of fatalities is unintended operation of equipment, followed by contact with moving or rotating plant (guarding/access to danger zone). These two causes of fatality are classified as the main causes in non-coal mining open-cut operations in general.

The main root cause of death in mining operations is fall of sides/highwall and accounts for about 24% of all mining fatalities. Unintended operation of equipment follows second accounting for 13% of all mining fatalities and fall from heights third at 9%. Almost every mining fatality has some involvement with equipment. About 77% of all mining accidents resulting in a fatality have occurred involving equipment.

8.2.3 Hazard Assessment

The risk assessment for probable hazards when no precautions are taken is as follows:
• The risk potential is very high with major consequence when equipment with high fire potential is used;
• The risk potential is extreme with major to catastrophic consequence while handling equipment in crushing is handled; and
• The risk potential is extreme with major consequence while handling explosives and blasting activities.

8.3 Occupational Health Impacts

The physical environment where exploration, mining, ore extraction and processing takes place can cause health impacts. Exposure to some of the major hazardous substances encountered in the mining and metal sector can result in a number of important health effects.

Mining as with all employment sectors will on occasions encounter cases of ‘stress’ and other adverse mental health and wellbeing effects which are attributable to, or contributed by, occupational factors, including shift work. A further potential adverse health effect is chronic fatigue brought about by the intense physical demands of mining activities.

• Likely Occupational Health Risks

There are a large number of hazards in mining that can pose a potential risk to health and wellbeing. Dust and noise are inherently associated with rock breaking. Ergonomic hazards are common in mining as miners generally handle heavy equipment and do heavy work, often in cramped conditions. In some instances, ergonomic hazards, which are associated with poor engineering design, contribute to increased safety risks.

Mining is a capital intensive industry which requires utilization of large equipment in most facets of operations. Drills, shovels, crushers, mills, screens and many other items of mining and mineral processing equipment are inherently noisy and most require some form of operator attendance.

The risk of tropical diseases such as malaria and dengue fever is substantial at some remote mining locations. Leptospirosis and ankylostomiasis were common in mines, but eradication of rats and improved sanitation will help control these hazards. Information available on exposure to airborne health hazards suggest that, depending on the commodity under consideration, between 9 and 50 per cent of exposed workers, who account for about half of the workforce, are overexposed to airborne pollutants.

Silicosis remains a problem in developing nations and silico-tuberculosis is important in Africa, where the high prevalence of HIV infection among miners increases the risk. Prolonged exposure to crystalline silica can also cause chronic obstructive pulmonary disease. There is some evidence for accelerated silicosis in rheumatoid arthritis and of renal disease following prolonged silica exposure. There is also now good evidence that prolonged exposure to crystalline silica increases the risk of lung cancer.
8.4 **Environment Safety Health Plan**

The company will set up a management structure that ensures that there are a sufficient number of competent people to manage the mining safely.

The emergency preparedness involves the company and the local community, as represented by the neighbours, local emergency response teams, the local government and nongovernmental organisations (NGOs) with specific interests in the area.

The company will ensure that health surveillance is made available before the persons are assigned to particular work activities in the mine, having regard to the risks they face.

8.5 **Disaster Management Plan**

The Disaster Management Plan included the following:

- Escape and rescue;
- Emergency response strategy;
- Emergency Response Organization;
- Emergency facilities such as assembly and rescue rooms and first aid;
- On-Site emergency preparedness Plan; and
- Off-Site Emergency preparedness Plan.

9.0 **RESETTLEMENT ACTION PLAN**

The resettlement plan provides an inventory of the housing and social infrastructure likely to be affected within the security perimeter of 500 m around mine sites of Minim-Martap and Ngaoundal. However, the list of persons eligible for compensation will be finalized based on Public Utility Decree (DUP) to be issued by Ministry of Land Affairs and State Property after the identification and verification of the legitimacy of the owners.

The level of compensation to the affected population is proposed in accordance with national legislations and World Bank guidelines taking into account direct and future losses due to the bauxite mining project to ensure that the living standard of the affected population is at least equivalent if not greater than their present condition.

After detailed field survey and discussions with local administrative authorities, it is estimated that the assets and developments likely to be affected by the project are 859 Boukarous in both the deposits. Potential sites for resettlement will be identified taking into account the harmonization of relations between the displaced and host populations. The study recommends a plan of development of basic infrastructures including the construction of two primary schools.

The total cost of compensation is estimated at 504.8 Million CFA (USD 1,009,600).
10.0 CONCLUSIONS AND RECOMMENDATIONS

The implementation of proposed environmental and social management plan and mitigation measures will ensure that the impacts of the bauxite mining project will be within the permissible national and international norms. It is recommended that the project shall adhere to the national regulations and international guidelines with regard to environment protection.

Further, there will be an overall socio-economic development in the Adamawa region. The project will also facilitate many other ancillary industrial activities in the region.