Proposed Balama Graphite Mine
District of Balama, Cabo Delgado Province, Northern Mozambique

LAND, NATURAL RESOURCE USE AND AGRICULTURE ASSESSMENT

Prepared for:

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LIST OF ABBREVIATIONS

BID	Background Information Document
CES	Coastal & Environmental Services
DESR	Draft Environmental Scoping Report
DNPOT	National Directorate for Land-Use Planning*
DUAT	*Direitos de Uso e Aproveitamento da Terra'***
ECO	*Environmental Control Officer*
EDM	*Electricidade de Moçambique***
EIA	Environmental Impact Assessment
FAPIM	Forestry and Agriculture Programme in Mozambique
GDP	Gross Domestic Product
HDI	Human Development Index
IAIA	International Association of Impact Assessments
IFC	International Finance Corporation
LoM	Life of Mine
MICOA	Ministry of Environmental Coordination*
MoA	Ministry of Agriculture
MZN	Mozambican Meticals
GDP	Gross Domestic Product
GoM	Government of Mozambique
PAEI	Agricultural Policy and Implementation Strategy*
PEDSA	*Plano Estratégico para o Desenvolvimento do Sector da Agricultura***
TA	Traditional Authority
ToR	Terms of Reference
TSF	Tailings Storage Facility
UN	United Nations
US	United States

* *English term*

** *Portuguese term*

EXECUTIVE SUMMARY

Project Overview

The Balama Graphite Mine project is located on a 106km^2 Prospecting Licence located approximately 7 km east of the small regional town of Balama in northern Mozambique, within the District of Balama in the Cabo Delgado Province. The site is approximately 265km by road (3.5 hours drive) west of the port town of Pemba.

It is planned that conventional open pit mining will be used to extract graphite ore. Values of ore processed will be 2 million tons per annum (tpa) depending on the production scenario chosen.

Approach

A desktop analysis and a field survey were undertaken. Soil distribution and land use reference maps were developed.

The following specialist reports have been prepared as part of the EIA process and should also be read in conjunction with this report:

- Vegetation Assessment
- Terrestrial Fauna Assessment
- Surface Water and Aquatic Assessment
- Socio-economic Impact Assessment
- Resettlement Policy Framework
- Waste Management Assessment
- Traffic, Transport and Visual Assessment
- Health Impact Assessment
- Air Quality Assessment
- Ground Water and Geochemical Assessment
- Noise Impact Assessment
- Legal Review
- Closure and Rehabilitation Study

Where relevant, summary content sourced from these documents is provided in this report.

A field survey was conducted on the 8-17 July 2013 in order to assess soils, land-use, natural resources use and agricultural potential onsite. The entire mining concession area was assessed.

The Guidelines for Soil Description (FAO 4th Ed. 2006) was used to classify soils in the field according to international guidelines as set out in the second edition of the World Reference Base for Soil Resources (WRB) (IUSS Working Group WRB, 2006).

Biophysical Environment

Cabo Delgado Province has a tropical climate with two distinct seasons. The wet season occurs from November to March and the dry season from April to November. Specific weather data for the project area is not available. Climate data for Montepuez, the nearest town to the project site (93km away), was therefore used. Montepuez has a tropical climate and is also a winter rainfall region. The average annual rainfall is approximately 942.3 mm. The driest month is August/September with 0 mm - 2 mm. Most precipitation falls in January, with an average of approximately 246.4 mm (http://www.weatherbase.com).

The average annual temperature in Montepuez is 24.2 °C. The warmest month of the year is November with an average temperature of 26.7 °C. In July, the average temperature is 21.1 °C making it the coolest month in the year. The average temperatures vary during the year by 5.6 °C.

The highest recoded temperature was a maximum of 50 °C, recorded in November, while the lowest recoded temperature was a minimum of 5 °C, recorded in May (http://www.weatherbase.com).

North-eastern Mozambique is predominantly underlain by Proterozoic rocks that form a number of gneiss complexes that range from Palaeo to Neoproterozoic in age. The project site is underlain by metamorphic rocks of the Neoproterozoic Lurio Group that are included within the Xixano Complex.

The study area is relatively flat to gently undulating with sporadic inselbergs (Mount Nassilala and Mount Coronge) rising from the flat plains. The altitudinal range varies from 480 to 830 m above sea level (asl) with the highest point occurring on Mount Nassilala.

The Mehucua River flows through the southern section of the project site in a south-west to north-east direction. A few small wetlands occur in the project area, the most notable being a swampland located approximately 2 km south west of the proposed site and a wetland located approximately 7 km east south-east. The largest water body in the area is the Chipembe Dam which is located 12 km northwest of the site and outside of the project area.

Compared with other countries in the region, Mozambique has a rich natural resource base including untransformed indigenous forests, savannah woodlands and coastal habitats. About 25% of the land has commercial forestry potential, 12.5% constitutes state-protected areas and a further 22% comprises potential wildlife habitat.

Land use in the area is primarily for subsistence agriculture. Crops such as maize, cotton and cassava are grown on the flat areas which are cleared using slash and burn techniques. Some small livestock is reared in the area although these animals were only noted near the villages and are not abundant in the project site.

Almost all households are heavily reliant on the natural resources for their livelihoods. Natural resources are used for construction, medicinal consumption and to supplement their food. Small scale charcoal production was also evident in the project site.

Soils

Most of the Syrah mining concession is underlain by red loam and sandy loam soils with high clay content soils found around the Mehucua River.

The mining area (i.e. the area where mining activities will take place) varies between medium textured red soils in the west to sandy loam soils that are easily eroded located centrally and eastwards.

Agriculture

With all agricultural production in the region being rain-fed, weather variability is a major factor in determining crops performance. The main growing season starts with the first rains in December. There is also a minor growing season, based on residual soil moisture, from March to July, accounting for approximately 10% of total output.

Agriculture is based on self-subsistent small, hand-cultivated units (called a *mashamba*) averaging 1.2 hectares in size. One farmer may hold multiple *mashambas*, containing multiple crops consisting of traditional varieties that are rain-fed, with little or no mechanization resulting in low productivity. Most households diversify to cope with low productivity and income. The majority practice extensive shifting cultivation (or slash-and-burn), only about one-third sell any crop output, and almost two-thirds live in households that lack food security (The World Bank Report, 2006)

Food crop production is the most important agriculture sub-sector accounting for around 80% of the cultivated area (2009). Maize and cassava are the major staples; other food crops include sorghum, millet, rice, beans, groundnut, sweet potatoes and a wide variety of vegetables. Maize occupies about 35% of total planted area in the Cabo Delgado Region. Cassava is an important component of the farmer's risk reduction strategy because it is drought tolerant and resistant to disease. Groundnut is cultivated on sandy soils and makes an important contribution to household diet and income. The main cash crops are cotton, sesame and sugar. Tree crops, especially coconut and cashew are an important source of cash earnings, and contribute to household food security (Special Report FAO/WFP, 2010)

The use of modern technologies and irrigation facilities is limited to a small number of commercial farms growing cash crops and vegetables and to out-growers of cotton-producing crops on contract. None of these sites is located within the mining concession area.

Based on soil types and identified biophysical attributes of the local area, the following agricultural recommendations are made:

- A conservation agriculture approach is recommended. This can be achieved through basic training to ensure the affected communities become self-sufficient in generating high protein foods as well as cash liquidity. The traditional slash and burn practices that depletes soil nutrition can be cancelled while less land could be used more efficiently. Agriculture could then, with correct rotations and cropping programmes, ensure more stable employment conditions for the local farmers.
- The following crops are recommended (taken from the KPC Report; unpublished):
    - Peanuts - high protein and a legume crop.
    - Beans & peas (Sugar beans, Pigeon Pea and Cow Peas) - high protein and a legume crop.
    - Sesame - cash crop that is drought resistant and grows well in most soil types.

  All these crops can be grown through multi-cropping with more traditional crops like cassava and maize.

Land use

As mentioned earlier land use in the project area is primarily for subsistence agriculture. Crops such as maize, cotton and cassava are grown on the flat areas which are cleared using slash and burn techniques. Some small livestock (chickens, geese, goats etc.) is reared in and around the villages.

Arial images show areas of high agriculture (where more than 50% of the land currently contains crops) and areas of low agriculture (where less than 50% of the land currently contains crops). These areas were plotted on a map (Figure 6.1) to illustrate their extent.

Natural Resources Use

Natural resources currently used in the Syrah Balama concession include:

- Water
- Wood
- Medicinal and food plants
- Grasses
- Soil and mud

Three issues were identified for the project site:

- Impacts on soils
- Impacts on agriculture

- Impacts on natural resources

Eight impacts were identified and discussed.

Impact number	Significance (before mitigation)	Significance (after mitigation)
Construction Phase		
1.1	MOD -	LOW -
1.2	MOD -	LOW -
2.1	HIGH -	MOD -
2.2	VERY HIGH -	MOD -
2.3	VERY HIGH -	LOW -
3.1	LOW -	LOW -
Operation Phase		
1.1	HIGH -	LOW -
2.1	VERY HIGH -	LOW -

Conclusions and Recommendations

- Topsoil must be stockpiled and replaced as a final graded layer over the subsoil contouring at a minimum at a depth equal to what was removed during construction
- An Environmental Control Officer (ECO) should monitor all excavations to ensure backfilling with subsoil first and then topsoil afterwards takes place;
- The new haul road contouring should assist in dispersing water run-off instead of concentrating it and increasing the risk of erosion;
- Disturbed areas should be rehabilitated as soon as construction has been completed. Rehabilitation should be undertaken progressively;
- Control the amount of runoff crossing exposed areas by using berms or temporary or permanent drainage ditches to divert water flow around the cleared areas;
- The access road should be designed no wider than necessary to accommodate the immediate anticipated use;
- Rivers and lakes should be kept in a natural state as far as possible;
- Minimise the alteration to topography;
- Minimise the area of impervious surfaces;
- Grade impervious surfaces to drain into vegetated areas;
- A hydrocarbon management Operating Procedure should be designed and implemented. Copies of this document should be made available at designated facilities where hydrocarbons are used or stored. The purpose of this procedure is to provide for the proper storage and handling of hydrocarbons, including waste hydrocarbons, on site and hence prevent any form of contamination;
- It is recommended that soil contaminated with hydrocarbon should be immediately removed and disposed of at a soil bioremediation facility on site;
- All staff must be trained on the correct management of bunded facilities, including the discharge of collected liquids;
- Spill kits must be readily available at strategic points throughout the site and staff must be trained on the correct use of these kits;
- Spillage and seepage of contaminants should be prevented at all times through the implementation of good housekeeping and management procedures;
- A monitoring program must be defined in the EMP;
- In the case of accidents immediate remedial measures should be implemented;
- Storage facilities should be adequately bunded and inspected on a regular basis;
- The tailings storage facility must be designed and operated to prevent infiltration of toxic leach into groundwater through the provision of appropriate liners and sub-drainage systems to collect or recycle water;
- Leak detection equipment should be installed with an appropriate Leak Response Plan;

- Surface and groundwater monitoring should be continuous throughout all phases of the project to ensure early detection;
- Groundwater monitoring points should be installed around the TSF, the pit and the waste rock dump.

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1 INTRODUCTION

1.1 Project location

The Balama Graphite Mine project is located on a 106km^2 Prospecting Licence located approximately 7 km east of the small regional town of Balama in northern Mozambique, within the District of Balama in the Cabo Delgado Province (Figure 1.1). The site is approximately 265km by road (3.5 hours drive) west of the port town of Pemba.

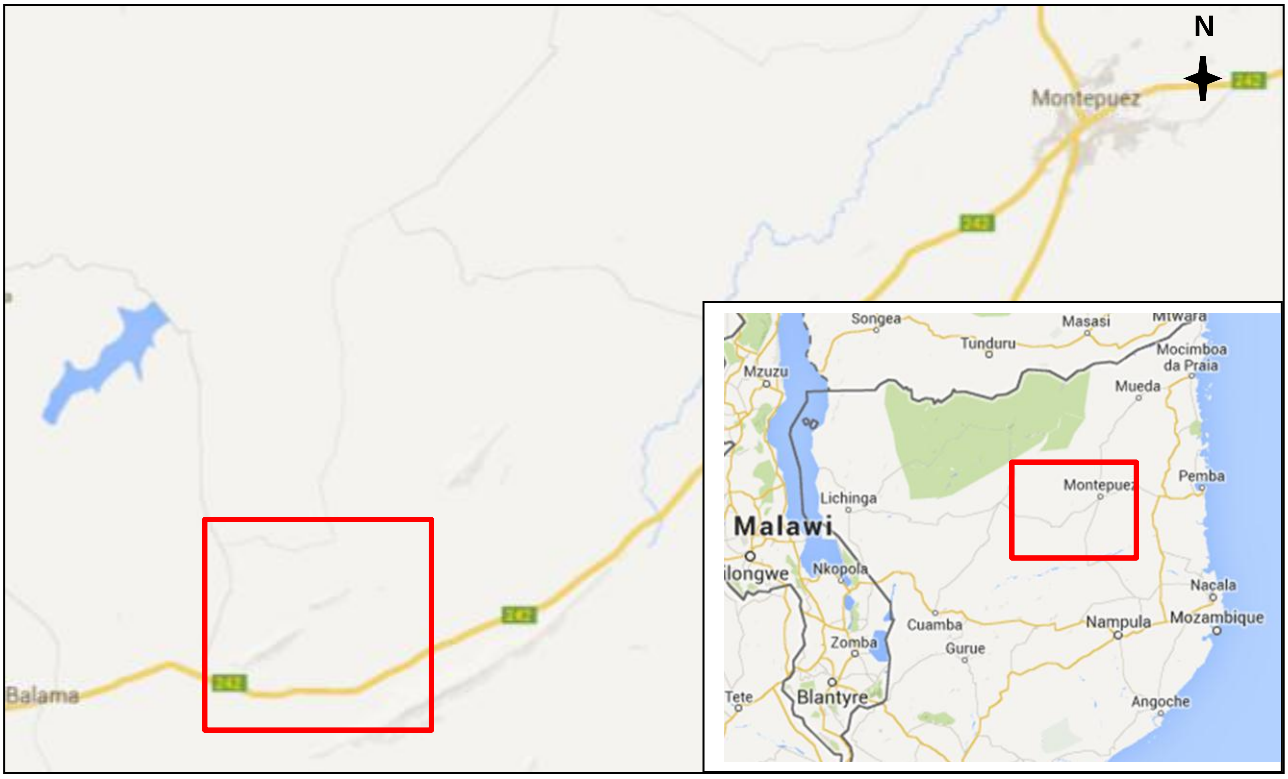

Figure 1.1. Locality map indicating the position of the proposed Balama Graphite Mine area.

1.2 Project description

It is planned that conventional open pit mining will be used to extract graphite ore. Values of ore processed will be 2 million tons per annum (tpa) depending on the production scenario chosen.

1.2.1 Mining process

Conventional flotation processing will be used to extract graphite from the ore. Water for this will be acquired from the Chipembe Dam, located approximately 13 km northwest of the project site via a new pipeline. It is estimated that 1 m^3 of water will be required per tonne of ore processed.

Ore will be delivered from the mine pit onto stockpiles at the processing plant using haul trucks. The ore will then be fed into the crusher bin using front-end loaders. The crushed ore will then be fed via a conveyor into a mill feed silo. At the mill, a spiral classifier is anticipated to be the most likely piece of equipment that will be used to classify the crushed ore. The ore will then undergo cleaning, flotation and regrinding. The tails will be transferred to a tailings thickener, with flocculent added to the thickener. The final concentrate will be pumped to final concentrate holding tanks ahead of a filter.

Once the graphite concentrate has been produced, it will be transported by road to the deep water port at Nacala and subsequently exported.

The Balama site is anticipated to have a large graphite deposit. It is anticipated that the mine could have a mine life of 50 years (minimum of 25 years with an option to extend with another 25 years). The plant will operate 365 days per year.

1.2.2 Size of infrastructure

The ultimate size of the Balama Graphite Mine will depend on further technical assessments but will typically consist of:

- A pipeline (±13 km) from the Chipembe dam to the project site.
- Pump houses at the dam and project site.
- Water reservoirs at the project site.
- Offices and accommodation at the project site to accommodate 250 people.
- A diesel powered electricity generation plant.
- An ore processing plant.
- A Tailings Storage Facility
- A waste rock dump

The project will also require infrastructure related to auxiliary services including the following:

- Roads to enable access to various parts of the development and for transportation of materials, equipment, supplies and employees;
- A lay-down area for construction materials and equipment. This area will continue to be used during the operational phase, although the actual area of land required may be reduced;
- Workshops for repair of equipment and machinery;
- Bunded storage areas for diesel fuel, lubricants and waste oil;
- Stores and a lay-down area(s) for equipment, spares and consumables;
- Offices for site staff;
- Ablution facilities and associated sewage treatment plants;
- Security measures

The proposed layout for the Balama Graphite Mine is shown in Figure 1.2 overleaf.

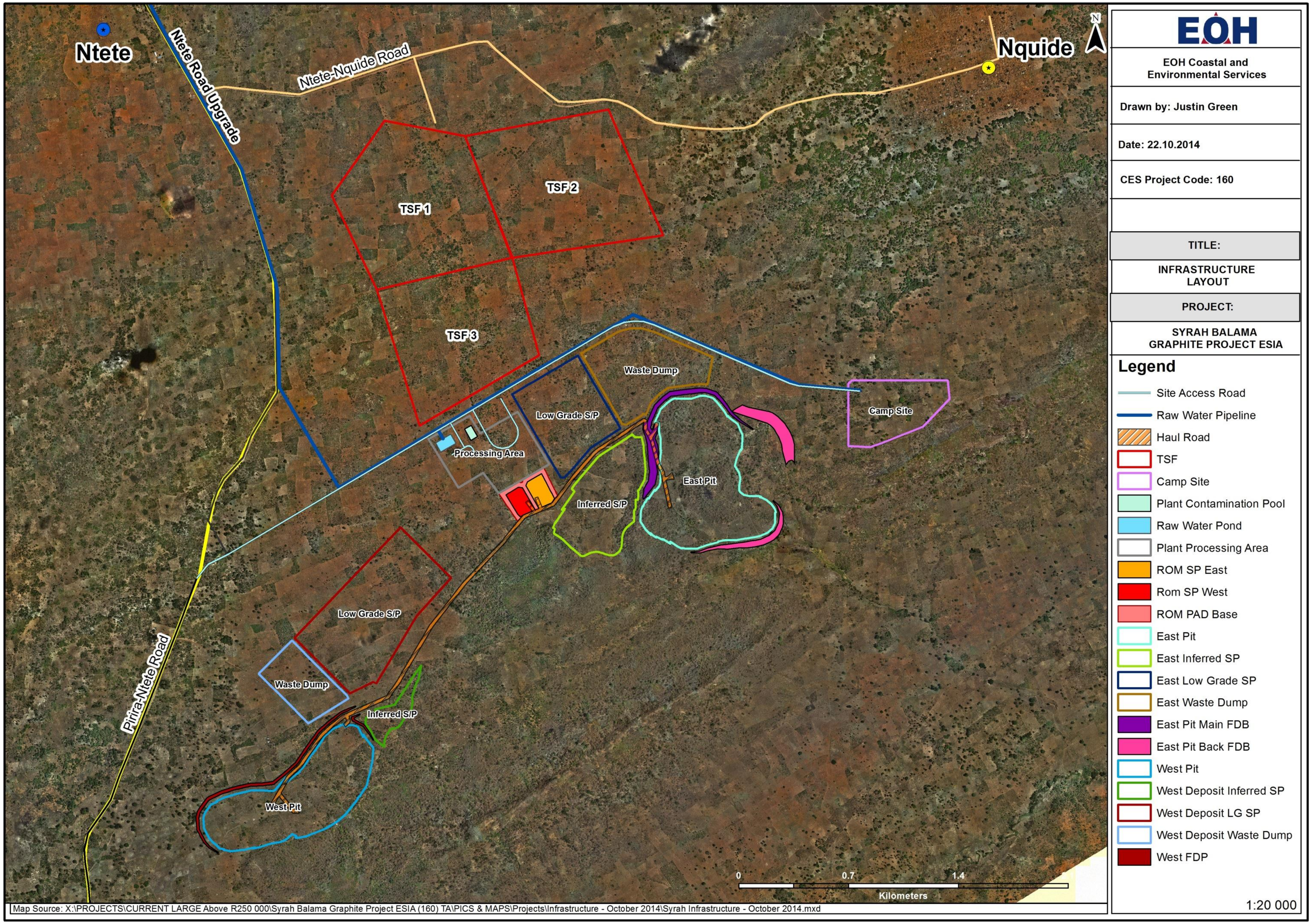

Figure 1.2. Proposed layout of the Balama Graphite Mine

1.3 Terms of Reference

The terms of reference for the soil assessment will be as follows:

- Characterise the soil and distribution of soil types.
- Characterise land use and capability (including in the new settlement areas).
- Develop recommendations for soil management and mitigation measures for soil degradation.
- Estimate soil potential linked to current land use.
- Identify appropriate crops types and yields, extrapolated from soil and climatic conditions.

The Natural Resource Use and Agriculture Assessments will have the following terms of reference:

- To provide a report on the *status quo* with reference to land use and agricultural activity.
- Determine GIS locations of important agricultural areas in proposed mine infrastructure and mine prospect locations.
- Develop a land use management plan for mining closure, incorporating conservation and agricultural objectives.
- To find ways and means to help the local people to improve their agricultural productivity.
- Evaluate the land capability of the area based on the broad soil and climatic analysis and comment on the potential of the area for agriculture and other land uses.
- Determine mechanisms of restoring the agricultural potential of the mined surface area or previously cropped areas affected by the mine path or footprint.
- Engage with the social scientists to ensure that questions related to land use are asked during the social impact assessment, to clarify the complexities associated with current land use and natural resource utilisation.
- Identify the most widely used natural resources in the project area and determine whether any of these are spatially limited to certain locations where proposed mining areas will be located.
- Identify the main fuel wood trees and assess their abundance and replaceability.
- Determine whether any grazing land falls within proposed mine infrastructure and mining areas and map these areas.
- Identify and assess the significance of impacts on soils, land and natural resource use that could result from the mining operation.

1.4 Approach

A desktop analysis and a field survey were undertaken. The methodology used is described below.

1.4.1 Desktop analysis

Soil distribution and land use reference maps were developed using the following resources:

- Aerial photographs (taken 2012)
- Topographical map
- Geological map of the Namuno area (Scale 1:250 000)
- Soil distribution map of the Balama District, Mozambique (Scale 1:1 393)
- Vegetation map (from the Vegetation Assessment Report; CES 2013)
- Satellite imagery from Google Earth

The abovementioned resources were used as a remote sensing technique. This allowed for a detailed soil and land use analysis of the study site.

The following specialist reports have been prepared as part of the EIA process and should also be read in conjunction with this report:

- Vegetation Assessment
- Terrestrial Fauna Assessment

- Surface Water and Aquatic Assessment
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Where relevant, summary content sourced from these documents is provided in this report.

1.4.2 Field survey

A field survey was conducted on the 8-17th July 2013 in order to assess soils, land-use, natural resources use and agricultural potential onsite. The entire mining concession area (as shown in Figure 1.2) was assessed.

The Guidelines for Soil Description (FAO 4th Ed. 2006) was used to classify soils in the field according to international guidelines as set out in the second edition of the World Reference Base for Soil Resources (WRB) (IUSS Working Group WRB, 2006).

1.5 Limitations and assumptions

This report is based on currently available information and, as a result, the following limitations and assumptions are implicit:–

- The report is based on a project description taken from design specifications for the proposed Balama Graphite Mine that have not yet been finalised, and which are likely to undergo a number of iterations and refinements before they can be regarded as definitive;
- Descriptions of the surrounding agricultural environment are based on extensive fieldwork and available literature.

2 RELEVANT LEGISLATION

The following legislation is relevant when considering impacts on the agricultural potential, existing Land and natural resources use of the area identified during the Planning and Design, Construction and Operation Phase of the proposed Balama Graphite Mine project.

Table 2.1: Agricultural legislation considered in the preparation of this assessment

Title of Agricultural legislation, policy or guideline	Date	Implications for proposed Balama Graphite Mine
		Mozambique Legislation
Constitution of the Republic of Mozambique, articles 109 and 111	2004	– All ownership of land is vested in the state. – The state shall recognize and protect land rights acquired through inheritance or by occupation, unless there is a legal reservation or the land has been lawfully granted to another person or entity.
Land Law No 19 of 1997	1997	– This law provides the legal framework for land ownership, as well as the control of land and natural resources in Mozambique. The process of determining land rights is also explained by this law.
Environmental Act No 20 of 1997	1997	– The objective of the Environment Law is to define the legal basis for judicious utilisation and management of the environment and its components, with a view to achieving sustainable development in the country
National Water Act No 7 of 1995	1995	– The project has the potential to significantly affect not only the reliability of water supply to the project's surrounding villages, but also the quality of this water.
Forest and Wildlife Act No 10 of 1999	1999	– This law bears relevance as the project will have significant impacts on the surrounding forest and natural resources. One of the main objectives of the law is to assist in conserving and utilising the forests and wildlife resources for the social, ecological and economic benefits of the future generations (Development Bank of Southern Africa, 2007). The law also identifies protected areas, including cultural and heritage sites.
		International Legislation
IFC Sector Specific Guidelines	2012	– The IFC is a member of the World Bank Group, and one of the largest development financing institutions that focuses exclusively on the private sector in developing countries (IFC, 2012). – The IFC its Performance Standard Guideline no'S 5 and 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources and Land Acquisition and Involuntary Resettlement) on Environmental and Social Sustainability is relevant for this study: • Protect and conserve biodiversity; and • Promote the sustainable management and use of natural resources through the adoption of practices that integrate conservation needs and development priorities.

3 DESKTOP ANALYSIS OF THE PROPOSED NEW MINING ENVIRONMENT

This section provides a short description of the current state of the natural environment of the proposed Balama Graphite Mine concession area in the Cabo Delgado Province of Mozambique.

3.1 Climate

Cabo Delgado Province has a tropical climate with two distinct seasons. The wet season occurs from November to March and the dry season from April to November. Specific weather data for the project area is not available. Climate data for Montepuez, the nearest town to the project site (93km away), was therefore used. Montepuez has a tropical climate and is also a winter rainfall region. The average annual rainfall is approximately 942.3 mm. The driest month is August/September with 0 mm - 2 mm. Most precipitation falls in January, with an average of approximately 246.4 mm (http://www.weatherbase.com).

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3.2 Geology

North-eastern Mozambique is predominantly underlain by Proterzoic rocks that form a number of gneiss complexes that range from Palaeo to Neoproterozoic in age (Boyd *et.al.,* 2010). The project site is underlain by metamorphic rocks of the Neoproterozoic Lurio Group that are included within the Xixano Complex.

The graphite layer is comprised of a sequence of metamorphosed carbonaceous politic and psammitic sediments within the Proterozoic Mozambique Belt (Figure 3.1). The sediments have been metamorphosed to graphitic schists (pelites) and graphitic sandstones (psammites).

In addition to the graphite, the prospect site has granite outcrops in the northeast. It appears that these are intrusive into the surrounding gneisses (Figure 3.1).

3.3 Topography

The study area is relatively flat to gently undulating with sporadic inselbergs (Mount Nassilala and Mount Coronge) rising from the flat plains (Figure 3.2). The altitudinal range varies from 480 to 830 meters above sea level (masl) with the highest point occurring on Mount Nassilala.

3.4 Surface hydrology

The Mehucua River flows through the southern section of the project site in a south-west to north-east direction (Figure 3.2). A few small wetlands occur in the project area, the most notable being a swampland located approximately 2 km south west of the proposed site and a wetland located approximately 7 km east south-east.

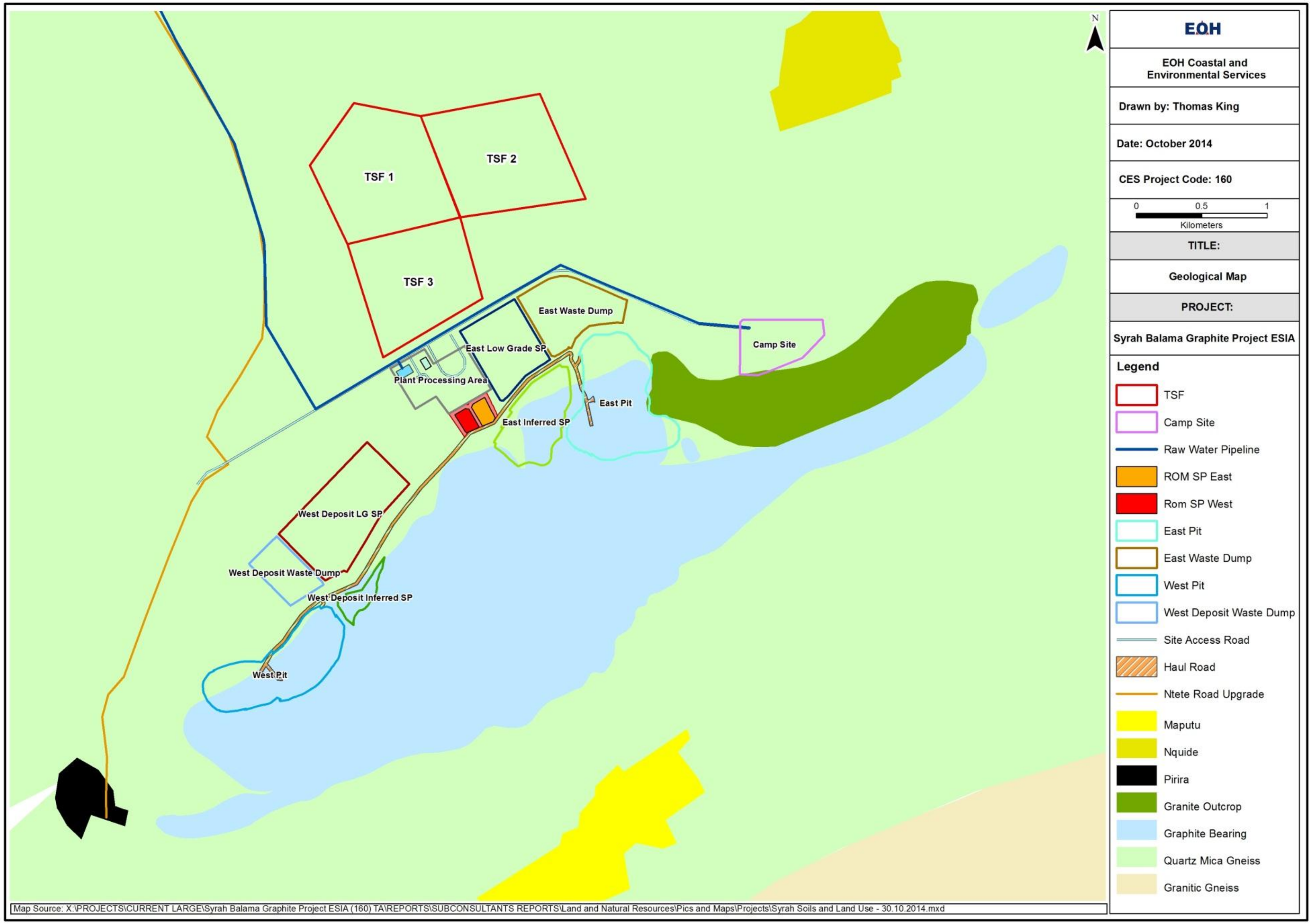

Figure 3.1: Detailed geological map of the area.

Figure 3.2: Topography of the area

4 SOILS

Most of the Syrah mining concession is underlain by red loam and sandy loam soils with high clay content soils found around the Mehucua River (Figure 4).

The mining area (i.e. area where mining activities will take place) varies between medium textured red soils in the west to sandy loam soils that are easily eroded located centrally and eastwards.

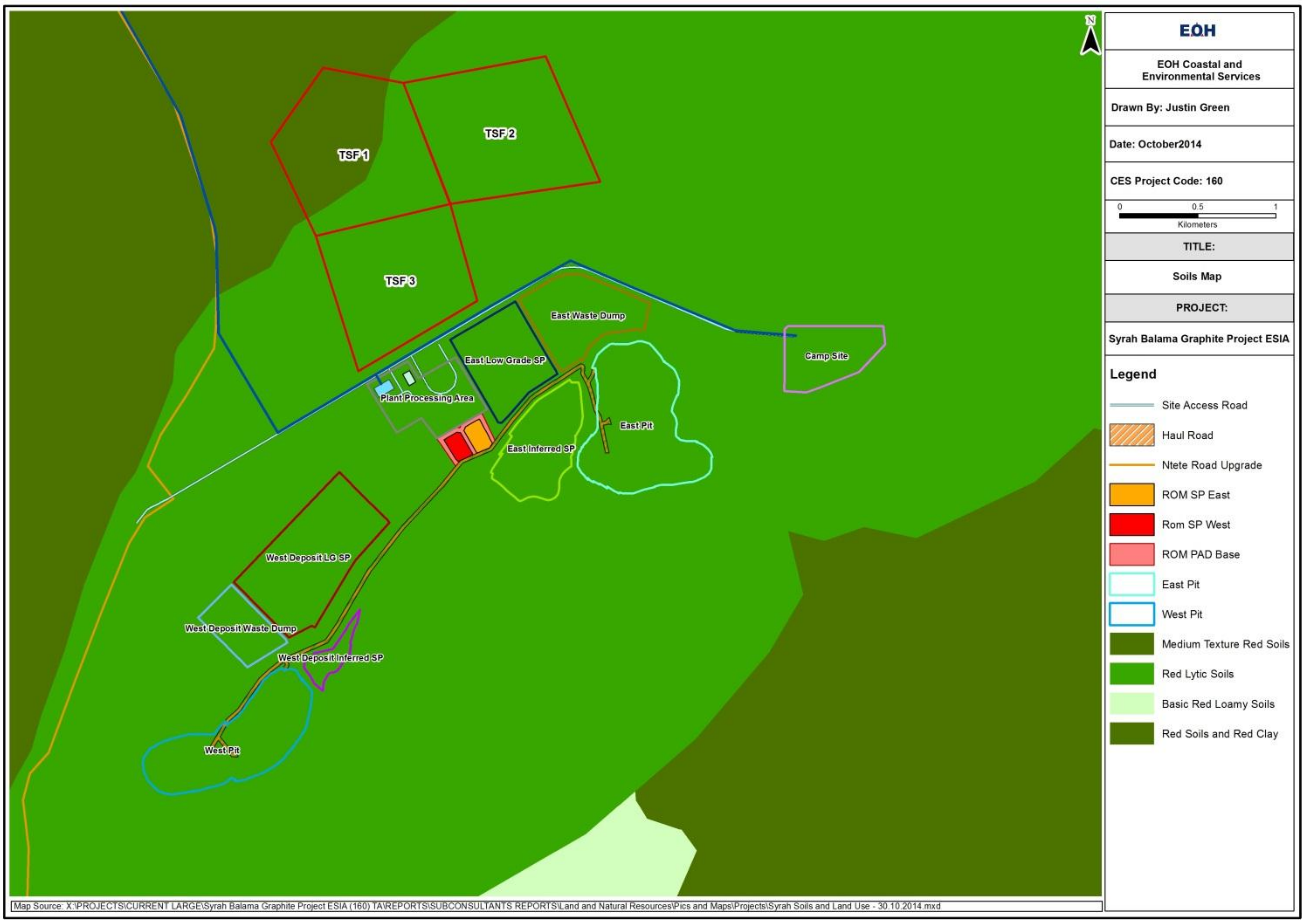

Figure 4.1: Soil types found within the mining concession area

Three exposed sites were assessed onsite to identify soil layers and verify soil characteristics (see Figure 4.2 below). The following procedure was followed in the identification of soils (as per the FAO Guidelines for soil description 4th ed., 2006):

1. the master horizons and layers present in the profile were demarcated
2. characteristics of each horizon were identified
3. soil groups were identified

4.1 Soil description (Visual classification)

This section presents the procedure to describe the different morphological and other characteristics of the soil. Firstly, the surface characteristics are recorded. Then a soil description is done horizon by horizon, starting with the uppermost horizon.

4.1.1 Soil profiles

Three exposed soil profiles were visually assessed across the study site (Figure 4.2).

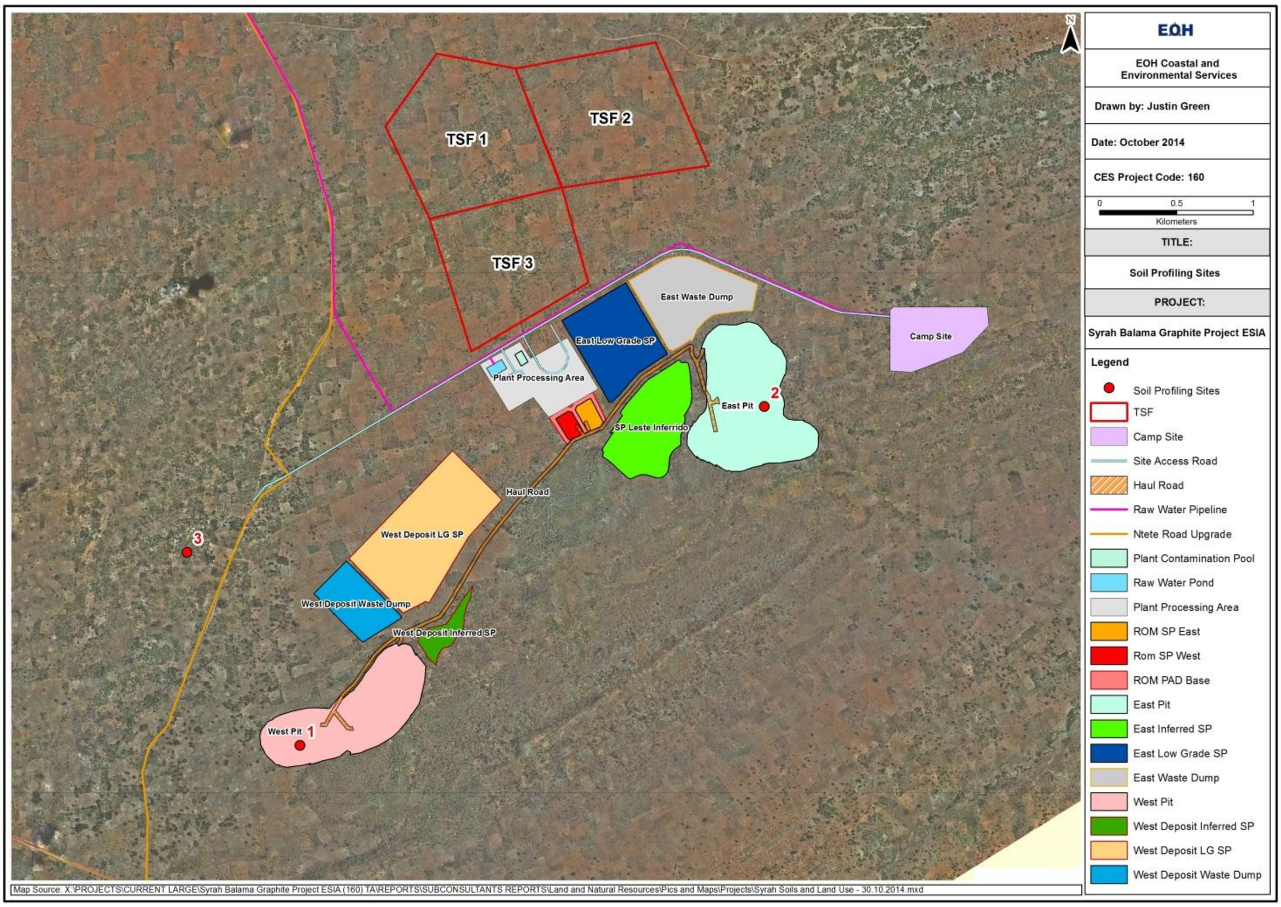

Figure 4.2: Locations of the 3 x soil profiling sites

The GPS coordinates for each profile site is shown in Table 4.1below.

Table 4.1: Coordinates for the soil profile sites.

Site #	GPS coordinates	
	X coordinate	Y coordinate
1	461615.00 m E	8526234.00 m S
2	464645.00 m E	8528463.00 m S
3	460860.00 m E	8527509.00 m S

4.1.2 Surface characteristics

The local landscape consists of a relative flat to low undulating topography with slopes ranging between 0 – 2% and covering up to 80% of the mine concession area surface. These areas are utilised for subsistence farming. Large termite mounds are scattered throughout the landscape while various gravel roads transect the site.

A linear surface in the southern regions of the mine concession area is characterised by inselbergs approximately >50m apart ranging between 480 and 830 masl in height with slopes ranging between 10 to >60%. These steep are covered by thick woodland vegetation (up to 80% cover) interspersed with exposed parent rock (up to 20% cover).

Table 4.2: Illustrating the different surface types found within the Syrah mining concession area.

The landscape is characterised by flat to low undulating plains containing sporadic inselbergs:	Agriculture dominates the flat plains:
	
Large termite mounds are scattered throughout the plains:	Various gravel roads transect the site:
	
The granitic outcrops contain large areas of bare rock	Thick, natural vegetation dominates the steep inselbergs.
	

4.1.3 Horizon boundaries

Horizon boundaries provide information on the dominant soil-forming processes that have formed the soil. In certain cases, they reflect past anthropogenic impacts on the landscape. Horizon boundaries are described in terms of depth, distinctness and topography (FAO, 2006).

Depth describes the distance between the upper and lower boundary for each horizon while the distinctness of the boundary refers to the thickness of the zone in which the horizon boundary can be located without being in one of the adjacent horizons (Table 4.3). The topography of the boundary indicates the smoothness of depth variation of the boundary.

Table 4.3: Classification of horizon boundaries, by distinctness and topography (Source: FAO, 2006)

Distinctness		(cm)	Topography		
A	Abrupt	0–2	S	Smooth	Nearly plane surface
C	Clear	2–5	W	Wavy	Pockets less deep than wide
G	Gradual	5–15	I	Irregular	Pockets more deep than wide
D	Diffuse	> 15	B	Broken	Discontinuous

Three main horizons were identified at Site 1, at Site 2 and at Site 3 (see Figure 4.3 - 4.5 below).

Table 4.4 below describes the different horizon boundaries.

Table 4.4: Description of the different horizon boundaries of each site.

Site #	Horizon	Depth (cm)	Distinctness	Topography
1.	1st horizon (Surface horizon)	50	Clear	Wavy
	2nd horizon	120	Abrupt	Smooth
	3rd horizon (Basal rock layer)	>200	Not determined	Not determined
2.	1st horizon (Surface horizon)	10	Clear	Irregular
	2nd horizon	30	Gradual	Irregular
	3rd horizon (Basal rock layer)	>100	Not determined	Not determined
3.	1st horizon (Surface horizon)	5	Abrupt	Smooth
	2nd horizon	60	Gradual	Smooth
	3rd horizon (Dry section)	30	Clear	Smooth
	3rd horizon (Moist section)	30	Not determined	Not determined

Figure 4.3: Showing the different horizons for Site 1.

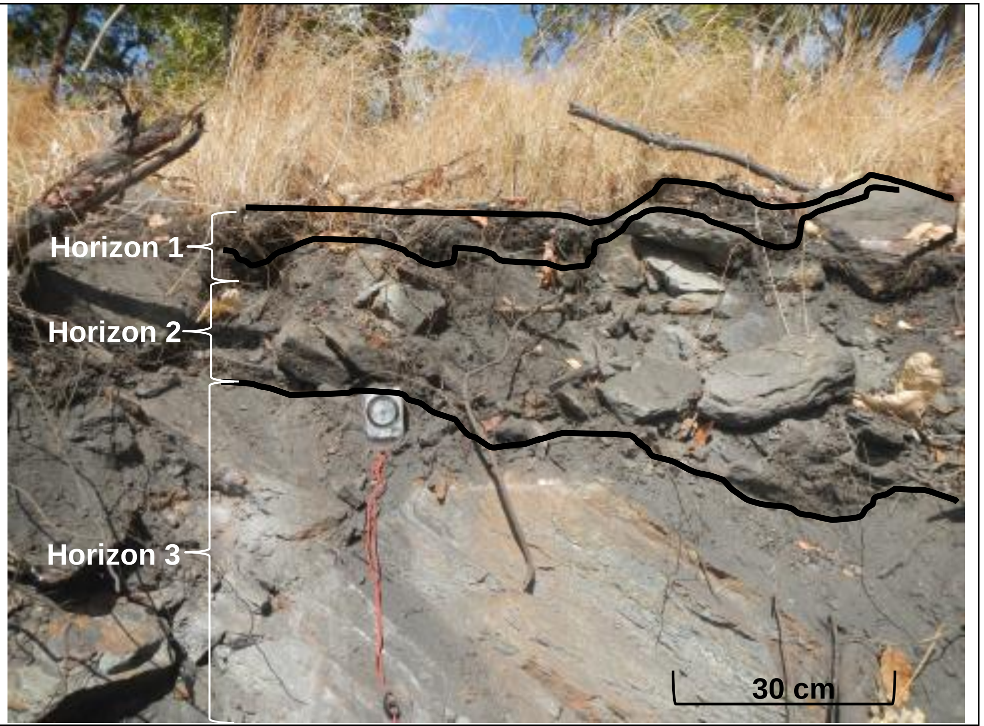

Figure 4.4: Showing the different horizons for Site 2.

Figure 4.5: Showing the different horizons for Site 3.

4.1.4 Soil horizon nature

This section presents the procedure on the description of soil texture and the nature of the primary rock and mineral fragments, which are subdivided into: (i) the fine earth fraction; and (ii) the coarse fragments fraction.

Fine earth fraction

Soil texture refers to the proportion of the various particle-size classes (or soil separates, or fractions) in a given soil volume.

Table 4.5: Description of the soil textures for each site.

Site #	Horizon	Texture	Classification
1.	1st horizon (Surface horizon)	Soil is moderately cohesive, adheres to the fingers, and has a rough and ripped surface after squeezing between fingers. Have moderate sand grains.	Loam
	2nd horizon		
	3rd horizon (Basal rock layer)	Soft rock	Graphite bearing soft rock
2.	1st horizon (Surface horizon)	Soil is moderately cohesive, adheres to the fingers, and has a rough and ripped surface after squeezing between fingers. Have moderate sand grains.	Loam
	2nd horizon		
	3rd horizon (Basal rock layer)	Hard rock	Rock
3.	1st horizon (Surface horizon)	Soil not floury, grainy, scarcely fine material in the finger rills, weakly shapeable, adheres slightly to the fingers.	Loamy sand
	2nd horizon		
	3rd horizon (Dry section)		
	3rd horizon (Moist section)		

Coarse fragments fraction

The presence of rock fragments influences the nutrient status, water movement, use and management of the soil. It also reflects the origin and stage of development of the soil.

Large rock and mineral fragments (> 2 mm) are described according to abundance, size, shape, state of weathering, and nature of the fragments (Table 4.6). Classification of each characteristic is described in Table 4.7 and Figure 4.6 below.

Table 4.6: Classification of large rock fragments by volume (Source: FAO, 2006)

Abundance:

		%
N	None	0
V	Very few	0–2
F	Few	2–5
C	Common	5–15
M	Many	15–40
A	Abundant	40–80
D	Dominant	> 80
S	Stone line	any content, but concentrated at a distinct depth of a horizon

Size:

	Rock fragments	(mm)
F	Fine gravel	2–6
M	Medium gravel	6–20
C	Coarse gravel	20–60
S	Stones	60–200
B	Boulders	200–600
L	Large boulders	> 600

Shape:

F	Flat
A	Angular
S	Subrounded
R	Rounded

Weathering:

F	Fresh or slightly weathered	Fragments show little or no signs of weathering.
W	Weathered	Partial weathering is indicated by discoloration and loss of crystal form in the outer parts of the fragments while the centres remain relatively fresh and the fragments have lost little of their original strength.
S	Strongly weathered	All but the most resistant minerals are weathered, strongly discoloured and altered throughout the fragments, which tend to disintegrate under only moderate pressure.

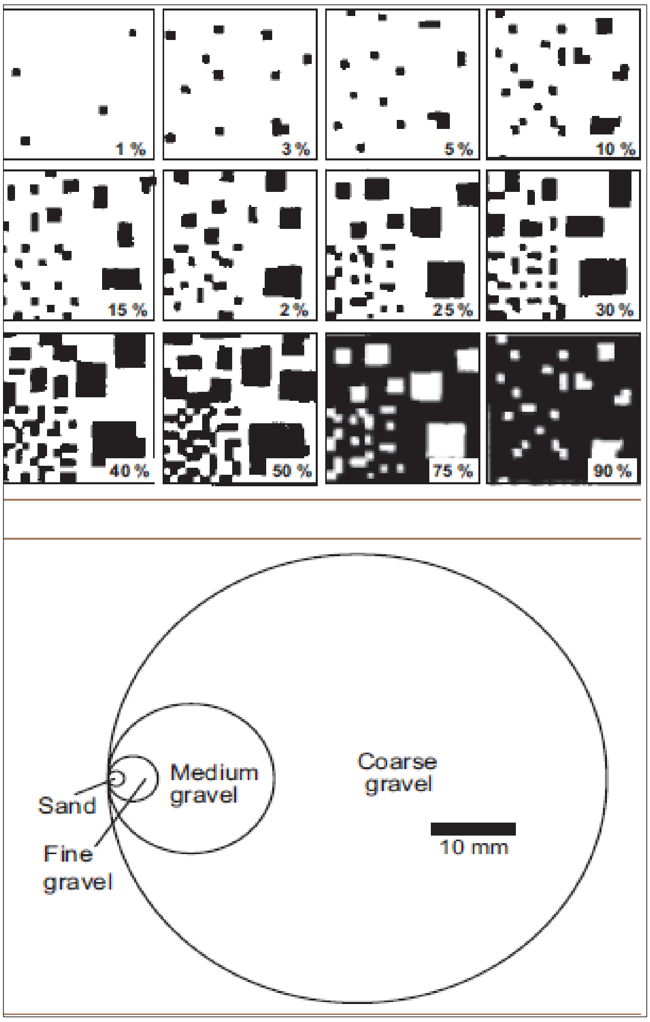

Figure 4.6: Charts for estimating proportions of coarse fragments and mottles. (Source: FAO, 2006)

Table 4.7: Description of the large rock and mineral fragments in each site.

Site #	Horizon	Abundance	Size	Shape	State of weathering	Nature
1.	1st horizon (Surface horizon)	Very few	Fine gravel	Subrounded to angular	Fresh or slightly weathered to weathered	Graphite rich metamorphic rock
	2nd horizon					
	3rd horizon (Basal rock layer)	Stone line				
2.	1st horizon (Surface horizon)	Very few	Fine gravel	Subrounded to angular	Fresh or slightly weathered to weathered	Metamorphic rock
	2nd horizon	Abundant	Course gravel and stones	Flat, angular	Fresh or slightly weathered to weathered	Metamorphic rock
	3rd horizon (Basal rock layer)	Stone line				
3.	1st horizon (Surface horizon)	None	N/A (Sand)	N/A (Sand)	N/A (Sand)	N/A (Sand)
	2nd horizon					
	3rd horizon (Dry section)					
	3rd horizon (Moist section)					

4.1.5 Soil colour

Soil colour reflects the composition as well as the past and present oxidation/reduction conditions of the soil. It is generally determined by coatings of very fine particles of humified organic matter (dark), iron oxides (yellow, brown, orange and red), manganese oxides (black) and others, or it may be due to the colour of the parent rock.

The colour of the soil matrix of each horizon was be recorded in dry conditions using the notations for hue, value and chroma as given in the Munsell Soil Color Charts (Munsell, 1975). Hue is the dominant spectral colour (red, yellow, green, blue or violet), value is the lightness or darkness of colour ranging from 1 (dark) to 8 (light), and chroma is the purity or strength of colour ranging from 1 (pale) to 8 (bright). Where there is no dominant soil matrix colour, the horizon is described as mottled and two or more colours are given.

Table 4.8: Description of the soil colour for each site.

Site #	Horizon	Hue	Value	Chroma
1.	1st horizon (Surface horizon)	Brown	3	2
	2nd horizon	Red	5	4
	3rd horizon (Basal rock layer)	Stone line		
2.	1st horizon (Surface horizon)	Brown	2	2
	2nd horizon	Brown	2	2
	3rd horizon	Stone line		

Site #	Horizon	Hue	Value	Chroma
	(Basal rock layer)			
3.	1st horizon (Surface horizon)	Red	2	2
	2nd horizon	Red	2	2
	3rd horizon (Dry section)	Red	4	4
	3rd horizon (Moist section)	Red	3	3

4.1.6 Visual soil horizon classification

Based on the characteristics classified in Section 4.1.5 above, the following Soil Groups (as described by the World Reference Base for Soil Resources (WRB; Deckers *et al*., 2000) were allocated for each sample (Table 4.9).

Table 4.9: Physical characteristics for each soil type.

Soil group	Description	Occurrence	Potential management
Red Arenosols	This soil group has a thin brown ochric surface horizon over deep subsoil. This group consists of sandy soils developed after *in situ* weathering of old, quartz-rich soil material or rock.	Approximately 80% of the mining concession area. Found on plains.	Soils are highly erodible with low water containing capacity. Sufficient storm water system must be developed.
Leptosols	These soil types accommodate very shallow soils over hard rocks. They are found in strongly eroded areas (like steep slopes). The A horizon is thin and has rich organic matter. For this reason, they have haplic characteristics. The pH is expected to be slightly acid.	Approximately 20% of the mining concession area. Generally on steep sloped inselbergs	Can be stripped to a depth of 30cm for material to be used for rehabilitation.

4.2 Soil description (Laboratory confirmation)

This section compares laboratory assessed soil samples collected onsite with the visual description in Section 4.1. This was done to confirm the soil classification made onsite (Section 4.1.).

4.2.1 Soil sampling

A qualitative survey method was undertaken during selection of the soil sample sites (as opposed to a quantitative grid survey approach). This was done based on the understanding of the landscape and outcome of the remote mapping exercise done during the desktop assessment. The Soil Distribution Map of the Balama District obtained from the Mozambique Government was used to predict the distribution of soil attributes in the field and 5 soil collection sites were selected (Figure 4.7). Soil was collected from each of these 5 sites for laboratory analysis.

Soil samples were send to Brookside Laboratories located in Heidelberg, Gauteng situated in South Africa for analysis (see Appendix A for results).

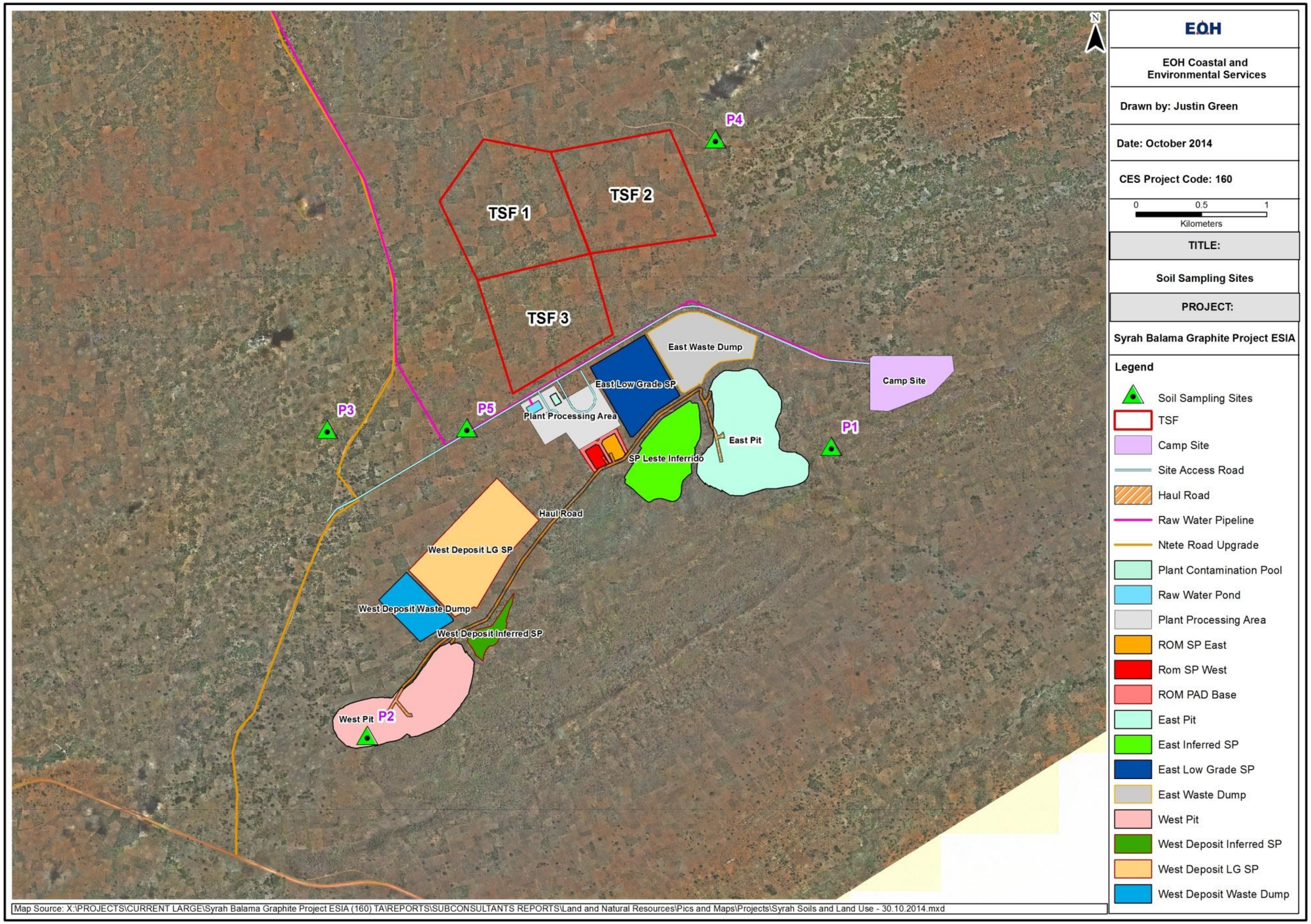

Figure 4.7: Locations of the 5 x soil sample sites

The GPS coordinates for each site is shown in Table 4.10 below.

Table 4.10: Coordinates for the soil sample sites.

Site #	GPS coordinates	
	X coordinate	Y coordinate
P1	465159.00 m E	8528408.00 m S
P2	461602.00 m E	8526192.00 m S
P3	461296.00 m E	8528536.00 m S
P4	464270.00 m E	8530763.00 m S
P5	462365.00 m E	8528548.00 m S

4.2.2 Laboratory results

Soils found on the flat plain landscape (P2-P5) had an average pH of 6.1 compared to soils on the sloped area at Site P1. Here soils are more acidic with a pH of 5.1. This is to be expected as the outcrop is of a granitic origin and is considered a more acidic parent rock for soils on these slopes.

Organic matter concentrations are contrasting when comparing soils on the sloped areas (P1 where the soil humus content is 2.43%) to soils on the plains (P2-P5 where the soil humus content is 0.88%). The low organic humus percentage may be due to a high erosion potential combined with traditional agricultural methods (slash-and-burn clearing, incorrect cropping etc.) practiced on the plains.

5 AGRICULTURE

5.1 Agriculture in Mozambique

Mozambique has experienced rapid economic growth over the last decade or more with a 7.2% GDP growth for agriculture from 2003-2010. Also, close to 80% of the adult population is employed in the agricultural sector. Despite this growth, poverty remains high and is concentrated in rural areas where many households derive their income from traditional agricultural activities.

There are about 36 million hectares of arable land in Mozambique, suitable for agriculture. At present, only 10% of the arable land (3.9 million hectares) is under cultivation. The remainder of the area is under pastures (44 million ha) and forest /woodlands (30.7 million ha). About 118,000 hectares are equipped for irrigation, covering 3% of the potential land (FAO Statistic Yearbook 2010 & Food and Agriculture Organization, Emergency Mozambique Fact Sheet).

Animal husbandry is an underdeveloped sector. Cattle, goats, sheep and pigs are reared in back-yard scavenger systems. There is a small fast-growing modern poultry industry. In 2009, livestock accounted for 1.2 million of head of cattle, 4.5 million sheep and goats, 1.3 million pigs, and 18 million poultry. Beef production was estimated at 22,000 tons; pig meat, 91,000 tons; poultry meat, 22,000 tons; cows' milk, 75,000 tons; and hen eggs, 14 million (FAO Statistic Yearbook 2010; Mozambique at a glance). The high prevalence of disease is the main constraints undermining an increase in livestock numbers in the Northern provinces. Newcastle disease affects poultry, tsetse flies affect cattle, and African swine fever affects pigs.

5.2 Agriculture in the mining concession area

With all agricultural production in the region being rain-fed, weather variability is a major factor in determining crop performance and is the main reason the growing season starts with the first rains in December. There is also a minor growing season, based on residual soil moisture, from March to July, accounting for approximately 10% of total output.

Agriculture is based on self-subsistent small, hand-cultivated units (called a *mashamba*) averaging 1.2 hectares in size. One farmer may hold multiple *mashambas*, containing multiple crops consisting of traditional varieties that are rain-fed, with low intensity fertiliser and pesticide control used and little or no mechanization resulting in low productivity. Most households diversify to cope with low productivity and income. The majority practice extensive shifting cultivation, only about one-third sell any crop output, and almost two-thirds live in households that lack food security (The World Bank Report, 2006)

Food crop production is the most important agriculture sub-sector accounting for around 80% of the cultivated area (The World Bank Report, 2006). Maize and cassava are the major staples; other food crops include sorghum, millet, rice, beans, groundnut, sweet potatoes and a wide variety of vegetables. Maize occupies about 35% of total planted area in the Cabo Delgado Region. Cassava is an important component of the farmer's risk reduction strategy because it is drought tolerant and resistant to disease. Groundnut is cultivated on sandy soils and makes an important contribution to household diet and income. The main cash crops are cotton, sesame, sugar. Tree crops, especially coconut and cashew are an important source of cash generation, and contribute to household food security (Special Report FAO/WFP, 2010)

The use of modern technologies and irrigation facilities is limited to a small number of commercial farms growing cash crops and vegetables and to out-growers of cotton-producing crops on contract. None of these sites are located within the mining concession area.

5.3 Site assessment

A field survey was conducted on the 8-17th July 2013 in order to assess the agricultural practises onsite. The site was visually assessed while various group discussions were held with local farmers.

Simple subsistence farming (also known as shifting cultivation or '*slash-and-burn'* agriculture) is practised within the mine concession. This is where sector farmers grow food only for themselves and their families. The sites (called *mashambas)* were probably selected many years ago when the area was covered by natural woodlot. These *mashambas* are cleared by fire and the ashes add to the fertility of the soil. Trees not burnt are cut down or left. These *mashambas* are small (1.2ha on average). "*Field rotation"* rather than "*crop rotation*" is typically practised and multi-cropping is common. Field rotation happens regularly, followed by long periods of fallowing (±10 years) where the *mashamba* left to regrow natural vegetation. Because of increasing population densities, fallow periods are shortened resulting in an increased pest potential and nutrient poor soils. Cultivation is supplemented by fishing and gathering fruits.

5.3.1 Cash crops

The main cash crops in the area are cotton, groundnuts and cashews. Cotton is grown under contract while groundnuts and cashews are smallholder crops. Food crops are grown as inter-crops with these cash crops.

There is a major gap between potential and actual yields in seed cotton. Yields in Mozambique are significantly constrained by a lack of high-yielding, pest-resistant varieties adapted to local agro-climatic conditions. Yields average 0.6 tons per hectare compared to 0.9 in Zimbabwe and over 1.0 in West Africa.

Cashew trees are often old and diseased. The most recent plantings date from the 1950s and 1960s, and average yields are only 1.5-3.0 kilograms per tree, whereas the potential can be as high as 10-15 kilograms. One-quarter of the national stock of about 25-26 million old trees is attacked by powdery mildew (*Oidium* sp.) and other diseases, which reduces yields by as much as 70%. During the dry season trees are damaged by fire. These problems not only affect yield, but also reduce quality (World Bank 2006, Mozambique Agricultural Development Strategy).

5.3.2 Food crops

As mentioned earlier, to ensure household food security, most cultivated land is used to grow low-value maize and cassava (more than 50% of the total land). In the remaining area, smallholders diversify with a wide variety of other food crops. Yields are low and show stagnant patterns.

Various fruit trees as well as vegetable plots were also found on the project site which provide additional sources of food.

Table 5.1: Main food crops grown in the Balama District

Food crops	Fruit trees found onsite	Vegetables
Cassava, maize, rice, sorghum, sweet potatoes, beans (mungbean), millet	Banana, mango, pawpaw, orange, coconut	Tomatoes, onions, cabbage, lettuce, carrots

5.3.3 Livestock

Although livestock make significant contributions to the livelihood of smallholders and the rural poor, the number of livestock found onsite was very low. The highest concentration of livestock within the mining concession was found within and close to villages. Livestock observed included chickens, ducks, pigs, goats and cattle.

Several constraints undermine an increase in livestock numbers, mainly a high prevalence to disease. For example, Newcastle disease is a major problem for poultry, tsetse flies affects cattle, and African swine fever affects pigs. In addition, the inadequacy of animal husbandry services is a common problem because extension services do not cover the district. The ability of communities to expand grazing for cattle is restricted by the availability and variability in pasture quality, access to water and veterinary services. There are some conflicts between crop agriculture and livestock, especially under drought conditions and when the animals are large (like cattle). Where there are crops nearby, animals need to be tethered to reduce the possibility of conflict. The lack of access to financial support and credit facilities is a problem in crop agriculture and also undermines the livestock sector. Poor families cannot raise credit to purchase animals, and women in particular have difficulty accumulating livestock. If widowed, they are stripped of all family assets upon the death of their husbands, including family animals.

Below is a photo sequence of agricultural activities found within the Syrah Balama mining concession.

Table 5.2: Showing the various types of agricultural activities found within the concession.

<table>
<tr><td colspan="2">Sleeping huts of various qualities are found scattered throughout the mining concession.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Most mashambas only consists of crop areas with no sleeping huts.</td></tr>
<tr><td></td><td></td></tr>
</table>

Fallow land is overgrown with fast-growing scrubs, grasses & woody climbers. Larger trees are either left or chopped down.

Cash crops include cotton and groundnuts.

Cotton:

Groundnuts:

Foodcrops include maize, cassava, mungbeans:

Mungbeans:

Harvested cassava:

5.4 Agricultural potential

Based on soil analysis in Section 4, the Syrah Balama mining concession is dominated by moderate potential soils (shallow soils on steep slopes & sandy loam on the plains). Much of the flat plains are currently covered by agricultural activities.

Based on characteristics identified in Section 4, the proposed Syrah Balama mine concession area is considered as **moderate agricultural potential for crop cultivation** and **moderate for livestock grazing**. Factors limiting agricultural potential are:

- Steep slopes in up to 20% of the area
- Limited surface water in the northern flat plains
- Unsustainable agricultural methods (e.g. traditional slash-and-burn agriculture)
- Limited access to agricultural infrastructure (e.g. irrigation equipment)

5.5 Recommendations

Based on soil types and identified biophysical attributes of the local area, the following agricultural recommendations are made:

- A conservation agriculture approach is recommended. This can be achieved through basic training to ensure the affected communities become self-sufficient in generating high protein foods as well as cash liquidity. The traditional slash-and-burn practices that deplete soil nutrition should be altered so that less land could be used more efficiently. Agriculture could then, with correct rotations and cropping programmes, ensure better food security and more stable employment conditions for the local farmers.
- The following crops are recommended:
    - Peanuts - high protein and a legume crop.
    - Beans & peas (Sugar beans, Pigeon Pea and Cow Peas) - high protein and a legume crop.
    - Sesame - cash crop that is drought resistant and grows well in most soil types.

  All these crops can be grown through intercropping with more traditional crops like cassava and maize.

6 LAND AND NATURAL RESOURSE USE

6.1 Current land use

Land use in the project area is primarily for subsistence agriculture. Crops such as maize, cotton and cassava are grown on the flat areas which are cleared using traditional slash-and-burn techniques. Some small livestock (chickens, geese, goats etc.) is reared in and around the villages.

Arial images show areas of high agriculture (where more than 50% of the land currently contains crops) and areas of low agriculture (where less than 50% of the land currently contains crops). These areas were plotted on a map to illustrate their extent (Figure 6.1).

6.2 Current land cover

The current land cover of the Syrah Mining concession area is defined as naturally occurring Miombo Woodland located on steep sloped inselbergs, surrounded by agricultural fields situated on flat plains surrounding the undulating inselbergs (Figure 1.2).

Areas of high and low agriculture were identified. High agriculture areas are areas where more than 50% of the local areas contain crops while low agriculture areas contain less than 50% crops per area.

Three large villages are found within the concession area namely Maputu, Pirira and Nquide. These villages are connected through existing gravel roads.

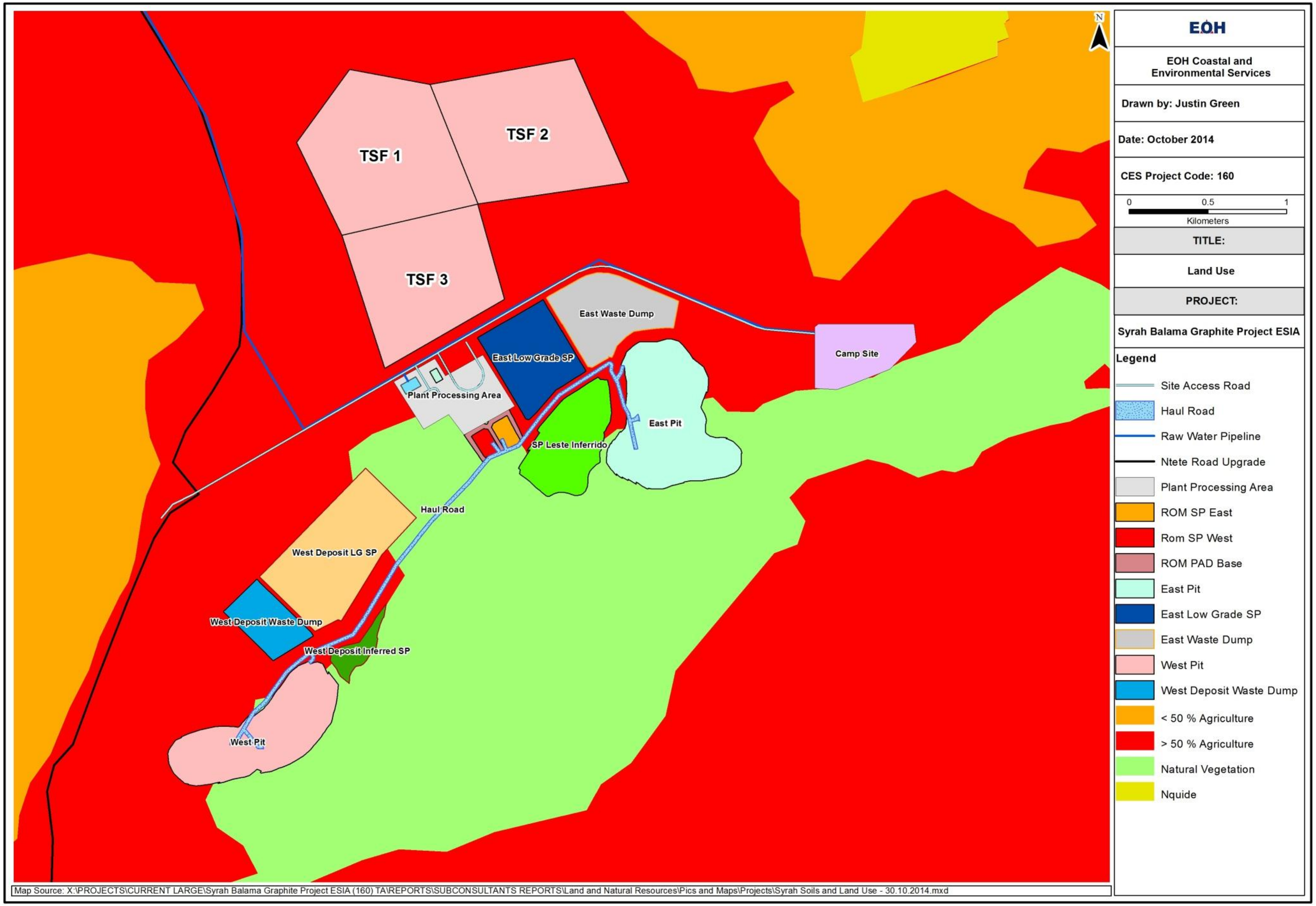

Figure 6.1: Current land cover of the mining concession area.

Various rivers and streams transect the site but are mostly concentrated to the southern and south-western parts of the concession area. The main river (Mehucua River) is situated in the south-eastern section of the mining concession and flows in a south-westerly direction.

6.3 Current natural resource use

Natural resources are defined as materials and components that occur naturally within the environment. A natural resource may exist as a separate entity such as fresh water, and air, as well as a living organism such as a fish, or it may exist in an alternate form which must be processed to obtain the resource such as metal ores, oil, and most forms of energy.

Various meetings were held with local farmers during the site visit dated 8-17th July 2013 to confirm current natural resource use. Various uses were also observed onsite.

Natural resources currently used in the local inhabitants in the Syrah Balama concession include:

- Water
- Wood
- Medicinal and foodplants
- Grasses
- Soil and mud

6.3.1 Water

Water (for both daily consumption and for agricultural activities) is a scarcity in the local area for most of the year. Some water is collected at existing streams but most water is collected from boreholes (groundwater source). Groundwater capacity is heavily utilised in the 7 months of dry season (April to October) and then only replenished during the 5 months of wet season (November to March).

6.3.2 Wood

Wood is considered as an important commodity as it is used for both fuelwood and as a building commodity. Fuelwood is collected regularly (every 2nd week on average per household) and households may even trade with fuelwood.

Wood in its unprocessed form (eg. tree branches) is also used as a building commodity for building new huts. Processed wood (cut wooden planks) is rarely used. Various types of furniture are also made from locally collected wood with some being sold at the local markets for cash.

Tree harvesting for small scale charcoal production is evident in the area, but only associated with newly cleared woodland areas. These cleared areas have been cleared by slashing and burning of the natural vegetation for crop farming by the local farmers.

6.3.3 Fruit

The local markets provide evidence that harvesting of wild food and medicinal plants are occurring at the site. These plants are used by the local communities for personal use and are also sold, providing a source of income.

Various naturally occurring fruit trees are found onsite. Most of these trees are introduced species which now grow wild. Fruit trees found onsite include:

- Paw-paw
- Mango
- Orange
- Banana

- Coconut

Medicinal plants used include:

Plant name	Common name
Colophospermum mopane	Mopane
Cucumis sp.	Kiwano
Elephantorrhiza elephantina	Chizezepasi/Elephant-root
Cassia abbreviata	Isihaqa
Cissus quadrangularis	Murunjurunju
Maerua edulis	Katunguru
Secamone parvifolia	Nyokani
Terminalia sericea	Mangwe
Gymnosporia heterophylla	Xivambulani

6.3.4 Grasses

Local growing thatch grass (*Hyparrhenia hirta*) is collected once a year (around September when the grass is dry) to build and fix up existing roofs for huts. Most infrastructures are built with these thatch roofs and required regular (yearly) maintenance.

6.3.5 Soil and mud

Dry soil is collected and mixed with water to create mud. Huts are build and maintained using this mud. Few brick houses are found onsite.

7 IMPACT IDENTIFICATION AND ASSESSMENT

7.1 Introduction

This chapter identifies the potential impacts (both negative and positive) of the proposed project on the natural and agricultural environments as well as impacts on soils found in the Syrah Graphite Mine concession. By so doing, it provides mitigation for the mine to reduce possible project-induced negative impacts, but also to enhance the positive impacts of the project. These impacts have been identified after conducting a site visit, as well as from a desktop study of the project site.

The impacts in this chapter are listed in no particular order. Each impact has been aggregated into several issues. Each issue (as a heading) has a common theme and management strategy at its core.

7.2 Methodology

Four factors need to be considered when assessing the significance of impacts, namely:

1. Relationship of the impact to **temporal** scales - the temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.

2. Relationship of the impact to **spatial** scales - the spatial scale defines the physical extent of the impact.

3. The severity of the impact - the **severity/beneficial** scale is used in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system (for ecological impacts) or a particular affected party.

4. The **likelihood** of the impact occurring - the likelihood of impacts taking place as a result of project actions differs between potential impacts. There is no doubt that some impacts would occur (e.g. loss of vegetation), but other impacts are not as likely to occur (e.g. vehicle accident), and may or may not result from the proposed development. Although some impacts may have a severe effect, the likelihood of them occurring may affect their overall significance.

Each criterion is ranked according to Table 7.1 to determine the overall **significance** of an activity. The criterion is then considered in two categories, viz. effect of the activity and the likelihood of the impact. The overall significance of the impact is determined using Table 7.2. The overall significance is either negative or positive.

The severity of impacts can be evaluated with and without mitigation in order to demonstrate how serious the impact is when nothing is done about it. The word ‘mitigation’ means not just ‘compensation’, but includes concepts of containment and remedy. For beneficial impacts, optimization means anything that can enhance the benefits. However, mitigation or optimization must be practical, technically feasible and economically viable.

The ***environmental significance*** scale is an attempt to evaluate the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the person making the judgment. For this reason, impacts of especially a social nature need to reflect the values of the affected society.

Prioritising

The evaluation of the impacts, as described above is used to prioritise which impacts require mitigation measures.

Negative impacts that are ranked as being of “**VERY HIGH**” and “**HIGH**” significance will be investigated further to determine how the impact can be minimised or what alternative activities or mitigation measures can be implemented. These impacts may also assist decision makers i.e. numerous **HIGH** negative impacts may bring about a negative decision.

For impacts identified as having a negative impact of "**MODERATE**" significance, it is standard practice to investigate alternate activities and/or mitigation measures. The most effective and practical mitigations measures will then be proposed.

For impacts ranked as "**LOW**" significance, no investigations or alternatives will be considered. Possible management measures will be investigated to ensure that the impacts remain of low significance.

Table 7.1: Ranking of evaluation criteria

EFFECT	**Temporal Scale**	**Description**	
	Short term	Less than 5 years	
	Medium term	Between 5-20 years	
	Long term	Between 20 and 40 years (a generation) and from a human perspective also permanent	
	Permanent	Over 40 years and resulting in a permanent and lasting change that will always be there	
	Spatial Scale		
	Localised	At localised scale and a few hectares in extent	
	Study Area	The proposed site and its immediate environs	
	Regional	District and Provincial level	
	National	Country	
	International	Internationally	
	Severity	**Severity**	**Benefit**
	Slight	Slight impacts on the affected system(s) or party(ies)	Slightly beneficial to the affected system(s) and party(ies)
	Moderate	Moderate impacts on the affected system(s) or party(ies)	Moderately beneficial to the affected system(s) and party(ies)
	Severe/ Beneficial	Severe impacts on the affected system(s) or party(ies)	A substantial benefit to the affected system(s) and party(ies)
	Very Severe/ Beneficial	Very severe change to the affected system(s) or party(ies)	A very substantial benefit to the affected system(s) and party(ies)
LIKELIHOOD	**Likelihood**		
	Unlikely	The likelihood of these impacts occurring is slight	
	May Occur	The likelihood of these impacts occurring is possible	
	Probable	The likelihood of these impacts occurring is probable	
	Definite	The likelihood is that this impact will definitely occur	

Tables 7.2 and 7.3 below provide the social significance of each impact:

Table 7.2: Matrix used to determine the overall significance of the impact based on the likelihood and effect of the impact.

		Effect													
		Slight			Moderate				Severe				Very Severe		
Likelihood	**Unlikely**														
	May Occur														
	Probable														
	Definite														

Table 7.3: Description of socio-environmental significance ratings and associated range of scores.

Significance Rate	Description	
Low	An acceptable impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in either positive or negative medium to short term effects on the social and/or natural environment.	
Moderate	An important impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in either a positive or negative medium to long-term effect on the social and/or natural environment.	
High	A serious impact, if not mitigated, may prevent the implementation of the project (if it is a negative impact). These impacts would be considered by society as constituting a major and usually a long-term change to the (natural &/or social) environment and result in severe effects or beneficial effects.	
Very High	A very serious impact which, if negative, may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts cannot be mitigated and usually result in very severe effects, or very beneficial effects.	

A Summary of Impacts and Issues Identified.

Issue Number	Issue	Impact
1	Impacts on soils	Construction Phase: 1.1 Removal of topsoil and soil erosion 1.2 Soil contamination Operation Phase: 1.1 Soil contamination
2	Impacts on agriculture	Construction Phase: 2.1 Disturbance to existing soil profile will result in a decrease in agricultural capability 2.2 Loss of agricultural land due to establishment of mine infrastructure 2.3 Loss of subsistence crops due to establishment of mine infrastructure Operation Phase: 2.1 Possible contamination of groundwater through leaching of

		toxic materials from TSF
3	Impacts on natural resources	Construction Phase: 3.1 Construction of mine infrastructure may result in a permanent loss of fruit trees, wood sources and other natural resources.

7.3 Impact Assessment

7.3.1 Construction Phase

Issue 1: Impacts on soils

Impact 1.1: Removal of topsoil and soil erosion

Cause and Comment:

The construction of the haul road, ancillary road and other associated infrastructure requires bulk earth works and moving quantities of soil in order to build the roads and other infrastructure such as the landfill site. A cut-to-fill method is mostly employed where some areas are excavated and others filled-up in order to achieve final levels. The excavation of areas require the removal of vegetation and the stripping of topsoil layers and, in many cases, also the sub-topsoil layers. The removal of topsoil and bulk earthworks can lead to soil erosion.

Mitigation Measures:

- All topsoil to be stockpiled and replaced as a final graded layer over the subsoil contouring;
- Contoured new haul road to assist in dispersing water run-off instead of concentrating it and increasing the risk of erosion;
- Rehabilitation of disturbed areas to be undertaken progressively during the construction phase.
- Divert water flow around cleared areas to minimise the amount of runoff crossing over exposed areas by using berms, with temporary or permanent drainage ditches.
- Design access roads to be no wider than necessary to accommodate the immediate anticipated use.
- Minimise the alteration to topography.
- Minimise the area of impervious surfaces.
- Grade impervious surfaces to drain into vegetated areas.
- Ensure fine materials being transported are covered with tarps or equivalent material.
- Construct sediment control dams and silt fences.

Significance Statement:

Without mitigation, the soil structure of the area will be damaged and possibly compromised over the short term. The severity of the impact will be severe, while the risk of such impact is probable.

Since the proponent is committed to implementing the mitigation measures listed above, the effects will be short term, local in scale and have a moderate impact. These impacts will only take place during the construction phase.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Short Term	Study Area	Severe	Probable	**MODERATE**
With Mitigation	Short Term	Localised	Moderate	May Occur	**LOW**

Impact 1.2: Soil contamination

Cause and Comment

Leakages and spillages from storage areas and construction vehicles could have a negative effect on the pH and salinity of the soil.

Mitigation measures:

- Design and implement a Hydrocarbon Management Operating Procedure. Copies of this document to be made available at designated facilities where hydrocarbons are used or stored. The purpose of this procedure is to provide for the proper storage and handling of hydrocarbons, including waste hydrocarbons, on site and hence prevent any form of contamination;
- Soil contaminated with hydrocarbon will immediately be removed and disposed of at a soil bioremediation facility to be established on site;
- All staff must be trained on the correct management of bunded facilities, including the discharge of collected liquids;
- Spill kits will be readily available at strategic points throughout the site and staff to be trained on the correct use of these kits;
- Prevent spillage and seepage of contaminants at all times through the implementation of good housekeeping and management procedures.
- Define a monitoring program in the EMP.
- Implement remedial measures in the case of accidents.
- Storage facilities will be adequately bunded and inspected on a regular basis.
- Workshops and fuelling areas to have drainage to a sump with a hydrocarbon separator.

Significance Statement:

The impact of contamination from existing storage infrastructure is considered short to medium term at a localised scale. The issue is considered moderate to severe and of **MODERATE** significance. It is probable that the impact will occur. Since the proponent is committed to implementing the mitigation measures listed above, the impact will be of LOW significance.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Short term	Study Area	Moderate to Severe	Probable	**MOD -**
With Mitigation	Short term	Localised	Slight	May Occur	**LOW**

Issue 2: Impacts on Agriculture

Impact 2.1: Disturbance to the existing soil profile will result in a decrease in agricultural capability

Agricultural capability describes the potential for agriculture in a specific area as well as limitations or special management practices needed to improve soil, such as topography, stoniness, soil moisture deficiency, low fertility, etc. Good agricultural lands have ideal climate and soil to allow a farmer to grow the widest range of crops, while non-arable lands (including woodlands and bush) have low potential for soil bound agriculture.

Because urbanisation (including industries like mining) change the agricultural landscape, the agricultural capability of that area is therefore also changed.

Levelling of the site and excavations for the construction and subsequent mining as well as associated mining infrastructure will disturb the existing soil profile. If topsoil becomes buried, or the subsoil and rock, that is less suitable for root growth, remains at the surface, the agricultural capability of the soil that will become available for agriculture again after decommissioning of the mining activities will be reduced.

Mitigation Measures:

- Strip and stockpile top soil to be retained for re-spreading over disturbed surfaces during rehabilitation. The Environmental Control Officer (ECO) to determine topsoil depth prior to stripping.
- ECO to monitor all excavations to ensure excavations are backfilled with subsoil first and then spread with topsoil.
- ECO to monitor depth and cover of topsoil spreading during rehabilitation.

Significance Statement:

Without proper soil management the possibility of a decrease in agricultural capability is high and the resultant impact may be HIGH negative during the construction phase. Since the proponent is committed to implementing the mitigation measures listed above the impact will be MODERATE negative.

Impact	**Effect**			**Risk or Likelihood**	**Overall Significance**
	Temporal Scale	**Spatial Scale**	**Severity of Impact**		
Without Mitigation	Permanent	Study Area	Moderate to Severe	Probable	**HIGH -**
With Mitigation	Long Term	Localised	Slight	May Occur	**MOD -**

Impact 2.2: Loss of agricultural land due to establishment of mining infrastructure

Cause and Comment:

Current agriculture within the concession area is based on subsistence level, hand-cultivated units (called a *mashamba*) averaging 1.2 hectares in size. One farmer may hold multiple *mashambas*, containing multiple crops consisting of traditional varieties that are rain-fed, with low intensity fertiliser and pesticide control used and little or no mechanization resulting in low productivity.

The occupation of the land by mining infrastructure will exclude agricultural use of that land for the duration of the project starting in the construction phase.

Land use is largely limited by available water and current agricultural methods, requiring larger than normal parcels of land to obtain sufficient yields. Thus, under the current agricultural practice land is in short supply and the loss of parcels of agricultural land will have very little impact on the total agricultural potential of the region.

Mitigation Measures:

- Utilise the IFC PS 5 to develop a RAP to include a detailed agricultural valuation of all the affected farmlands and owners' possessions to outline appropriate compensation strategies and entitlement matrixes; and
- Develop livelihood restoration strategies aimed at assisting households with re-establishing and improving their livelihoods. As the villagers are primarily involved in subsistence agriculture, it makes sense to provide agricultural support and/or training as a livelihood restoration strategy. Options include supporting the cotton and maize production capacity of the area by investing in market access, seed provision and agricultural training programmes. A key focus of such programmes needs to be the empowerment of vulnerable children and youth, as well as women (especially female-headed households).

Significance Statement:

Without mitigation, the impact will be VERY HIGH during the construction phase and will be permanent in nature and very severe. After mitigation the impact will be MODERATE due to the reduction in the temporal scale and the severity.

Although this impact takes place during construction, it is a permanent impact. It should be noted that the proponent is committed to implementing the mitigation measures listed and the mitigation measures must be in place prior to the commencement of construction.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Permanent	Study Area	Very Severe	Definite	VERY HIGH -
With Mitigation	Long Term	Localised	Moderate	Definite	MOD -

Impact 2.3: Loss of subsistence crops due to establishment of mining infrastructure

Cause and Comment:

The occupation of the land by mining infrastructure will result in the loss of various subsistence and cash crops currently grown on the land. This includes maize, beans, cassava, cotton and ground beans.

Mitigation Measures:

- The same mitigation measures as presented above (for impact 2.2) apply to this impact.

Significance Statement:

Without mitigation the impact will be considered to be VERY HIGH as the loss of a single season of crops will severely compromise the local communities food security, however with the implementation of the strategies developed as part of the RAP, the impact is considered to be LOW.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Permanent	Study Area	Very Severe	Definite	VERY HIGH -
With Mitigation	Short Term	Localised	Moderate	Definite	LOW -

Issue 3: Permanent loss of natural resources

Natural resources are defined as materials and components that occur naturally within the natural environment. A natural resource may exist as separate entities such as fresh water and air, as well as living organisms such as animals or fish, or it may exist in an alternate form which must be processed to obtain the resource such as metal ores, oil, and most forms of energy.

Natural resources currently used in the Syrah Balama concession include:

– Water
– Wood
– Medicinal and foodplants

– Grasses
– Soil and mud

Impact 3.1. Construction of new mining infrastructure may result in permanent loss of fruit trees, wood sources and other natural resources.

Cause and comment

Approximately 350 ha of vegetation will be cleared for the construction of the mine and associated infrastructure This will result in significant impacts on natural resource use since these resources provide households with building materials, food, medicine and income (i.e. charcoal production).

Mitigation and enhancement management

- A RAP has been drafted to include a detailed agricultural valuation of all the affected farmlands and owners' possessions in order to develop appropriate compensation strategies and entitlement matrixes; and
- Livelihood restoration strategies will be considered, aimed at assisting households with re-establishing and improving their livelihoods. As the villagers are primarily involved in subsistence agriculture, it makes sense to provide agricultural support and/or training as a livelihood restoration strategy. Options include supporting the cotton and maize production capacity of the area by investing in market access, seed provision and agricultural training programmes. A key focus of such programmes needs to be the empowerment of vulnerable children and youth, as well as women (especially female-headed households).
- Villagers will have controlled access to the proposed mining area prior to clearing commencing to harvest all available resources.
- The implementation of measures that would allow local residents to access the forest resources that are cleared will also help to meet local needs and reduce the pressure on the remaining forest resources in the short term.
- Any rehabilitation programmes will involve a stakeholder engagement process to determine the needs of the local communities and how these can be integrated into rehabilitation programmes.
- As part of the social corporate responsibility some funding is to be made available for the initiation of community projects such as a bee keeping project, woodlots, etc. These projects will be established in degraded areas in close proximity to villages and not in indigenous forest. This will also help to alleviate existing impacts on natural resources.

Significance statement

The removal of vegetation will be required for the construction of the mine and associated infrastructure. The nature of the impact would be long term as this is an open cut mine and thus rehabilitation options are limited. The impact is of moderate severity and of MODERATE significance as it is anticipated that under the no-go situation these areas will be regularly harvested and even cleared for agricultural purposes. With mitigation measures in place this impact could be reduced to that of LOW significance.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Short-term	Study area	Slight	Unlikely	**MODERATE -**
With Mitigation	Short-term	Study area	Slight	Unlikely	**LOW -**

7.3.2 Operations Phase

Issue 1: Impacts on soils

Impact 1.1: Soil contamination

Cause and Comment

Leakages and spillages from storage and infrastructure facilities could have a negative effect on the pH and salinity of the soil.

Mitigation measures:

- Design and implement a Hydrocarbon Management Operating Procedure. Copies of this document to be made available at designated facilities where hydrocarbons are used or stored. The purpose of this procedure is to provide for the proper storage and handling of hydrocarbons, including waste hydrocarbons, on site and hence prevent any form of contamination;
- Soil contaminated with hydrocarbon will immediately be removed and disposed of at a soil bioremediation facility to be established on site;
- All staff must be trained on the correct management of bunded facilities, including the discharge of collected liquids;
- Spill kits will be readily available at strategic points throughout the site and staff to be trained on the correct use of these kits;
- Prevent spillage and seepage of contaminants at all times through the implementation of good housekeeping and management procedures.
- Define a monitoring program in the EMP.
- Implement remedial measures in the case of accidents.
- Storage facilities will be adequately bunded and inspected on a regular basis.
- Workshops and fuelling areas to have drainage to a sump with a hydrocarbon separator.

Significance Statement:

The impact of contamination from storage infrastructure is considered long term at a regional scale. The issue is considered moderate to severe and of HIGH significance. It is probable that the impact will occur. Since the proponent is committed to implementing the mitigation measures listed above the impact will be of LOW significance.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Long Term	Regional	Probable	Moderate to Severe	HIGH -
With Mitigation	Short Term	Localised	May Occur	Slight	LOW -

Issue 2: Impacts on agriculture

The remaining mined rock which has been ground to a slurry to allow removal of the graphite is tailings which are transferred and kept in a tailings storage facility (TSF). Water is decanted from the TSF and recycled while the dewatered solids remain. The tailings can contain sulphur which can convert to sulphuric acid if the tailings are exposed to oxygen. Acidity can be consumed by carbonates also contained in the ore but if not consumed could promote the leaching of metals in the ore that can migrate and contaminate the environment if not properly contained. Normal management of tailings would maintain high pH if necessary by the addition of lime during processing to avoid formation of acid. The impact is further mitigated by constructing the TSF with a clay liner, which will effectively prevent the penetration of any potentially contaminated leachate into the environment via the ground water.

Impact 2.1: Possible contamination of groundwater through leaching of toxic materials from tailings storage facility

Cause and Comment:

Potential environmental impacts may include groundwater and surface water contamination due to the leaching of metals. However, based on the groundwater modelling, plume migration from the fractured aquifer beneath the TSF will be negligible to nil as the TSF will be clay lined, and no water supply borehole is predicted to be impacted due to seepage of AMD water from the TSF.

Mitigation Measures:

- Mining must target low sulphur oxidised ore of which there are large quantities with low sulphur levels.
- The levels of sulphur and carbonates in the ore are to be tested and investigation made to determine the potential for acid formation. If there is potential for acid formation lime must be added to the ore being processed to consume any acid formed;
- The tailings storage facility will be designed and operated to contain tailings to prevent infiltration of leachate with the potential to cause AMD.
- Geotechnical studies will be undertaken to determine the need for appropriate liner and sub-drainage systems to collect or recycle water.
- Install leak detection equipment with an appropriate Leak Response Plan.
- Monitor surface and groundwater on a continuous basis throughout all phases of the project to ensure early detection.
- Install groundwater monitoring points around the TSF.

Significance Statement:

A moderate potential exists for AMD formation from the TSF due to the high sulphur content and acid generation potential. As a result of AMD, the potential exist for low pH water, bearing high concentrations of Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, V, Zn and U to seep into the aquifers beneath these facilities during the operational phase, if the TSF and waste rock dumps are not lined. These ccontaminants will seep downward to the weathered aquifer beneath these facilities and are predicted to migrate further vertically to the underlying fractured aquifer, from where the plume will be directed towards the pits. However, as the TSF will be clay lined. This would result in an impact of HIGH significance. However, as the TSF will be clay lined plume migration from the fractured aquifer beneath the TSF is likely to be negligible to nil .and the impact will be LOW negative.

Impact	Effect			Risk or Likelihood	Overall Significance
	Temporal Scale	Spatial Scale	Severity of Impact		
Without Mitigation	Permanent	Regional	Probable	Very Severe	**HIGH**
With Mitigation	Short Term	Localised	Unlikely	Moderate	**LOW**

8 IMPACT STATEMENT, CONCLUSION & RECOMMENDATIONS

The Balama Graphite Mine project is located on a $106km^2$ Prospecting Licence located approximately 7 km east of the small regional town of Balama in northern Mozambique, within the District of Balama in the Cabo Delgado Province. The site is approximately 265km by road (3.5 hours drive) west of the port town of Pemba.

It is planned that conventional open pit mining will be used to extract graphite ore. Values of ore extracted will range between 200,000 and 8,000,000 tons per annum (tpa) depending on the production scenario chosen.

In total, 3 issues and 8 impacts were identified and discussed. Six of these impacts can be reduced to low if mitigation measures suggested are implemented. The other will be of moderate significance after mitigation.

8.1 Recommendations for the proposed Balama Graphite Mine

All the mitigation measures provided below are to be implemented in the Construction and Operation Phases of the proposed Balama Graphite Mine.

- All topsoil must be stockpiled and replaced as a final graded layer over the subsoil contouring
- ECO to monitor all excavations to ensure excavations are backfilled with subsoil first and then spread with topsoil;
- Contoured new haul road to assist in dispersing water run-off instead of concentrating it and increasing the risk of erosion;
- Rehabilitation of disturbed areas to be undertaken progressively during the construction phase;
- Divert water flow around cleared areas to minimise the amount of runoff crossing over exposed areas by using berms, with temporary or permanent drainage ditches ;
- Design access roads to be no wider than necessary to accommodate the immediate anticipated use;
- Minimise the alteration to topography;
- Minimise the area of impervious surfaces;
- Grade impervious surfaces to drain into vegetated areas;
- Ensure fine materials being transported are covered with tarps or equivalent material;
- Design and implement a Hydrocarbon Management Operating Procedure. Copies of this document to be made available at designated facilities where hydrocarbons are used or stored. The purpose of this procedure is to provide for the proper storage and handling of hydrocarbons, including waste hydrocarbons, on site and hence prevent any form of contamination;
- Soil contaminated with hydrocarbon will immediately be removed and disposed of at a soil bioremediation facility to be established on site;
- All staff must be trained on the correct management of bunded facilities, including the discharge of collected liquids;
- Spill kits will be readily available at strategic points throughout the site and staff to be trained on the correct use of these kits;
- Prevent spillage and seepage of contaminants at all times through the implementation of good housekeeping and management procedures;
- Define a monitoring program in the EMP;
- Implement remedial measures in the case of accidents;
- Storage facilities will be adequately bunded and inspected on a regular basis;
- The tailings storage facility will be designed and operated to contain tailings to prevent infiltration of leachate with the potential to case AMD;
- Install leak detection equipment with an appropriate Leak Response Plan;

- Monitor surface and groundwater on a continuous basis throughout all phases of the project to ensure early detection;
- Install groundwater monitoring points around the TSF.

8.2 Specialist opinion

The impacts of all the aspects of the proposed Balama Graphite Mine were considered and deemed to be acceptable, provided that the mitigation measures provided in this report are implemented.

Although limited agricultural and natural resource use output within the affected area will be impacted by the proposed development, no problematic areas or fatal flaws were identified for the site.

All the identified impacts on agriculture, Land use and Natural Resources Use are considered to be low reversibility because although the land will be able to be returned to its current Land Use status after closure natural species may take years to regrow to its current status, with very little change in agricultural potential.

Impacts on agriculture, land use and natural resources use are also considered to have low irreplaceability of resource loss because:

1. of the small area of land involved,
2. that it is highly unlikely to be irreplaceably lost to agriculture,
3. and that it is of moderate agricultural potential for both crop production and livestock grazing.

Based on soil types and identified biophysical attributes of the local area, the following agricultural recommendations are made:

- A conservation agriculture approach is recommended. This can be achieved through basic training to ensure the affected communities become self-sufficient in generating high protein foods as well as cash liquidity. The traditional slash and burn practices that depletes soil nutrition can be cancelled while less land could be used more efficiently. Agriculture could then, with correct rotations and cropping programmes ensure more stable employment conditions for the local farmers.
- The following crops are recommended:
  - Peanuts - high protein and a legume crop.
  - Beans & peas (Sugar beans, Pigeon Pea and Cow Peas) - high protein and a legume crop.
  - Sesame - cash crop that is drought resistant and grows well in most soil types.

  All these crops can be grown through multi-cropping with more traditional crops like cassava and maize.

REFERENCES

Boyd, R., Bingen, B., Viola, G., Thomas, R.J., Jacobs, J., Henderson, I.H.C., Nordgulen, Ø., Sandstad, J.S., Engvik, A.K., Smethurst, M., Skar, Ø., Solli, A., Key, R.M. and Daudi, E.X. (2010) Geological Evolution Of North-eastern Mozambique, in the context of the Pan-African Gondwana Assembly. South African Journal of Geology, v. 113, p. 87

Deckers J., Driessen P., Nachtergaele F. and Spaargaren O. (2000) World Reference Base for Soil Resources – in a nutshell. European Soil Bureau, Research Report No. 7

Food and Agriculture Organization (FAO) (2006) Guidelines for Soil Description 4th Ed. World Soil Resources Report. 110p. FAO Doc. No. A0541/E. Available from: *fpt://fpt.fao.org/docrep/fao/009/a0541e/a0851e00.pdf*

Food and Agriculture Organization (FAO). Statistic Yearbook 2010. Text Online: *http://www.fao.org/economic/ess/ess-publications/ess-yearbook/en/*

Food and Agriculture Organization/World Food Program (FAO/WFP). Special Report and Food Security Assessment Mission to Mozambique, 12 August 2010. Text Online: *http://www.fao.org/docrep/012/ak350e/ak350e00.htm#3*

Food and Agriculture Organization (FAO). Emergency Mozambique Fact Sheet. Text Online: http://www.fao.org/fileadmin/templates/tc/tce/pdf/Mozambique_factsheet.pdf

International Finance Corporation (IFC) 2012. Performance Standards and Guidance Notes. Text Online: h*ttp://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Sustainability+Framework+-+2012/Performance+Standards+and+Guidance+Notes+2012/*

IUSS Working Group WRB. 2006. World reference base for soil resources 2006. 2nd edition. World Soil Resources Reports No. 103. FAO, Rome. ISBN 92-5-105511-4

Munsell Color. (1975) Munsell Soil Color Charts. Munsell Color, Baltimore, Maryland.

The World Bank. Mozambique at a glance, 2/25/2011. Text Online: *http://devdata.worldbank.org/AAG/moz_aag.pdf*

The World Bank. Mozambique Agricultural Development Strategy Stimulating Smallholder Agricultural Growth, February 23, 2006. Text Online: *http://siteresources.worldbank.org/MOZAMBIQUEEXTN/Resources/Moz_AG_Strategy.pdf*

APPENDIX A
SOIL ANALYSIS – LABORATORY RESULTS

kg/ha

BROOKSIDE LABORATORIES, INC.

56292-21

SOIL AUDIT AND INVENTORY REPORT

Name: Border Seeds — City: — State:

Independent Consultant: Vermi Solutions — Date: 10/24/2012

Sample Location: RAY DE KOCK		51	53	56	57	
Sample Identification						
Lab Number		0020-1	0021-1	0022-1	0023-1	
Total Exchange Capacity (ME/100 g)		7.53	11.34	12.18	8.87	
pH	Buffer (SMP/Sikora)	7.3	7.1	NA	a NA	
	H_2O (1:1)	6.7	6.4	7.2	7.5	
Organic Matter (humus) %		0.85	0.77	2.43	1.04	
ANIONS: SOLUBLE SULFUR*	ppm	5	5	7	6	
PHOSPHORUS: MEHLICH III kg/ha	P as P_2O_5	133	241	262	128	
	ppm of P	26	47	51	25	
PHOSPHORUS: BRAY II kg/ha	P as P_2O_5	164	672	441	513	
	ppm of P	32	131	86	100	
PHOSPHORUS: OLSEN kg/ha	P as P_2O_5					
	ppm of P					
EXCHANGEABLE CATIONS: CALCIUM*	kg/ha	2018	3351	3371	2484	
	ppm	901	1496	1505	1109	
MAGNESIUM*	kg/ha	544	600	851	699	
	ppm	243	268	380	312	
POTASSIUM*	kg/ha	412	365	1151	464	
	ppm	184	163	514	207	
SODIUM*	kg/ha	85	69	78	76	
	ppm	38	31	35	34	
ALUMINUM (KCl Ext.)	kg/ha	4	11	4	9	
	ppm	2	5	2	4	
BASE SATURATION PERCENT						
Calcium	%	59.83	65.96	61.78	62.51	
Magnesium	%	26.89	19.69	26.00	29.31	
Potassium	%	6.27	3.69	10.82	5.98	
Sodium	%	2.19	1.19	1.25	1.67	
Aluminum	%	0.30	0.49	0.18	0.50	
Hydrogen	%	4.50	9.00	0.00	0.00	
EXTRACTABLE MINORS						
Boron* (ppm)		0.32	0.33	0.63	0.61	
Iron* (ppm)		76	104	75	73	
Manganese* (ppm)		22	64	109	126	
Copper* (ppm)		0.99	1.47	2.30	1.52	
Zinc* (ppm)		1.08	4.23	3.55	1.71	
Aluminum* (ppm)		339	512	589	410	
OTHER TESTS: Soluble Salts (mmhos/cm)						
Chlorides (ppm)						
NO_3-N (ppm)		< 0.5	0.7	1.7	2.1	
NH_4-N (ppm)		2.2	2.2	1.6	4.0	
Total Acidity (ME/100 g)		0	0	0	0	

* Mehlich III Extractable

a - alkaline soil