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TL CEMENT, LDA

VOLUME II

Baucau Cement Project

Environmental Impact Statement Limestone Mine

301012-02135-REP-0001

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PROJECT 301012-02135 - BAUCAU CEMENT PROJECT

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Your Dream, We will Build!

TL CEMENT Lda.

Air Quality Impact Assessment Study of Clinker Cement Project

Baucau - TimorLeste

Final Report

No : 15.3380 - FR – 001

Rev. 0, Jan 2016

Prepared by:

PT. **BITA** BINA SEMESTA

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EXECUTIVE SUMMARY

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker. The air quality impact assessment study has been conducted to predict the impact to the air quality during the construction and operation phase of this cement manufacturing project, as well as setting up the mitigation measures for negative impacts.

The concentration of primary air pollutant in the form of PM_{10}, $PM_{2.5}$, carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), hydrocarbon (HC) and secondary air pollutant in the form of ozone, were measured in six representative sensitive receptors for the baseline study, which are located in settlement area (Bahu, Triloca, Aldeia Osso-ua, Walaicama and Bucoli,) and school area (Aldeia Parlementu).The baseline data shows that background concentrations of all measured parameters were below the limit according to international air quality guidelines. Baucau meteorological data were collected from Baucau Meteorological Station, located at 08° 28'12"S and 126° 27'0" E, 451 m above the sea level, and about 5 km away from the location of future cement plant. The relative humidity was recorded between 28%-100%, with daily temperature between 18^{o}C to 32^{o}C. In general, as the temperature increases the relative humidity usually decreases or vice versa. The wet season lasts from December to June while the dry season lasts from July to November. During the wet season, the highest rainfall was recorded in December (203 mm), while for the dry season the highest rainfall was in November (20 mm). There were many days, especially from July to October where there were no rain at all (0 mm/day). Those days might have the highest level of air pollution, since there would not be pollutant washout by rain through the wet deposition mechanism.

Since 87.5% of hourly meteorological data for one year from Baucau station were missing, complete hourly meteorological data for one year were collected from *weblakes* to conduct the air quality modelling. Metrological data from *weblakes* are generated using MM5, a prognostic meteorology model developed by Pennsylvania State University and the U.S. National Centre for Atmospheric Research (NCAR) which is capable of generating high resolution of hourly meteorological data.This complete set hourly meteorological data is very important since it will strongly influence the accuracy of predicted future ambient concentration during construction and operation phase of the project.According to annual behaviour of prevailing winds, the receptors that undergo the most frequent exposure to the air pollutant will be those who live in North West of Baucau since prevailing winds mostly blow from South East direction. These receptors may also have the highest probability to expose to the highest level of air pollutant concentration, since in the driest month (July - September), the prevailing winds also blow to this direction. Receptors that live in other directions may also expose to the emitted air pollutant, but in a lower exposure frequency.

Impact assessment of cement TL activities was carried out quantitatively by using modelling tools, both during construction and operation phase. The impact assessment divided into two major parts, i.e.; the emission inventory and prediction of future ambient air quality. Emission rates from inventory calculation become the input for prediction of future ambient air quality combine with other supporting data such as meteorological data and topographical data. ISC AERMOD View, a steady state plume model was used to predict the ambient concentration surrounding the project area during construction and operation phase. This model was chosen over other available models since the prediction was carried out for a short range transport (less than 50 km), only limited meteorological data available in project area, and previous study comparing AERMOD with other model such as RAMS showed similar results for short term average concentration when using identical input data. Steady state models generally do not underestimate the estimated concentration; therefore provide a sound basis for regulatory compliance model. Results of prediction are presented in the form of isopleth of each concentration over the receptor area.

During the construction phase, predicted ambient concentration for all averaging time and all air pollutant parameters were below the ambient standard. While during operation phase, predicted ambient concentration for PM_{10}-$PM_{2.5}$ (24 hour and annual averaging time), CO-SO_2 (1 hour, 24 hour, and annual averaging time) and NO_2 (annual averaging time) were also below the ambient standard. Only 1 hour NO_2 concentrations (highest concentration: 222 µg/Nm^3) were predicted to be slightly above the standard (200 µg/Nm^3 according to WHO standard)). Total number of 1 hour NO_2 calculated data were 3,924,480 data (derived from 448 receptors x 8760 hour in a year), and total number of exceedance (data above ambient standard) are 25 data only, therefore the exceedance percentage was only 0.0006%. The location which would undergo probable exceedance of 1 hour NO_2 concentration was located inside the limestone mining area, and would not reach the closest sensitive receptor, i.e. the settlement area in Aldea Osso-ua (the 1 hour NO_2 concentration in this location was predicted to be 100 to 150 µg/Nm^3)

Modelling results also showed that during the construction phase, the highest concentration might occur less than 500 m away from the construction activities. During the operation phase, the highest concentrations generally occurred farther at 1 up to 3 km away from the main sources (such as stacks). In general, pollutants tend to disperse to the North West direction from the sources, in the opposite direction from where the prevailing winds blow (prevailing winds blow mostly from south east direction). Moreover, the area located in the south east direction from the sources (plant and mining area) has a higher level, which is capable of preventing pollutant dispersion by topographic barrier. The dispersed pollutants are predicted to be able to reach the sensitive areas, but the concentration level reaching these areas are all below the standard for each averaging time. Sensitive receptors which may experience higher dispersed concentration than other receptors are located around the jetty plant area (scattered small cluster of fisherman village), settlement area in Aldeia Osso-ua, and settlement area in Wailacama north east of clay quarry.

Although the impact assessment using modelling tool has shown that the future ambient concentration generally below the ambient standard, mitigation during construction and operation phase must be implemented to keep the concentration of air pollutants in the ambient air in allowable level. Parameters which will be monitored are PM_{10}, $PM_{2.5}$, CO, NO_2, and SO_2 (representing the primary air pollutant) and ozone (representing the secondary air pollutant). Monitoring will be conducted in sensitive receptors such as settlement area in Bahu (east-south east of cement plant), School area in Aldeia Parlemento (east of cement plant and north east of limestone mine), settlement area in Aldeia Osso-ua (close to cement plant area), and settlement area in Wailacama (north east of clay quarry). Mitigation for emission sources will also be conducted to keep the emission concentrations not to exceed the limit value. Particulates (from kiln, thermal power plant, cooler ESP stack, cement mill bag house, and coal mill bag house) will be maintained not to exceed 30 mg/Nm^3), gases (from kiln only) not to exceed 200mg/Nm^{3}for SO_2, 800 mg/Nm^{3}for $NO_2$and 500 mg/Nm^{3}for CO. A mitigation monitoring and reporting program will also be developed and reported to the local environmental agency for a certain period of time (at least every six month) to ensure the air quality parameters do not violate the standard.

1. INTRODUCTION

1.1. Brief Project Description

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker.

Clinker refers to small lumps (3.0-25.0mm diameter), produced by heating limestone and other materials such as clay and sand in a cement kiln. Clinker, if stored in dry conditions, can be kept for several months without appreciable loss of quality. Because of this, it can easily be handled by ordinary mineral handling equipment, clinker is traded internationally in large quantities. Clinker is then ground to a fine powder, along with gypsum and other substances to produce useable cement.

The proposed project will provide cement for both domestic use and international sale. A feasibility study is currently being undertaken to demonstrate the commercial viability of the project.

The proposed project represents a significant investment of approximately $350 million and the largest industrial project undertaken in Timor-Leste to date. It is anticipated to create 1000 jobs at the peak of the construction. It will then continue to have 700 permanent employees during operation. The project aims to develop local capacity and will develop a training center.

The spin off benefit would be indirect employment to local community members, through the multiplier effect due to downstream socio-economic benefits and consequent improvement in the living conditions of local population in the project area.

A. Cement Clinker Plant

The plant includes clinkerisation and cement grinding facilities with a rated capacity of 5,000 tons per day (tpd) of clinker and 100 tons per hour (tph) of cement. The plant also includes a waste heat recovery (WHR) power plant.

Up to 60% of 0.53 Mtpa of cement will be sold in the local markets and balance 40% will be shipped to Australia in 8,000 Deadweight-Ton (DWT) ships either in bulk or in. Balance clinker of 1.15 Mtpa will be shipped in vessels of 40,000 DWT ships to Australia.

The project involves developing a green field plant including, but not limited, to the engineering, design, manufacturing and supply of new equipment for cement plant, a waste heat recovery based power plant, a captive thermal power plant of approx. 30 MW and Port (Double wharf jetties) about 1.5-2 Km from the plant site.

B. Thermal Power Plant bottom and fly ash utilization

The waste from the thermal power plant will be fly ash and bottom ash. The total ash will be utilised in the cement grinding for producing PPC based on the coal data and ash in the coal the fly/bottom ash generation will be approximately 50 t/day i.e. approx 16500 t/annum. This will produce around 66000 t/a of PPC based on 25% ash in PPC. All ash from the thermal power plant will be transported pneumatically to the cement grinding section.

C. Mines and Raw Materials

The raw and fuel material requirements for the proposed plant are to be met from different sources as given in Table below.

Table 1.1 Raw Materials

No.	Material	Source	Source Locality	Remarks
1.	Limestone	Local	SucoTirilolo, Bahu, Caibanda, Triloca, Bucoli, Wailili and Fatumaca in administrative post Baucau, Vemasse and Venilele , Baucau Municipality	Primary raw material. Transported from mine site to crusher by trucks.
2.	Clay	Local	Suco Wailacama, Baucau administrative post in Baucau municipality	A corrective material. Transported from quarry to plant by road.
3.	Iron Ore	Import	Australia	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.
4.	Gypsum	Import	Australia or other	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and pipe conveyor.
5.	Coal	Import	Australia/ Indonesia	Fuel source and corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.

D. Limestone Deposit

The limestone deposit is accessible from Baucau by a tar road. The mine is located about 1 km from the main road and Bucoli village. The mining area is located around 0.5 km from the coastline where a jetty is proposed to be constructed. The limestone concession area (I-1) which shall meet the initial limestone requirement of the plant covers an area of 576 ha. The deposit area is generally undulating and hilly. As observation result, the limestone bearing area is covered by thick or scattered trees, thorny bushes and tall grass.

E. Clay Deposit

Clay is found to occur close to the plant site in Suco Wailacama in Baucau administrative post, less than 10 km west of the plant site. Clay shall be used as corrective to compensate for silica and alumina deficiency in the raw mix. Clay is proposed to be transported to the plant site by trucks.

F. Jetty

A dedicated jetty is proposed at a distance of 2 km from the plant site. Inbound material, (e.g., coal, gypsum, iron ore) and outbound clinker shall be transported between the plant and the jetty by a 0.5 km long conveyor belt + 1.5 km Pipe Conveyor (fully enclosed). The maximum load during unloading is estimated as 1000 tons per hour and during loading is estimated as 1000 tons per hour.

G. Utilities

a. Power

Power will be supplied by captive thermal power plant of approximately 30 mega-watts (MW) capacity and Waste Heat Recovery power plant.

Power for initial phase of plant operation when cement grinding is commissioned will be from grid power. Tapping from the nearby grid line of 20 KV will be tapped and step down to 11 KV at the plant substation. Generator sets will be utilized for construction power.

Emergency power requirement for initial commissioning of cement grinding is not required. For full plant 1.5 MW generator will be required. Thermal power plant shall include black start power requirement separately.

b. Water Supply

The water requirement for the cement project shall be met from groundwater by drilling bore wells. A makeup water supply of approximately 3,150 m^3/day is required for operations including requirement of mines, colony and green belt which may be possible to obtain this from one or two boreholes.

An underground aquifer is reported to occur below the mining blocks. As there is no industry in the area, the exploitation of water resources during the operation is not expected to adversely affect the water availability in the area for other competing users.

A detailed hydro geological study is proposed to be carried out to assess the availability of groundwater in the area. Water shall be required for:

- Process Water Circuit
- Cooling water (required for machine cooling)
- Make-up water shall be provided while re-circulating water shall be in a close loop
- Water required for township
- Water for on-site facilities
- Construction and operations (dust suppression)

c. Waste Water

The cement plant is being designed as a Zero Discharge facility and there shall be no discharge of waste water outside the plant premises. All the process waste water shall be treated in Water Treatment Plant and reused for plantation purposes. The waste water generated from domestic activities shall also be treated and reused for dust suppression, green belt development to the extent possible.

d. Solid Waste

Domestic solid waste generated from plant and jetty area shall be segregated and will be sent to waste disposal site as allocated by the local administrative authorities.

1.2. Location Study

The proposed cement plant and marine jetty are located in Suco Tirilolo, Aldeia Ossoa, in the Baucau administrative post of Baucau municipality, Timor-Leste. The location is about 120 km east of Dili and approximately 16 km west of Baucau.

The Proponent has been granted a Prospecting License for limestone over three blocks, including, Block I-1 (Bucoli North Area-1), covering areas of 576 ha. The prospecting blocks are spread over Sucos Tirilolo, Bahu, Caibada, Triloka, Bucoli, and Wailili in administrative posts of Baucau, Vemasse and Venilele in Baucau municipality.

Sources of clay are located at Suco Wailacama within 10 km from proposed plant site. Corrective iron ore and additive gypsum are proposed to be procured from Australia. Coal will be used as a fuel for the kiln and power supply at the cement plant and is proposed to be procured from either Indonesia or Australia. The location of plant, mines (Block I-1) and jetty are shown in figure below.

Source : *https://commons.wikimedia.org/wiki/File:Sucos_Baucau.png*
https://www.mof.gov.tl/about-the-ministry/statistics-indicators/sensus-fo-fila-fali/download-suco-reports/baucau-suco-reports/

Figure 1.1 Location of TL Cement Development Project

1.3. Scope Of Work

According to scope of works from WorleyParsons, the air quality impact assessment study will assess the following task :

- Preparation of baseline status of the ambient air quality through a scientifically designed ambient air quality monitoring network based on the following considerations: a) metrological conditions on synoptic scan; b) topography of the study area; c) representative of likely impacted area within the study area; d) location of residential areas representing different activities.
- Preparation extensive air quality modelling to predict the likelihood of impacts on sensitive receptors, and
- Identifying avoidance measures or design mitigation measures.

2. METHODOLOGY

The methodology section describes the detail methodology used in data collection, calculation, and assessment which includes:

- Description of established method for measurement of air quality background concentration[1] and collection of meteorological data. Collected data shall be used to set up the air quality baseline surrounding the project area.
- Description of methodology for prediction of impacts on air quality, started with emission inventory to calculate emission rate of pollutants generated from project activities during construction and operation phase, continue with prediction of impacts on air quality due to generation of air pollutants using modelling tool. Results of air pollutant inventory shall be used as the emission rate input for the air quality modelling, and the output of modelling will give the description of predicted air pollutants during the construction and operation phase of the project.
- Description of assessment method, begins with calculation of emission rates, prediction of future ambient air quality using modelling tool, analyse modelling output and impacts to the surrounding area of the projects as well as to the sensitive receptors.

2.1 Data Collection and Calculation

2.1.1 Air Quality Background Concentration and Meteorological Data

Measurement of Air Quality Background Concentration

Measurement of air quality parameters was conducted in selected sampling points in order to have the description of air quality background concentration around the project area. Seven air quality parameter, i.e. PM_{10}, $PM_{2.5}$, carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone, and hydrocarbon were measured using international standard method as shown in **Table 2.1**.

Table 2.1 Sampling Location and Method for Collecting Primary Air Quality Data

No.	Location	Sampling Method	Sampling Duration	Equipment
1. 2.	PM_{10} $PM_{2.5}$	Gravimetric method, Japan International Standard (JIS) No. Z 8814 1994	24 hours	Low Volume Sampler
3.	Carbon Monoxide	Iodine Pentoxide Method	1 hour	Midget Impinger, Spectrophotometry,
4.	Nitrogen Dioxide	Griess Saltzman Method, ASTM D1607 - 91(2011).	1 hour	Midget Impinger, Spectrophotometry,
5.	Sulphur Dioxide	Pararosaniline Method, ASTM 2914 (2007)	1 hour	Midget Impinger, Spectrophotometry,

[1] Background" can be defined as concentrations of chemicals in the atmosphere, in the immediate area of an environmentally impacted site. Background concentrations can be naturally occurring (i.e., the concentration is not due to a release of chemicals from human activities), or anthropogenic (i.e., the presence of a chemical in the environment is due to human activities, but is not the result of site-specific use or release of waste or products, or industrial activity).

No.	Location	Sampling Method	Sampling Duration	Equipment
6	Ozone	Methods of Air Sampling and Analysis, 1989	1 hour	Midget Impinger, Spectrophotometry,
7.	Hydrocarbon	NIOSH 1501, 2003	3 hours	Absorber, Gas Chromatography

PM_{10} and $PM_{2.5}$

The PM_{10} and $PM_{2.5}$ were measured using Japan International Standard (JIS) no. Z 8814 1994. This Japanese Industrial Standard specifies low volume air sampler of the suction capacity not more than 30 l/minute and has grading capacities out of the air samplers which is used for measurement of mass concentration of airborne dust. The sampler consists of a grading device, filter, holder, flow meter and an suction pump, as shown in **Figure 2.1.**

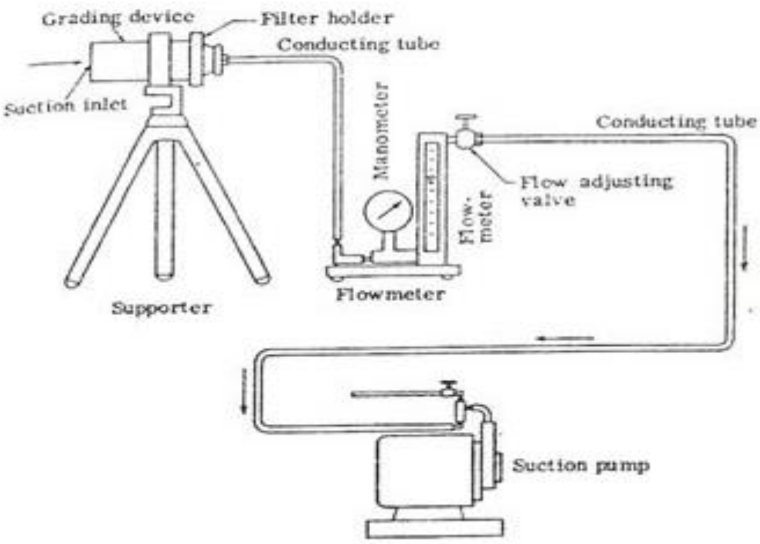


Figure 2.1 Arrangement of Low Volume Sampler for Measuring Ambient PM_{10} Concentration

This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) in ambient air over a 24-hour period. The measurement process is non-destructive, and the PM_{10} sample can be subjected to subsequent physical or chemical analyses. Using this method, an air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one size fractions within the PM_{10} size range. Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM_{10}. The total volume of air sampled, corrected to reference conditions (25^{o}C, 1 atm), is determined from the measured flow rate and the sampling time. The mass concentration of PM_{10} in the ambient air is computed as the total mass of collected particles in the PM_{10} size range divided by the volume of air sampled, and is expressed in micrograms per cubic meter (µg/m^3).

Carbon Monoxide (CO)

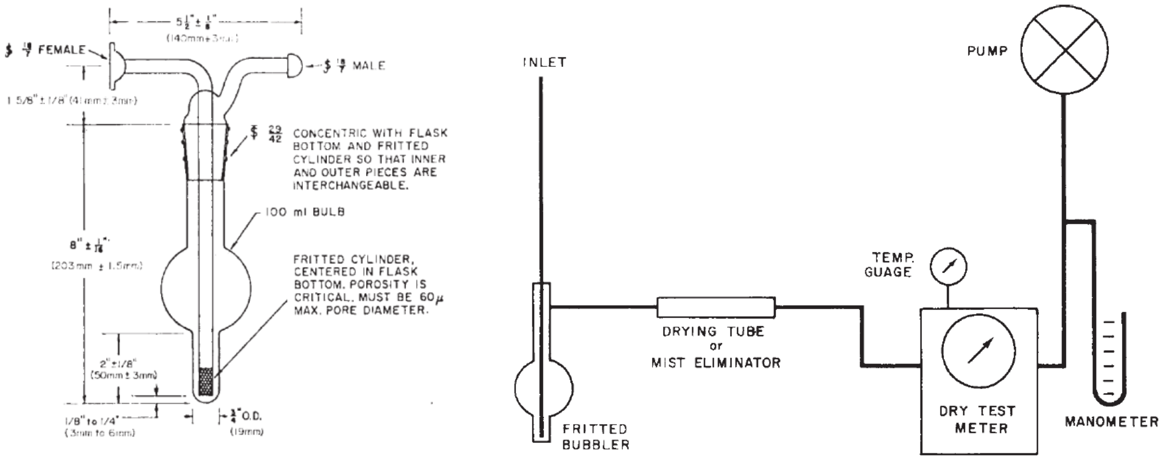
Carbon monoxide was measured using the iodine pentoxide method. The determination consists basically of the passage of a known volume of the gas to be analysed, first through a purifying and drying train, and then a heated tube of iodine pentoxide. Iodine and carbon dioxide are formed in amounts proportional to the quantity of carbon monoxide in the sample, according to the reaction

$$I_2O_5 + 5CO \rightarrow I_2 + CO_2$$

Either the liberated iodine or the carbon dioxide formed may be determined. Where the carbon monoxide concentration is low (0-50 ppm) the iodometric finish is more sensitive and allows smaller gas samples to be used. Concentration of carbon monoxide of the order of 1-2 ppm can be determined.

Nitrogen Dioxide (NO_2)

The ambient nitrogen dioxide concentration was measured using Griess-Saltzman method according to ASTM D1607 - 91(2011), with sampling systems described in **Figure 2.2**. The NO_2 is absorbed in an azo-dye-forming reagent; a red-violet color is produced within 15 min, the intensity of which is measured spectrophotometrically at 550 nm. This test method covers the manual determination of nitrogen dioxide (NO_2) in the atmosphere in the range from 4 to 10 000 µg/m^3 (0.002 to 5 ppm(v)) when sampling is conducted in fritted-tip bubblers. The maximum sampling period is 60 min at a flow rate of 0.4 L/min.



(a). Fitted Buller for Sampling Nitrogen Dioxide

(b). Sampling Train

Figure 2.2 Sampling System for Measuring Ambient NO_2 Concentration

Sulphur Dioxide (SO_2)

Ambient SO_2 concentration was determined using West Gaeke method according to ASTM 2914 (2007), the sampling system is described in **Figure 2.3**. The SO_2 is absorbed by aspirating a measured air sample through a tetrachloromercurate (TCM) solution, resulting in the formation of a dichlorosulfonatomercurate complex. Ethylenediaminetetraacetic acid disodium salt (EDTA) is added to this solution to complex heavy metals that interfere with this method. Dichlorosulfonatomercurate, once formed, is stable to strong oxidants (for example, ozone and oxides of nitrogen). After the absorption is completed, any ozone in the solution is allowed to decay. The liquid is treated first with a solution of sulfamic acid to destroy the nitrite anion formed from the absorption of oxides of nitrogen present in the atmosphere. It is treated next with solutions of formaldehyde and specially purified acid-bleached pararosaniline containing phosphoric acid (H_3PO_4) to control pH. Pararosaniline, formaldehyde, and the bisulphite anion react to form the intensely colored pararosaniline methyl sulphonic acid which behaves as a two-colour pH indicator**.** The pH of the final solution is adjusted to the desired value by the addition of prescribed amounts of 3 N H_3PO_4 to the pararosaniline reagent. These test methods are applicable for determining SO_2 over the range from approximately 25µg/m^3 (0.01 ppm(v)) to 1000µg/m^3 (0.4 ppm(v)), corresponding to a solution concentration of 0.03 g SO_2/mL to 1.3 g SO_2/mL. Beer's law is followed through the working analytical range from 0.02 g SO_2/mL to 1.4 g SO_2/mL. These test methods incorporate sampling for periods between 30 min and 24 h.

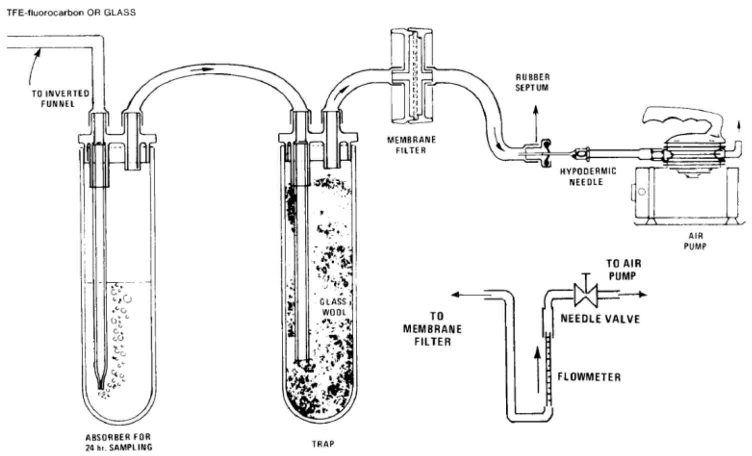


Figure 2.3. Sampling System for Measuring Ambient SO_2 Concentration

Ozone

Ozone was measured by micro-amounts of ozone and other oxidants liberate iodine when absorbed in a 1% solution of potassium iodide buffered at pH 6.8 ± 0.2. The iodine is determined spectrophotometrically by measuring the absorption of triiodide ion at 352nm. The stoichiometry is approximated by the following reaction:

$$O_3 + 3KI + H_2O = KI_3 + 2\,KOH + O_2$$

This method covers the manual determination of oxidant concentrations between 0.01 to 10 ppm (19.6 to 19.620 µg/m^3) as ozone.

Hydrocarbon

Non-methane hydrocarbon was determined using method published by NIOSH 1501, 2003. A solid sorbent tube contain of certain absorber in a glass tube sampler were exposed to the air flow at 0.01 to 1 L/min for 3 hours. The absorbed gases were then determined using gas chromatography.

Collection of Meteorological Data

Primary meteorological data were taken during measurement of air quality background concentration. These primary data were useful for correction of concentration of air quality parameter at standard temperature and pressure. Concentration at standard temperature and pressure can be compared to any international air quality standard. Secondary data of daily meteorological data particularly wind speed and direction, rainfall, temperature, pressure, and cloud cover, were collected from Baucau weather station which is located in Baucau District at 8°28'12.00" South and 126°27'0.00" East World Geodetic System 84 coordinate. Other additional secondary meteorological data were also collected from *www.weblakes.com* which provides hourly meteorological data all around the world.

2.1.2 Prediction of Impacts on Air Quality

2.1.2.1 Emission Inventory of Air Pollutants Generated from Project Activities

During the construction and operation phase of the cement plant, there shall be activities which will contribute to the emission of air pollutants to the ambient air. These mainly related to the following activities:

- Construction phase, include: site preparation, the use of construction equipment during construction phase, and mobilization of materials and equipment
- Operation phase, include: mining activities, plant operation, and mobilization of raw materials

Emission factor calculation can be applied to quantify the level of each air quality parameter emission rates from each specified activity. An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category i.e., a population average (www.epa.gov). The general equation for emissions estimation using emission factors are:

$$E = A \times EF \times (1-ER/100)$$

Where:
E = emissions (in mass of PM_{10} per year)
A = activity rate (unit depends on the emission factor's unit)
EF = emission factor (units are various)
ER = overall emission reduction efficiency, %

The form of the formula might change in a more complex way, usually because of the detail calculation of the activities. The level of accuracy shall also depend on the availability data of the site specific activities. The followings are the anthropogenic activities during the construction and operational phase of cement plant which may contribute to emit additional air pollutants to the ambient air.

- **Site Preparation**

  Earth moving activities during construction and wind erosion are sources of PM_{10} and $PM_{2.5}$ emissions. PM_{10} and $PM_{2.5}$ emissions caused by earth moving and wind erosion may be calculated using the methodologies outlined in Section 13.2.3 "Heavy Construction Operations" of A-42. All possible emission factors are shown in **Table 2.2**.

Table 2.2. Emission Factor for Activity Related to Site Preparation

Construction Phase	Dust Generating Activities	Emission Factor	Unit	Source
Site preparation	Bulldozing (top soil)	PM_{10}: : $0.75 \frac{18.6\,(s)^{1.5}}{(M)^{1.4}}$ $PM_{2.5}$: $0.022 \frac{78.4\,(s)^{1.2}}{(M)^{1.3}}$	Kg/hour	AP.42 Sec.13.2, Table 13.2.3
	Loading of excavated	$k * 0.0016 * \frac{(\frac{U}{2.2})^{1.3}}{(\frac{M}{2})^{1.4}}$	Kg/Mg	Ap.42

Construction Phase	Dust Generating Activities	Emission Factor	Unit	Source
	material into trucks Truck dumping of fill material, road base or other materials	k=0.35 for PM_{10},& 0.053 for $PM_{2.5}$		Sec. 13.2.4
	Active storage pile (emission due to wind erosion and maintenance	$*$0.85 for TSP	Mg/ (hectare) /year	Ap.42 Sec.11.9, Table 11.9.2

- **Mobilization of Vehicles during Construction and Operational Phase**

Particulate emissions from paved and unpaved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and re-suspension of loose material on the road surface. In general terms, re-suspended particulate emissions from paved roads originate from, and result in the depletion of the loose material present on the surface. The quantity of particulate emission factor from re-suspension of loose material on the road surface due to vehicle travel on a dry paved road and unpaved road may be estimated using the empirical expression as shown in **Table 2.3**. The emission of concern from paved and unpaved roads is particulate matter (PM) including PM less than 10 microns in aerodynamic diameter (PM_{10}) and PM less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$).

Table 2.3 Emission Factor Mobilization of Vehicles during Construction and Operation Phase

Dust Generating Activities	Emission Factor	Unit	Source
Paved road	$E = k * (sL)^{0.9} * (W)^{1.02}$ k = 0.62 for PM_{10} & k =0.15 for $PM_{2.5}$	g/VKT	Ap.42 Sec.13.2.1
Unpaved road	$E = k\ 5.9 \left(\frac{s}{12}\right)\left(\frac{S}{30}\right)\left(\frac{W}{3}\right)^{0.7}\left(\frac{w}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)$ K = 0.36 for PM_{10}, and 0.095 for $PM_{2.5}$	lb/VMT, (1lb/VMT = 281.0 g/VKT)	Ap.42 Sec.13.2.2

Note: Source: AP42 USEPA (www.epa.gov), sec. 13.2.3 Heavy Construction Operation
s = material silt content (%), between 0.44-19%,
K = particle size multiplier (dimensionless)
U = mean wind speed, m/s
M = material moisture content (%), between 0.25-4.8%
sL = road surface silt loading (g/m^2), between 0.03-400 g/m^2
W = average weight of the vehicles travelling the road (ton)
S = mean vehicle speed (mph)
w = mean number of wheels (dimensionless)
p = number of days with at least 0.254 mm of precipitation per year

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on correction parameters that characterize (a) the condition of a particular road and (b) the associated vehicle traffic. Parameters of interest in addition to the source activity (number of vehicle passes) include the vehicle characteristics (e.g., vehicle weight), the properties of the road surface material being disturbed (e.g. silt content, moisture content), and the climatic conditions (e.g., frequency and amounts of precipitation). Dust emissions from unpaved roads have been found to vary directly with the fraction of silt in the road surface material. Silt consists of particles less than 75 µm in diameter, and silt content can be determined by measuring the proportion of loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method.

Besides emission of particulates, gases are also emitted from the combustion of fuels during mobilization of vehicles. Emission factors for calculating the emission rates are derived from the Air Resources Board of California USA which develop the emission factor by taking the weighted average of vehicle types and simplifying them into three categories – passenger/light-duty (< 8,500 pounds) and medium-/heavy-duty vehicles (e.g., delivery trucks, > 8,500 pounds), and heavy duty (33,0001 to 60,000 pounds as shown in **Table 2.4**.

Table 2.4 Emission Factors for Mobilization of Vehicles during Construction and Operation Phase

No	Parameter	Emission factor (pounds/mile)		
		Passenger Vehicles (< 8,500 pounds)	Delivery Trucks (>8,500 pounds)	Heavy-Heavy Duty Diesel Trucks (33,001 to 60,000 pounds)
1	PM_{10}	0.00009	0.00050	0.00105
2	$PM_{2.5}$	0.00006	0.00041	0.00088
3	CO	0.00614	0.01169	0.00767
4	NO_x	0.00060	0.01285	0.02123
5	SO_x	0.00001	0.00003	0.00004

Source : *http://www.aqmd.gov/home/regulations/ceqa/air-quality-analysis-handbook/emfac-2007-(v2-3)-emission-factors-(on-road)*, model year 2015

- **Operation of Heavy Equipment During Construction and Operation Phase**

  Construction equipment emissions estimates are generally developed using two basic methodologies (non-road and on road) depending on the type of construction equipment. Non road construction equipment (e.g., bulldozers, backhoes, front end loaders, etc.) are generally operated off road and on the construction site. On road construction equipment (e.g., semi-trucks for material hauling), in contrast can be operated on public roads. Non road estimation methods which are described in the USEPA report, *Non road Engine and Vehicle Emission Study—Report* are able to be used for construction activities which would require heavy duty construction equipment.

  Air pollutants in the form of particulates and gases emitted by operation of heavy equipment are mainly because of the results of combustion of fuels. The amounts of emitted pollutants are calculated based on various emission factors (**Table 2.5, 2.6, and 2.7**) in unit of gram/hour or gram/bhp-hour, and various activities data information such as operational hours and engine power.

Table 2.5 Emission Factor for Equipment Activities during Construction Phase

No	Equipment	Requirement for Each Location					Con-dition	Emission Factor									
		Jetty	Plant	Lime stone Mine	Clay Mine	Stock pile		TOG	VOC	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	Unit
													paved		unpaved		
1	Water truck/fuel truck, MHDT						idle		3.17	26.30	75.05	0.04	0.53	0.49	0.53	0.49	g/hr
		2	5				On site		0.39	4.62	7.31	0.01	1.88	0.36	2.41	0.47	g/hr
2	Pile driving rig	2	2														
3	Crane	2	5				175 HP	0.830		3.410	5.100	0.006	0.260	0.239			g/bhp-hr
4	Low & Flat bed trailer, HHDT	2	5				idle		10.78	45.96	114.93	0.06	0.76	0.70			
							On site		4.83	10.14	19.56	0.03	2.30	0.72	2.83	0.82	g/hr
5	Prime mover and or self propelled transporter with power pack		2														
6	Fork lift		3				175	0.661		3.353	4.320	0.006	0.249	0.229			g/bhp-hr
7	Welding generators		5				50	2.441		6.028	5.549	0.007	0.525	0.483			
8	Excavator			3	1		175	0.696		3.377	4.523	0.006	0.259	0.239			g/bhp-hr
9	Bulldozer / Ripper			1	1	3	500	0.784		3.053	4.700	0.006	0.140	0.129			g/bhp-hr
10	Dump Truck, HHDT			7	4		Idle		10.78	45.96	114.93	0.06	0.76	0.70	0.76	0.70	g/hr
							On site		4.83	10.14	19.56	0.03	2.30	0.72	2.83	0.82	g/hr
11	Motor Grader			1			175	0.766		3.369	5.100	0.006	0.260	0.239			g/bhp-hr
12	Wheel Loader					5	250	0.430		1.194	2.800	0.006	0.109	0.100			g/bhp-hr
13	Power generators	1	1				229		0.44	1.27	3.87	0.01	0.13	0.12			g/bhp-hr

Source: - http://www.fhwa.dot.gov/environment/air_quality/conformity/methodologies/emfac.cfm
- www.portoflosangeles.org/EIR/SCIG/DEIR/APPENDIX_C1.pdf

Note : The number of equipment is based on similar project of cement factory and or assumption of the expert.

Table 2.6 Emission Factor for Equipment Activities during Operation Phase of Limestone Mine

No	Activity Data (A)								Emission Factor (EF)					
	Equipment	Capa-city	Require-ment	Condi-tion	Capacity		Operating hours	Vehicle Mile Travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit
			R		Cap		OH	VMT	EF					
					bhp	bhp	hours/year	Mile/year						
1	**Main Maining Equipment**													
1.1	Drilling machine	385 Hp	3		385	379.61	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]
1.2	Excavator with rock breaker	40 ton class, 175 Hp	1		175	172.55	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]
2	**Loading**													
2.1	Hydraulic excavator	4.5 m^3 bucket cap., 450 Hp	3		175	172.55	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]
2.2	Loader	4 m^3 bucket, 350 Hp	1		250	246.5	3300		0.109	0.1	1.194	2.8	0.006	g/bhp-hr[a]
3	**Transportation**													
3.1	Off highway dump truck, HHDT	36 ton payload cap., 450 Hp	2	Idle			330		0.76	0.7	45.96	114.93	0.06	g/hr[a]
			8	On site			2970		2.3	0.72	10.14	19.56	0.03	g/hr[a]
4	**Ancillaries**													
4.1	Bulldozer with ripper	300 – 350 Hp	1		350	345.1	3300		0.14	0.129	3.053	4.7	0.006	g/bhp-hr[a]

No	Activity Data (A)								Emission Factor (EF)					
	Equipment	Capa-city	Require-ment	Condi-tion	Capacity		Operating hours	Vehicle Mile Travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit
			R		Cap		OH	VMT	EF					
					bhp	bhp	hours/year	Mile/year						
4.2	Grader	140 – 150 hp	1		150	147.9	3300		0.26	0.239	3.369	5.1	0.006	g/bhp-hr[a]
4.3	Jeeps - Double Axle drive		2					36,828	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]
4.4	Water sprinkler (truck chassis mounted)		1					17,820	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]
4.5	Fuel tanker (truck chassis mounted)		1					17,820	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]
4.6	Mobile service van		1					36,828	9.3E-05	6.0E-05	6.1E-03	6.0E-04	1.E-05	pounds/mile[b]

Source: -[a] http://www.fhwa.dot.gov/environment/air_quality/conformity/methodologies/emfac.cfm

- [a]www.portoflosangeles.org/EIR/SCIG/DEIR/APPENDIX_C1.pdf
- [b]http://www.aqmd.gov/home/regulations/ceqa/air-quality-analysis-handbook/emfac-2007-(v2-3)-emission-factors-(on-road)

Note : The number of equipment is based on similar project of cement factory and or assumption of the expert.

Table 2.7 Emission Factor for Equipment during Operation Phase of Clay Mine

No	Activity Data							Emission Factor (EF)					
	Equipment	Cap	Requirement	Capacity		Operating Hour	Vehicle mile travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit
			R	Cap		OH	VMT	EF					
				HP	BHP	hour/year	mile/year						
1	Hydraulic excavator	3 m^3	1	175	172.55	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]
2	Tippers	10 ton	20				41,450	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile
3	Water sprinkler (truck chassis mounted)		1				12,435	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile
4	Fuel tanker (truck chassis mounted)		1	175			12,435	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile

Source: -[a] http://www.fhwa.dot.gov/environment/air_quality/conformity/methodologies/emfac.cfm

- [a]www.portoflosangeles.org/EIR/SCIG/DEIR/APPENDIX_C1.pdf

- **Cement Plant Operation**

Emissions from cement plant operation as shown in **Figure 2.4** can be broadly divided into five stages:

- ***Quarrying of raw materials*** (limestone and mine quarrying),

  Particulates are mainly emitted from the activity of land clearing, blasting, loading and handling extracted material, material stockpile and material transportation.

- ***Raw material handling***

  Activities during raw material handling, e.g. crushing, transferring, stockpiling, area the main sources of particulate emission

- ***Pyro processing to produce clinker***

  The production of clinker takes place in a kiln system in which the minerals of the raw mix are transformed at high temperatures into new minerals with hydraulic properties. The fine particles of the raw mix move from the cool end to the hot end of the kiln system and the combustion gases move the other way from the hot end to the cold end. This results in an efficient transfer of heat and energy to the raw mix and an efficient removal of pollutants and ash from the combustion process.

- ***Cement mill to produce cement***

  The final step in cement manufacturing involves a sequence of blending and grinding operations that transforms clinker to finished Portland cement. Up to 5 percent gypsum is added to the clinker during grinding to control the cement setting time, and other specialty chemicals are added as needed to impart specific product properties. This finish milling is accomplished almost exclusively in ball or tube mills. Typically, finishing is conducted in a closed circuit system, with product sizing by air separation

- Storage, packing, and delivery of cement

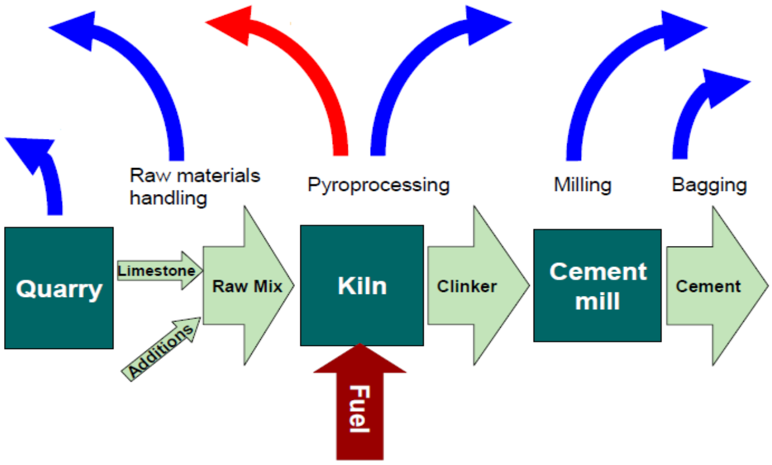


Figure 2.4 Emission of Cement Production, Combustion emissions are indicated in red, process emissions are indicated in blue (Source: EMEP/EEA, 2013)

Emission factors for calculating air pollutant emissions from cement production are described in **Table** below.

Table 2.8 Emission Factors for Quarrying Activities in Cement Production

No	**Activity**			**Emission Factor**				**Source**
				TSP	**PM_{10}**	**$PM_{2.5}$**	**Unit**	
1.1	*Limestone mining* *Size: (*2347.15 m x 2446.07 m)							
	Land clearing	Overburden	Bulldozing	$\frac{2.6\,(s)^{1.2}}{(M)^{1.3}}$	$0.75\,\frac{0.45\,(s)^{1.5}}{(M)^{1.4}}$	$0.105\,\frac{2.6\,(s)^{1.2}}{(M)^{1.3}}$	kg/hour	AP.42 Sec.13.2, Table 13.2.3
								AP 42 Sec 11.9, Table 11.9.2
	Truck load/ unloading	Overburden		10^{-3}				AP 42 Sec 11.9, Table 11.9.4
	Blasting	Overburden/ limestone	1 to 2 times a week		$0.00022\,(A)^{1.5}$ PM10k=0.52, PM 2.5k=0.03		Kg/blast	AP 42 Sec 11.9, Table 11.9.2
	Drilling	Limestone			$4*10^{-5}$		kg/Mg	AP 42 Sec 11.9.2 Table 11.9.2-1
	Loading and handling		Transferred material		$k*0.0016*\frac{(\frac{U}{2.2})^{1.3}}{(\frac{M}{2})^{1.4}}$ PM10: k=0.35, PM 2.5: k=0.053		kg/Mg	AP 42 Sec. 13.2.4
	Limestone transportation		Calculated as mobile sources					
1.2	*Clay mining*							
	Land Clearing		Bulldozing	$\frac{2.6\,(s)^{1.2}}{(M)^{1.3}}$	$0.75\,\frac{0.45\,(s)^{1.5}}{(M)^{1.4}}$	$0.105\,\frac{2.6\,(s)^{1.2}}{(M)^{1.3}}$	kg/hour	AP.42 Sec.13.2, Table 13.2.3
	Blasting		**2 to 3 times a week**					
	Clay stockpile		Wind erosion					

Note: - De-dusting bag filters for dust suppression system
- All transfer points shall be properly de-dusted
- The nuisance bag filters for equipment shall ensure dust emission level of 30 mg/ Nm^3.

Main emission from stacks during operation phase come from the kiln, cooler ESP, cement mill, coal mill, and thermal power plant. **Table 2.9** shows the characteristics of the stack and its emission concentration.

Table 2.9 Emission Factors for Other Point Sources

No	Point Source	Stack Diameter	Stack Height	Gas Stack Tem-perature	Velo-city	Output concentration			
						PM_{10}	SO_2	NO_x	CO
		D	H	T	v	C			
		m	m	Celsius	m/s	mg/Nm^3			
1	Kiln/Raw mill bag House stack	4	120	120	18	30	200	800	500
2	Cooler ESP stack	3.4	35	110	18	30			
3	Cement Mill bag House Stack	1.5	55	90	18	30			
4	Coal Mill Bag House Stack	2	65	77.5	18	30			
5	Thermal Power plant Stack	2.5	90	140	18	30	200	800	500

2.1.2.2 Prediction of Future Air Quality using Modelling Tool

After calculating the emission rate of each air pollutants from all activities during cement plant construction and operation phase, the air quality modelling shall be conducted to predict the quality of ambient air both in the construction phase and operation phase.

This study use ISC AERMOD View for predicting the impact to the air quality. The AERMOD is a steady state gaussian plume model that is appropriate for estimating impact for short-range transport for distance less than 50 kilometers (km). Other models are also available such as RAMS, a mesocale model, which is capable of modelling weather system such as land/sea and mountain circulation and suitable to model meteorological condition in a complex coastal area. Another well-known model is CALFUFF, a non-steady-state lagrangian gaussian puff model, which is recommended to be used for modelling impact with distances greater than 50 km, and the use on case by case basis in complex flow situation for shorter distances.

ISC AERMOD VIEW model was chosen for calculating the air quality impact due to the following reasons:

- Modelling area is less than 50 km, a short range transport model (AERMOD) should be more suitable than a long range transport model (RAMS or CALPUFF)
- Limited meteorological data available in Baucau.

  Recorded meteorological data from Baucau Meteorological Station cannot represent the specific onshore-offshore recirculation because each day it only recorded the meteorological condition at 9:00, 15:00 and 18:00 East Timor Time.
- Previous studies comparing AERMOD and RAMS. AERMOD and CALPUFF give the following results:

- Modelling study to compare AERMOD and RAMS showed that both models configuration predicted very similar short term average concentration when using identical input data (Borrego and Incecik, 2004).
- According to Rood (2014),
  - Framework of a Lagrangian puff model is better suited for long range compared to the steady-state models.
  - The steady-state models generally did not underestimate the high-end concentrations at the distances studied, and therefore provide a sound basis for regulatory compliance modeling. Based on the overall performance, assessment models that rely on the Gaussian plume (e.g. AERMOD) model are not necessarily inferior to the current state-of-the-art models (e.g. Calpuff) in terms of meeting regulatory performance objectives.
  - The need for consistency and assurance that estimated concentrations are not underestimated are legitimate reasons for using steady-state models for regulatory compliance determination.
  - Another compelling reason to use steady-state models for regulatory compliance demonstration is the fact that they are simpler to run, require less user judgment, and are less prone to error than Lagrangian puff models.

2.1.3 Impact Assessment Method

The impact assessment on air quality consists of the following steps:

- Calculate the emission rates of air pollutants during construction and operation phase using emission inventory method;
- Predict the future ambient air pollutant concentration using AERMOD VIEW Software, utilize calculated emission rates and collected Baucau meteorological data for the modelling input;
- Present the modelling results in the form of isopleth concentration of 1st high 1 hour concentration, 1st high 24 hour concentration, and 1st high annual concentration;
- Compare calculated ambient concentration with the international standard, analyse the dispersion pattern as well as impacts to the sensitive receptors.

  The ambient air quality parameter either as the result of primary measurement (baseline data) or prediction using modelling shall be compared to the international standard as shown in **Table 2.10.**

Table 2.10. International Ambient Air Quality Standard

No.	Parameter	Time Average				Note
		1 hour	3 hour	24 hour	Annual	
1	PM_{10}			150[a]	70[a]	Interim Target (ITs -1)
2	$PM_{2.5}$			75[a]	35[a]	
3	CO	40000[b]				Not to be exceeded more than once per year
4	NO_2	200[a,c]			40[a,c]	
5	SO_2	350[c]		125[a]		
6	Ozone	235[d]				

No.	Parameter	Time Average				Note
		1 hour	3 hour	24 hour	Annual	
7	Hydrocarbon		160[e]			As non-methane hydrocarbon

Source:
[a] http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf
[b] http://www3.epa.gov/ttn/naaqs/criteria.html
[c] http://ec.europa.eu/environment/air/quality/standards.htm
[d] http://www.gpo.gov/fdsys/granule/CFR-2011-title40-vol2/CFR-2011-title40-vol2-sec50-9
[e] http://regulations.delaware.gov/AdminCode/title7/1000/1100/1103.shtml

According to guidance from European Union (2005), the ambient air quality standard for PM_{10} is 50 µg/m^3 for 24 hour-mean with permitted exceedance 35 times per year. In the final rule published by EPA on January 15, 2013, the PM_{10} standards was retained as no more than one exceedance of concentrations of 150 µg/m^3 per year on average over three years. In 2006, the World Health Organization (WHO) published global air quality guidelines (AQGs) for PM_{10} (WHO 2006; Krzyzanowski and Cohen 2008). Thus far, there have been four versions (WHO 1987, 2000a, b, 2006) of the World Health Organization Air Quality guidelines (WHO AQGs), the guidelines which provide an international reference that countries, particularly those without the resources to conduct their own assessment, can use to develop AAQSs. The 2006 WHO AQGs are composed of a single guideline value and interim targets (ITs). The interim targets provide a stepwise approach to achieving the air quality guideline value. The guideline values can be used by developed countries, with the capacity to implement a strict AAQS, while developing countries, with higher levels of air pollution, could select an interim target level achievable based on their own air quality management infrastructure, and progress towards the AQG value at their own pace. For standards which are not provided by WHO guideline, taken from United State Protection Agency (for CO, ozone, and hydrocarbon standard), and from European Commission for Environment (for NO_2 and SO_2 standard).

3. ENVIRONMENTAL BASELINE

3.1 Baucau Meteorological Data

Meteorological phenomena such as wind velocity, wind direction, temperature, pressure, as well as the cloud cover has a very close relation with the air quality as well as the calculation of air pollutant dispersion. The air movement (wind) and the exchange of heat (convection and radiation) dictate the fate of pollutants as they go through stages of reaction, transformation, dilution, dispersion, and transport. Knowledge of prevailing wind direction and its velocity also determine where the pollutants shall be dispersed. This is very essential in order to be able to identify places which undergo the highest exposure frequency to the dispersed air pollutants.

Meteorological data in Baucau were collected from Baucau Meteorological Station, located at 08° 28'12"S and 126° 27'0" E with the altitude 451 m above the sea level. The collected data were in the form of average daily data from January 2014 until September 2014. These data are presented statistically in the form of average, minimum, and maximum data and or in the form of monthly average to show the gradual changes from time to time.

Figure 3.1 and **Figure 3.2** shows the daily data of relative humidity (%) and temperature (^{o}C) respectively, recorded from Baucau Meteorological Station. The humidity data tends to clearly decrease from January to September, and start to increase again from August to December. Highest relative humidly was recorded as high as 100% and lowest was recorded as low as 28%. Relative humidity indicates the ratio of the current absolute humidity to the highest possible absolute humidity (which depends on the current air temperature). A reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more, creating the possibility of rain. This doesn't mean that the relative humidity must be 100 percent in order for it to rain, it must be 100 percent where the clouds are forming, but the relative humidity near the ground could be much less. The daily average temperature recorded as high as 31.8^{o}C (in November) and as low as 18.4^{o}C (in February). In general, as the temperature increases the relative humidity usually decreases or vice versa. Therefore, in September to November when the higher average of temperatures was observed, the humidity was recorded in the lower average.

From the daily and monthly precipitation data as shown in **Figure** 3**.3** and **Figure 3.4**, it is clearly showed that the wet season lasts from December to June while the dry season lasts from July to November. During the wet season, the highest rainfall was recorded in December (203 mm), while for the dry season the highest rainfall was in November (20 mm). There were many days, especially from July to October where there were no rain at all (0 mm/day). Those days may have the highest level of air pollution, since there will not be pollutant washout by rain through the wet deposition mechanism.

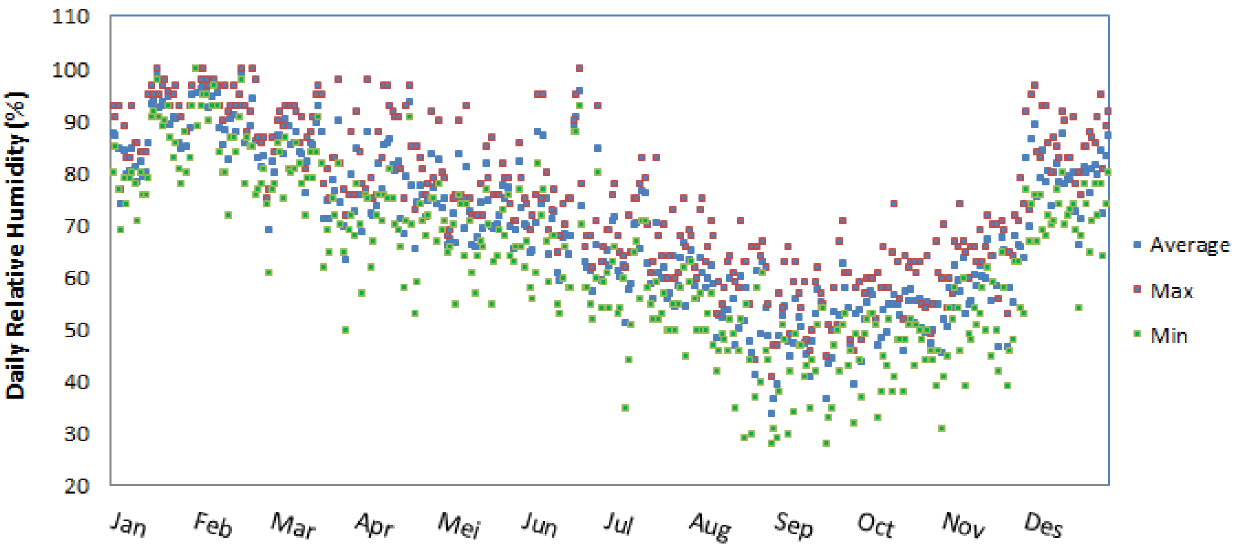


Figure 3.1 Daily Data of Relative Humidity

(Source: Baucau Meteorological Station)

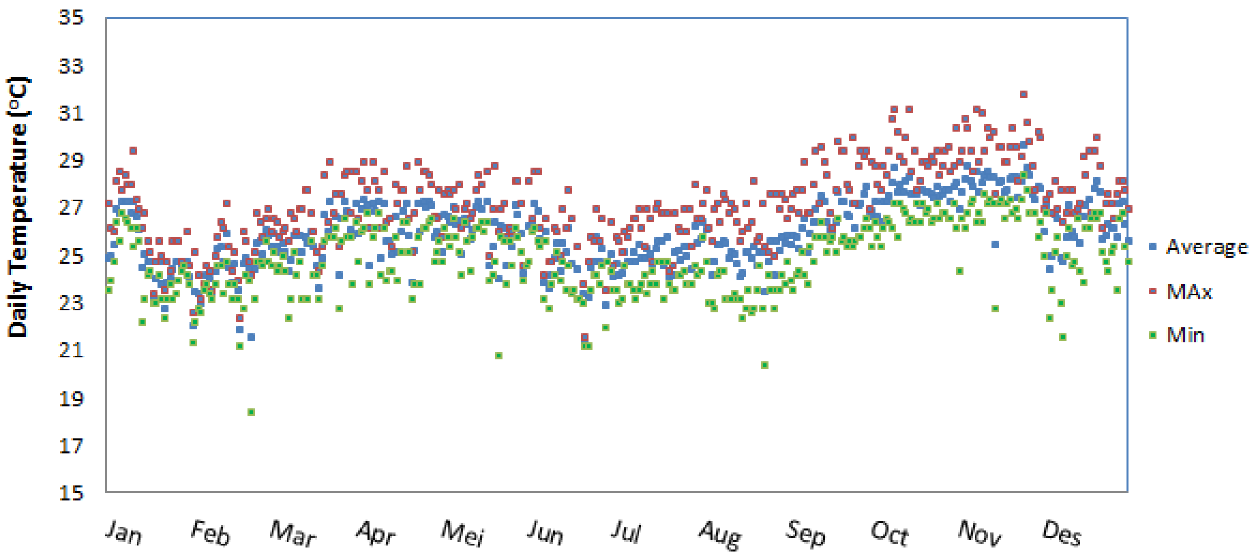


Figure 3.2 Daily Data of Temperature

(Source: Baucau Meteorological Station)

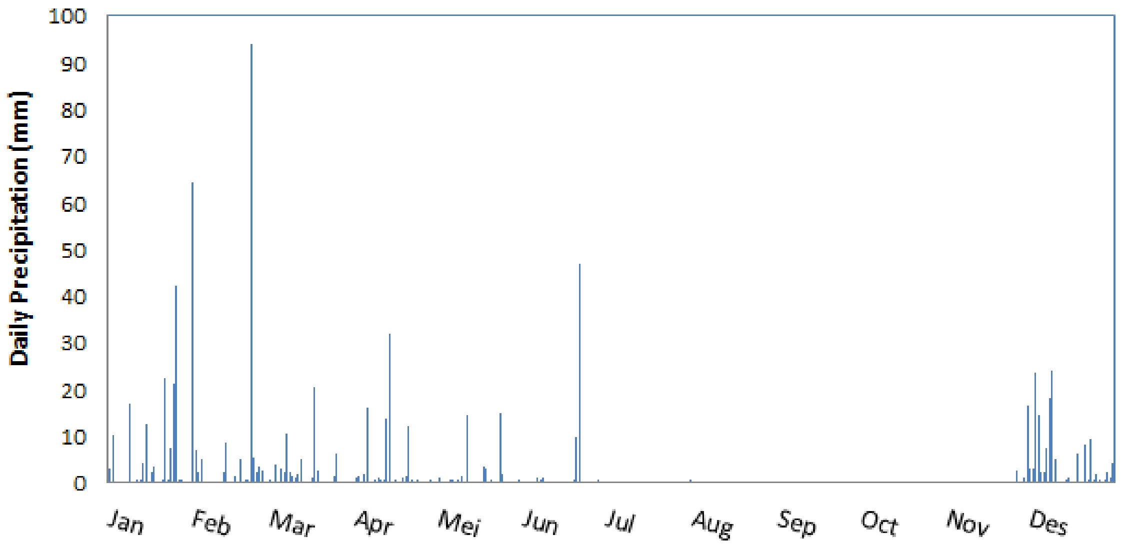


Figure 3.3 Daily Data of Precipitation

(Source: Baucau Meteorological Station)

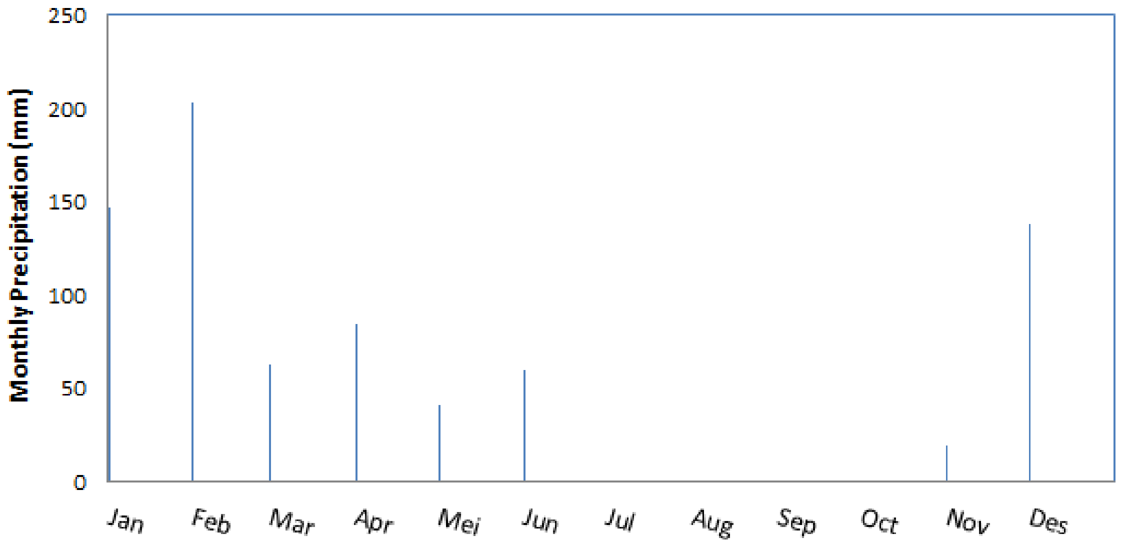


Figure 3.4 Monthly Data of Precipitation

(Source: Baucau Meteorological Station)

Meteorological data which include wind speed, wind direction, temperature, pressure, precipitation, and cloud cover are going to be used as input parameters in the air quality modelling using AERMOD VIEW software. Since this software requires hourly meteorological data for all parameters, other additional data which can supply these hourly data were collected from *www.weblakes.com*, The weblakes page provides meteorological data all around the world. Local meteorological data from Baucau meteorological station only provide daily average, minimum, and maximum data which were calculated from three times measurement at 9:00, 15:00, and18:00 East Timor Local Time. The availability data from this station cannot fulfil the requirement of the software, i.e., at least 99% hourly meteorological data should be available. This availability data is very important since it will strongly influence the accuracy of predicted ambient concentration.

A windrose diagrams which are shown in **Figure 3.5** to **Figure 3.9** illustrate summary of statistical information concerning direction and speed of the wind recorded from in Baucau Area using two data sources (Baucau meteorological station and *www.weblakes.com*). A line segment is drawn in each of sixteen compass directions from a common origin. The length of a particular segment is proportional to the frequency with which winds blow from that direction, while thicknesses of a segment indicate frequencies of occurrence of various classes of wind speed.

From this windrose diagram, it can be identified the prevailing wind directions, i.e., the direction from which the wind blows most frequently, not necessarily the direction from which the strongest wind comes. **Figure 3.5** shows the annual windrose diagram and denotes the prevailing winds most generally blow from South East to North West. Therefore it can be predicted that air pollutants shall most probably be dispersed to the opposite directions from the prevailing winds, i.e. the North East direction. Differences in wind rose pattern for these annual wind directions occur due to the difference of number of data source. Annual windrose from Baucau were generated from 3 sets hourly data for each day (only 1095 data), while annual windrose from *www.weblakes.com* were generated from 24 sets hourly data for each day (8760 data).

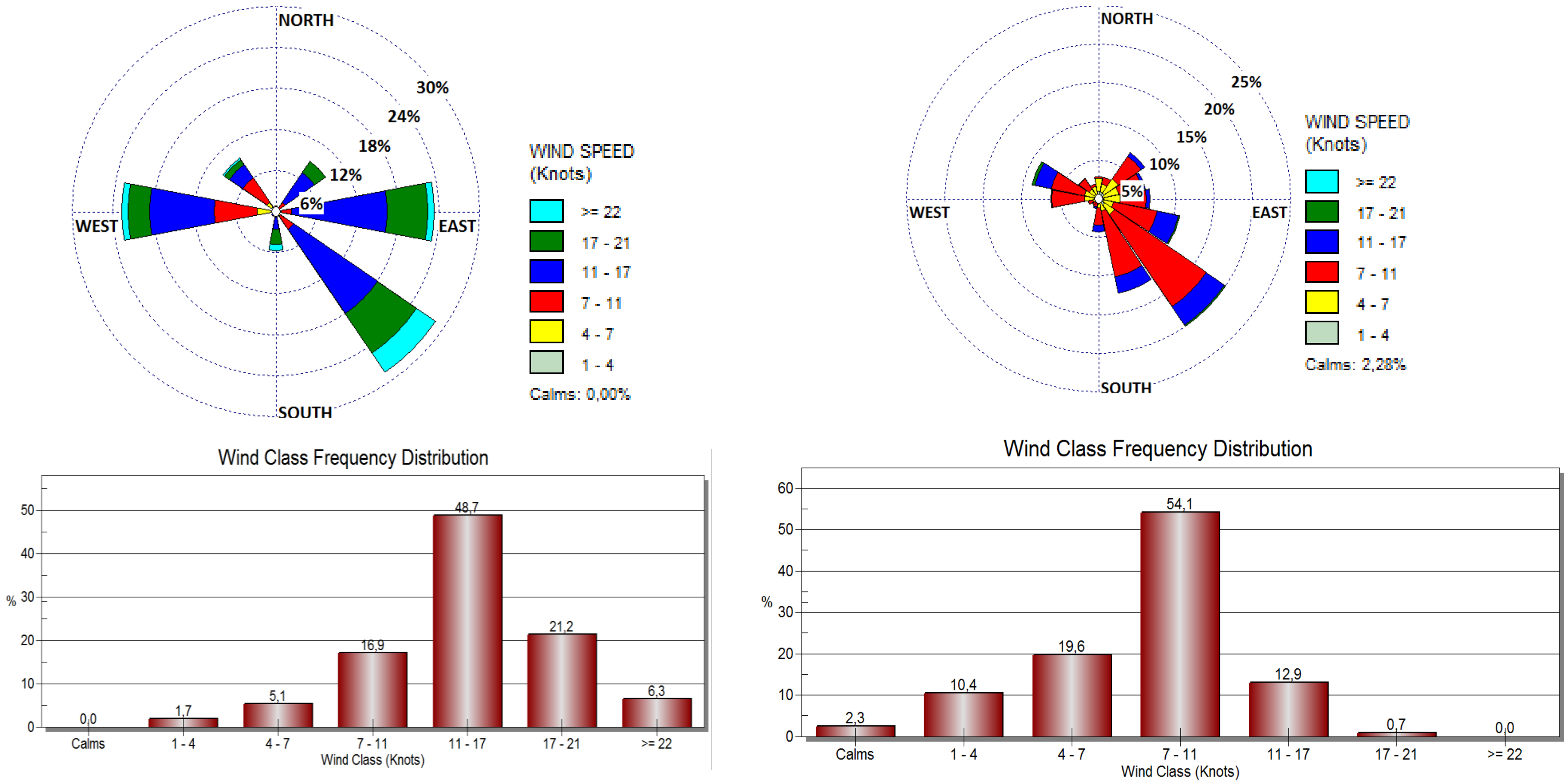
Figure 3.5 also indicates significant differences between wind speed data from Baucau meteorological station and from Weblakes. Wind speeds from Baucau are generally higher than weblakes, and this can be explained as follows:

- Windrose for Baucau station was generated from very limited data, i.e. wind speed at 9:00, 15:00. and 18:00 East Timor Time, or in total only 12.5% of total hourly data in a year (1095 data out of 8760 data). There are 87.5% missing data, especially data for night wind speeds. These missing data might consist of low wind speeds because the coastal wind speed during the night is generally lower than during the day.
- Windrose for Weblakes was generated from 8670 data, no missing data and data are available for either day wind speeds or night speeds.

The wind class frequency distribution as shown in **Figure 3.5**, describes the range of wind speed which occurred in Baucau. The winds most frequently blow have the velocity range between 11 – 17 knots according to Baucau Meteorological Station (frequency of occurrence: 48.7%), and between 7 - 11 knots according to *www.weblakes.com* (frequency of occurrence 54.1%). Differences in the class of wind speed which most frequently occur from these two data source are also influenced by the difference number of data source.

The wind directions are mostly governed by local topography, onshore and offshore winds, or local mountains and valleys. Therefore it is also necessary to identify the gradual change of wind directions and velocity from month to month as shown from **Figure 3.6** until **Figure 3.9.** From January to March, the prevailing winds blow from West to East and North West to South East. In April occur changes in wind direction, and from May to August the wind are distinctly blow from South East to North West. In October the directions of prevailing winds start to change again, predominantly blow from West to East. In December the prevailing winds mostly blow from the opposite direction of wind that blows in November.

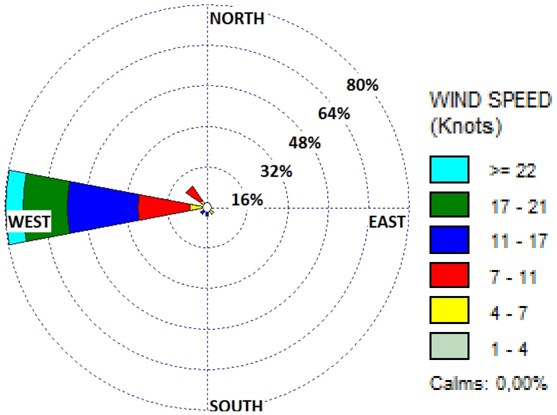
According to this behaviour of prevailing winds, the receptors that undergo the most frequent exposure to the air pollutant shall be those who live in North West of Baucau. These receptors may also have the highest probability to expose to the highest level of air pollutant concentration, since in the driest month (July - September), the prevailing winds also blow to this direction. Receptors that live in other directions may also expose to the emitted air pollutant, but in a lower frequency exposure.



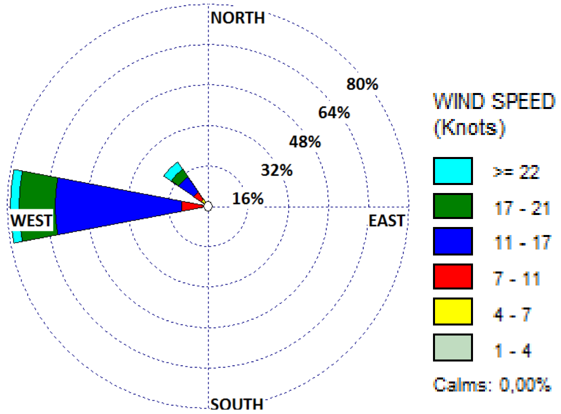
Source: Baucau Meteorological Station, 2014

Source (www.weblakes.com, 2014)

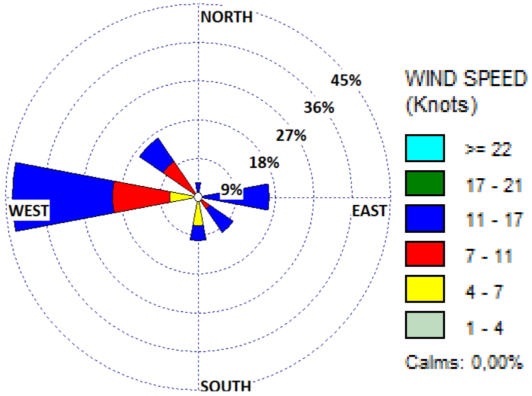
Figure 3.5 Annual Wind Rose and Wind Class Distribution Data



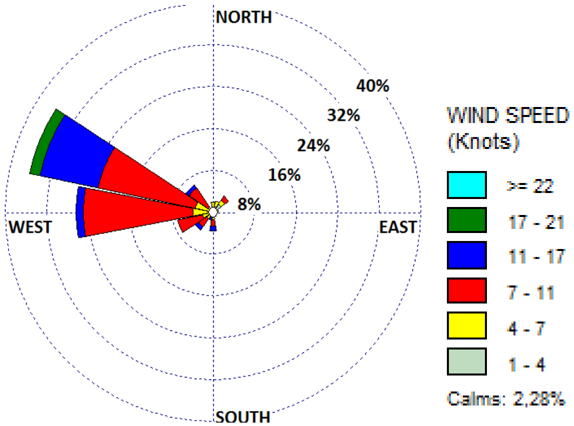
January (Baucau Meteorological Station)



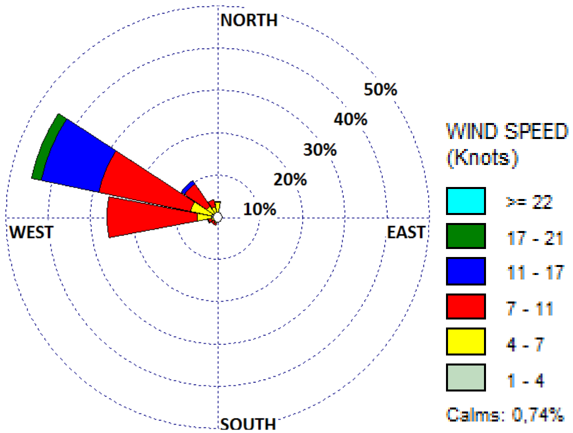
February (Baucau Meteorological Station)



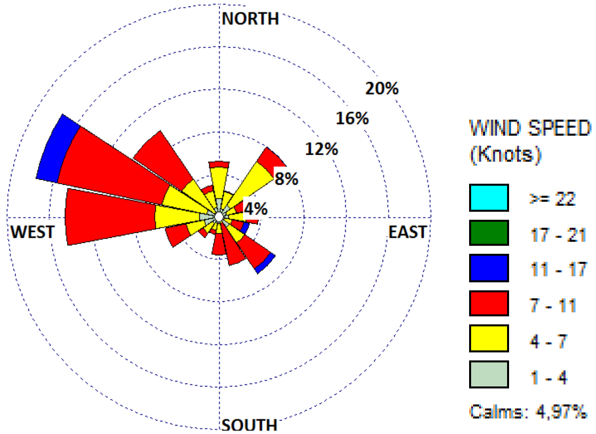
March (Baucau Meteorological Station)



January (www.weblakes.com)

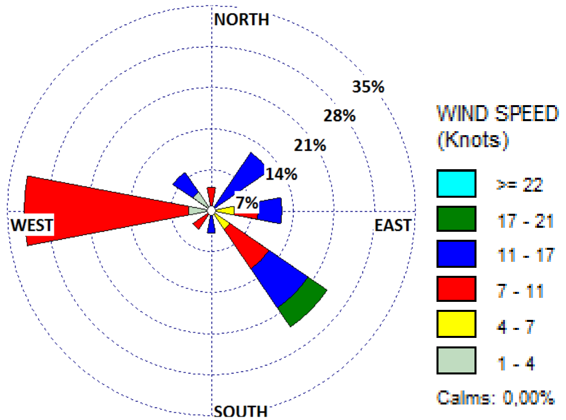


February (www.weblakes.com)

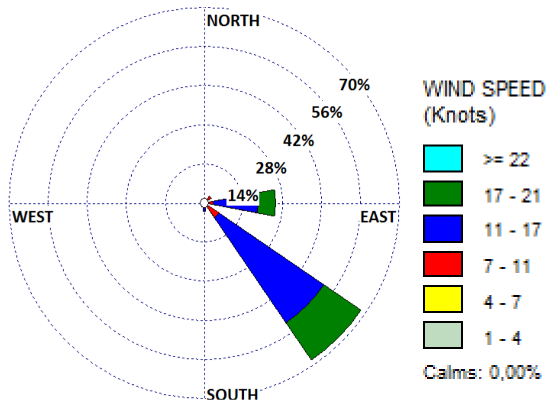


March (www.weblakes.com)

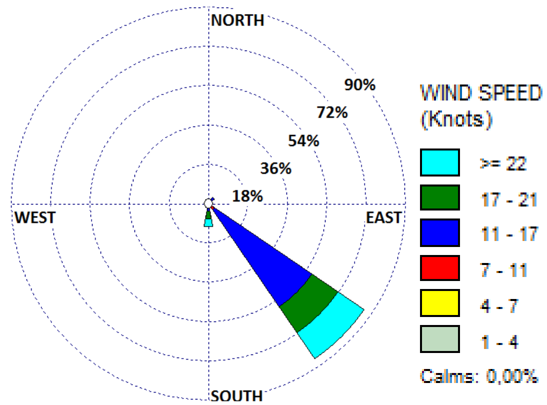
Figure 3.6 Monthly Windrose for Baucau Area from January to March 2014



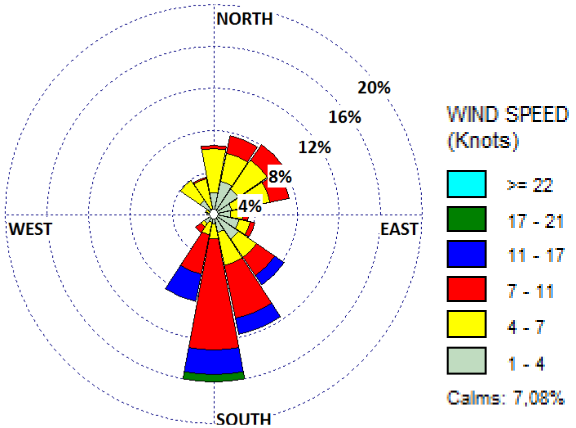
April (Baucau Meteorological Station)



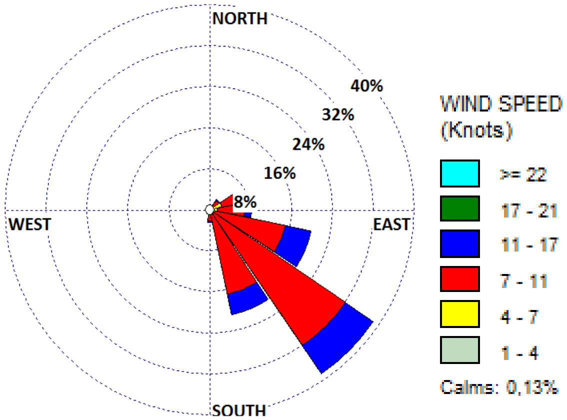
May (Baucau Meteorological Station)



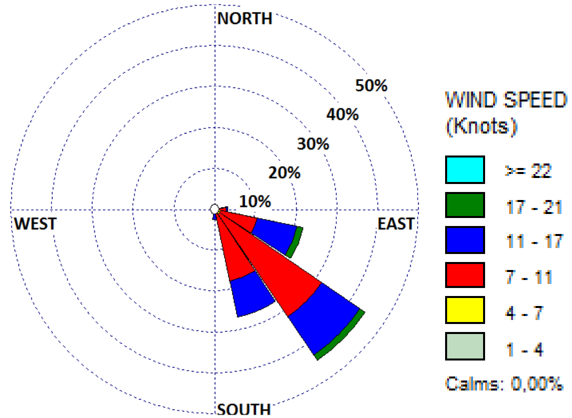
June (Baucau Meteorological Station)



April (www.weblakes.com)

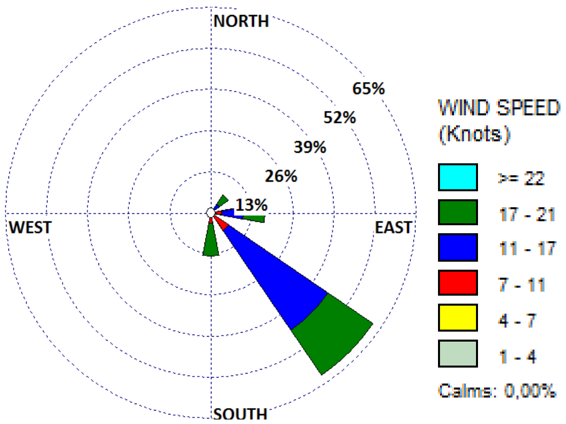


May(www.weblakes.com)

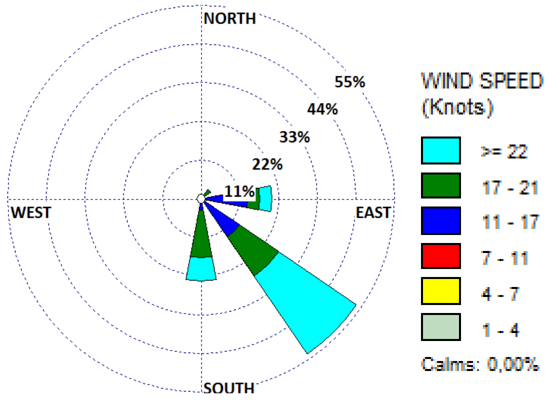


June(www.weblakes.com)

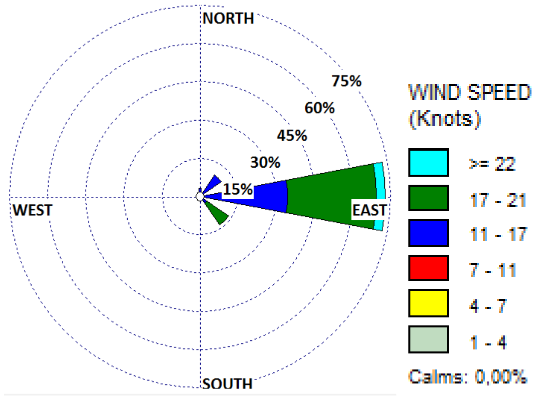
Figure 3.7 Monthly Windrose for Baucau Area from April to June 2014



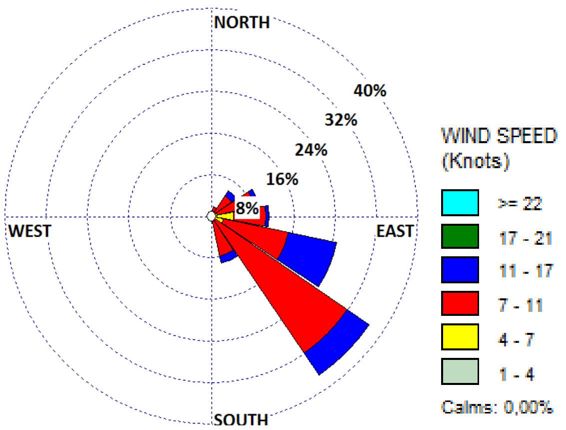
July (Baucau Meteorological Station)



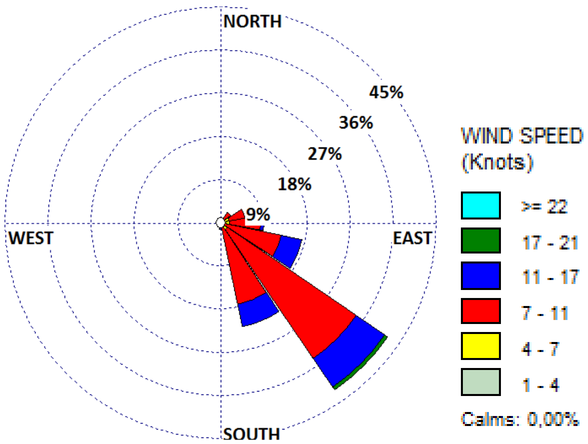
August (Baucau Meteorological Station)



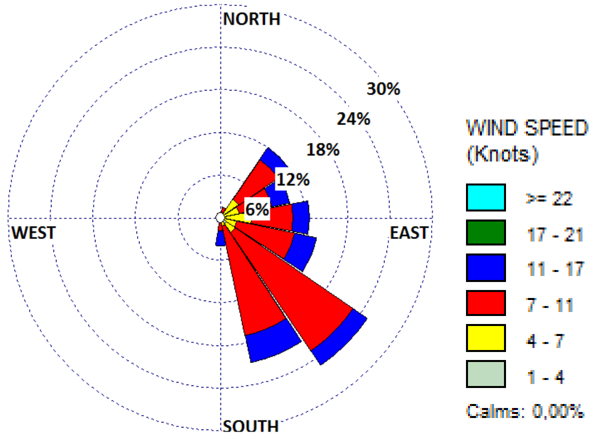
September (Baucau Meteorological Station)



July (www.weblakes.com)

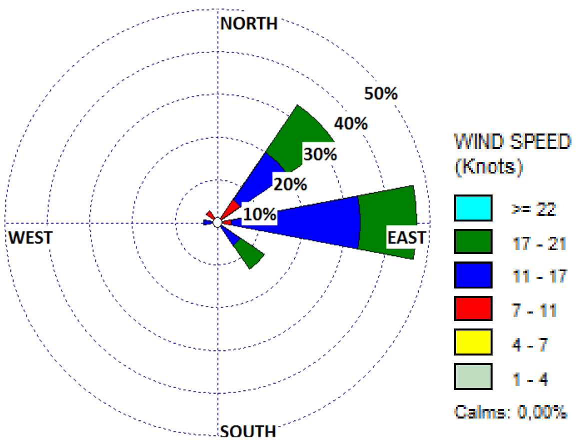


August (www.weblakes.com)

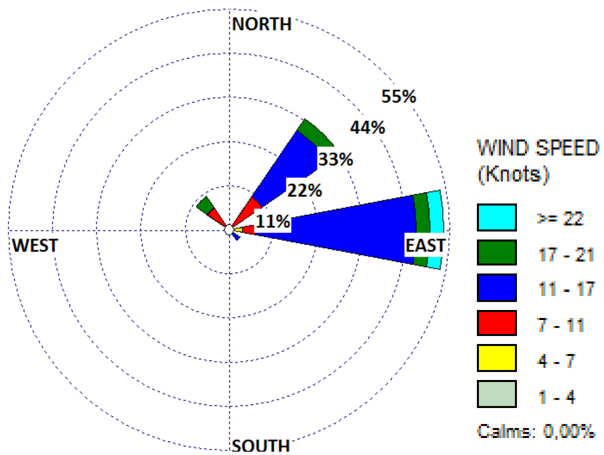


September (www.weblakes.com)

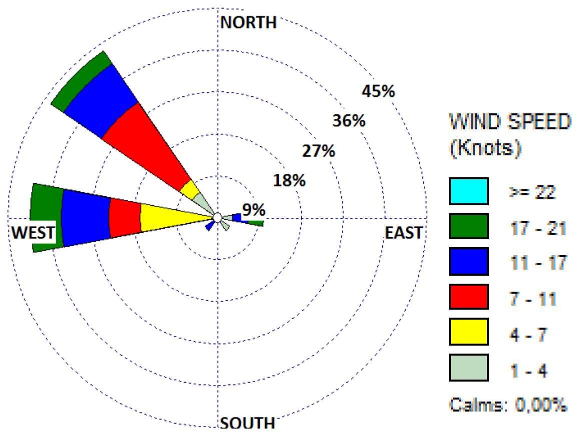
Figure 3.8 Monthly Windrose for Baucau Area from July to September 2014



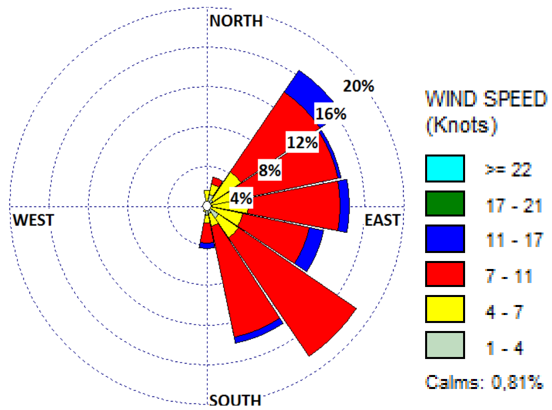
October (Baucau Meteorological Station)



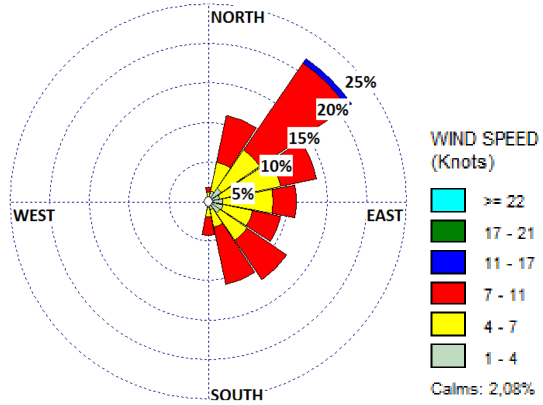
November (Baucau Meteorological Station)



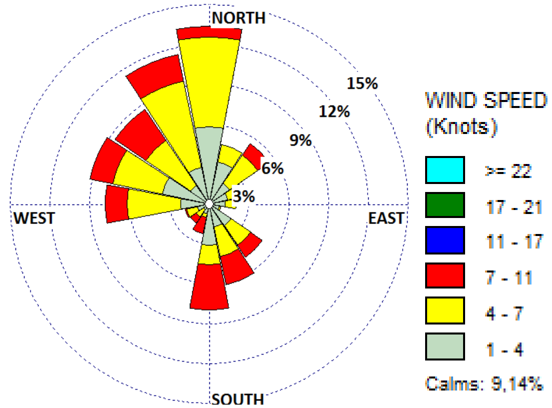
December (Baucau Meteorological Station)



October (www.weblakes.com)



November (www.weblakes.com)



December (www.weblakes.com)

Figure 3.9 Monthly Windrose for Baucau Area from October to December 2014

3.2 Air Quality Baseline

To analyse the baseline conditions within the study area, site visits and data collection exercise was carried out between 21st and 30th of May 2015 in order to:

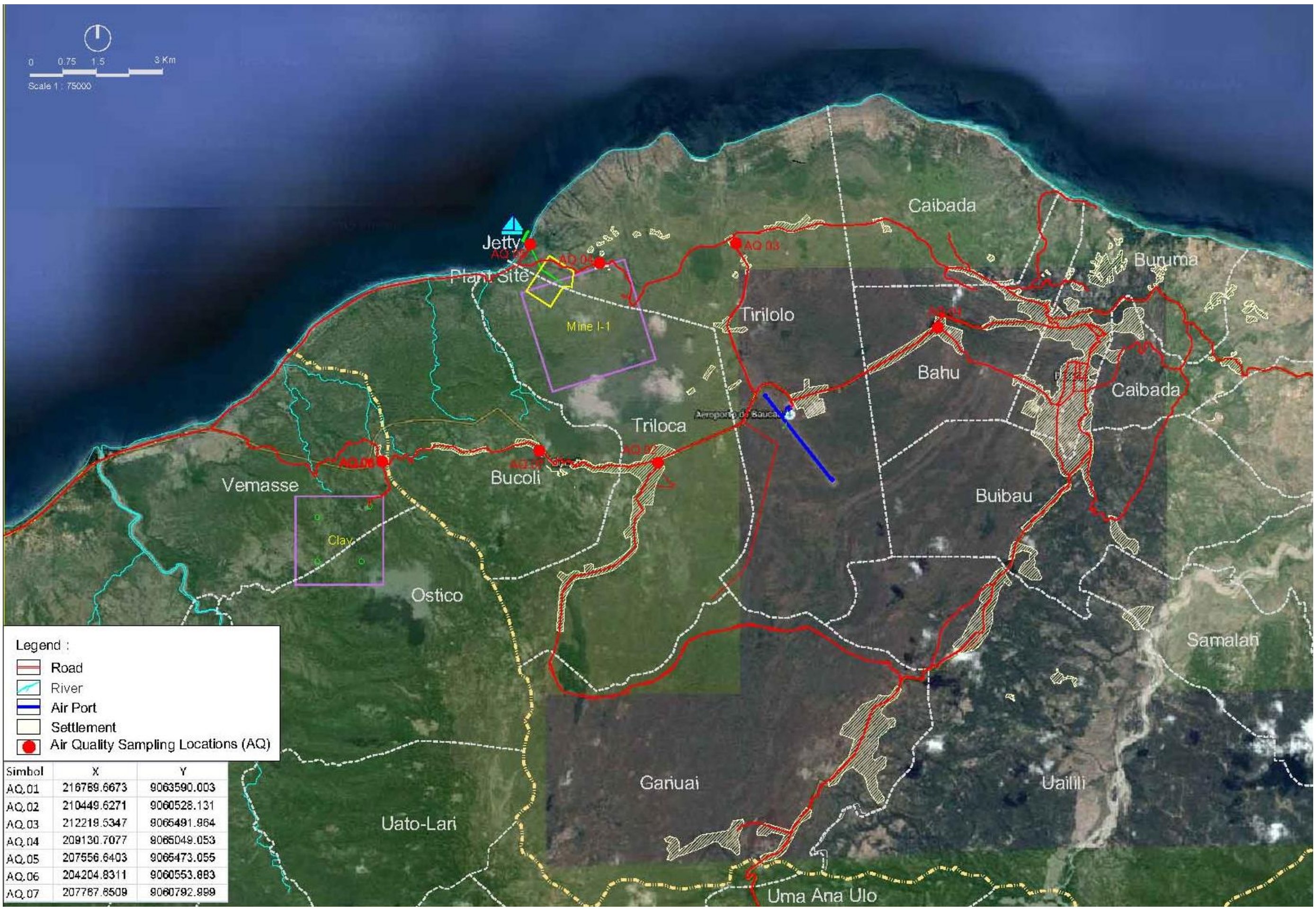
- Assess the ambient air quality with the project and surrounding areas
- Identify the existing Air Sensitive Receptors within the study area ; and
- Establish the existing air emission sources (*i.e.* impact sources) in the vicinity of the study area that might have potential (*i.e.* incremental) impact(s) on the general air quality

Seven locations as shown in **Table 3.1, Figure 3.10** until **Figure 3.24** had been chosen to represent the air quality baseline around the project area. The site selection was carried out based on the followings considerations:

- Locations which will undergo the impact of dispersed air pollutant emitted from the cement plant activities.
- Locations which are occupied by local people.

Table 3.1 Sampling Location for Collecting Primary Air Quality Data (Representative Location of Sensitive Receptors)

No.	Location	Zone	Easting	Northing	Description	Note
1.	AQ-1 Bahu	52L	216789	9063590	Settlement Area	East – south east of cement plant activities
2.	AQ-2 Check Point Triloca	52L	210449	9060528	Settlement Area	South of cement plant activities
3.	AQ-3 Aldeia Parlementu	52L	212219	9065491	School Area	East of cement plant and north east of limestone mine
4.	AQ-4 Aldeia Osso-ua	52L	209130	9065049	Settlement Area	Close the Plant Area
5.	AQ-5 Jetty Plan	52L	207556	9065473	Jetty Area	Within the Jetty Area
6.	AQ-6 Wailacama	52L	204204	9060553	Settlement Area	North east of clay quarry
7.	AQ-7 Bucoli	52L	207767	9060792	Settlement Area	South of mine and plant, North east of clay mine



Simbol	X	Y
AQ.01	216789.6673	9063590.003
AQ.02	210449.6271	9060528.131
AQ.03	212219.5347	9065491.964
AQ.04	209130.7077	9065049.053
AQ.05	207556.6403	9065473.055
AQ.06	204204.8311	9060553.883
AQ.07	207767.8509	9060792.999

Figure 3.10 Location of Air Quality Measurement

The results of air quality measurement in these locations will be considered as the background concentration of measured parameters, i.e. the concentration before the project begins. Several activities either during construction phase or during operation phase shall contribute to the increase of emission of air pollutants to the ambient air surrounding the project area.

Emission of particulates during construction phase mainly originate from the works related to site preparation, material stock piling, and vehicle movement on unpaved or paved road. Pollutant in the form of gases mainly emitted as the result of fuel combustion from operation of heavy equipment. During the operation phase, emissions from the kiln are a combination of combustion and process emissions but the emissions of the main pollutants - NO_x, sulphur oxides (SO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), as well as heavy metals and persistent organic pollutants (POPs) are assumed to originate mainly from the combustion of the fuel.

Figure 3.11 AQ-1, Location of Air Quality Measurement in Bahu

Figure 3.12 AQ-1, Location of Air Quality Measurement in Bahu (Another Point of View)

Figure 3.13 AQ-2, Location of Air Quality Measurement in Check Point Triloca

Figure 3.14 AQ-2, Location of Air Quality Measurement in Check Point Triloca (Another Point of View)

Figure 3.15 AQ-3 Location of Air Quality Measurement in Aldeia Parlementu

Figure 3.16 AQ-3 Location of Air Quality Measurement in Aldeia Parlementu (Another Point of View)

Figure 3.17 AQ-4 Location of Air Quality Measurement in Aldeia Osso-ua

Figure 3.18 AQ-4 Location of Air Quality Measurement in Aldeia Osso-ua
(Another Point of View)

Figure 3.19 AQ-5 Location of Air Quality Measurement in Jetty Plan

Figure 3.20 AQ-5 Location of Air Quality Measurement in Jetty Plan
(Another Point of View)

Figure 3.21 AQ-6 Location of Air Quality Measurement in Wailacama

Figure 3.22 AQ-6 Location of Air Quality Measurement in Wailacama (Another Point of View)

Figure 3.23 AQ-6 Location of Air Quality Measurement in Bucoli

Figure 3.24 AQ-6 Location of Air Quality Measurement in Bucoli
(Another Point of View)

PM$_{10}$ and PM$_{2.5}$

Particulate is the term of dispersed air pollutant in the solid or liquid form in the atmosphere. PM$_{10}$ is the dispersed solid particulate with a diameter of 10 micrometers or less, while PM$_{2.5}$ µm has diameter of 2.5 µm or less. These particulates are likely responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract.

Results of measurement of 24 hour ambient concentrations of PM$_{10}$ and PM$_{2.5}$ in seven locations (AQ1 until AQ7) are shown in **Figure 3.25 and Figure 3.26**. All measured PM$_{10}$ concentrations are below the standard (150 µg/m^3) according to US EPA (2013) and WHO (2005). Similarly, 24 hour PM ambient concentrations of PM$_{2.5}$ are also below the standard (75 µg/m^3) according to WHO (2005), and the standard (35 75 µg/m^3) according to US EPA (2012).

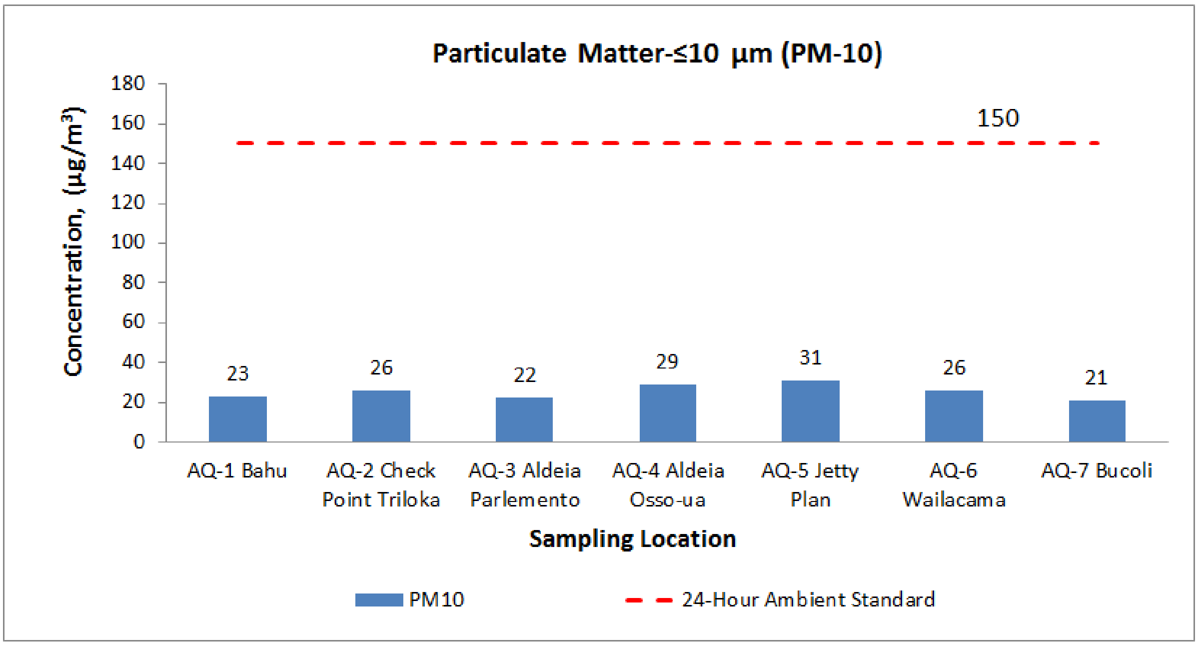


Figure 3.25 24 Hour-Ambient Concentration of PM$_{10}$

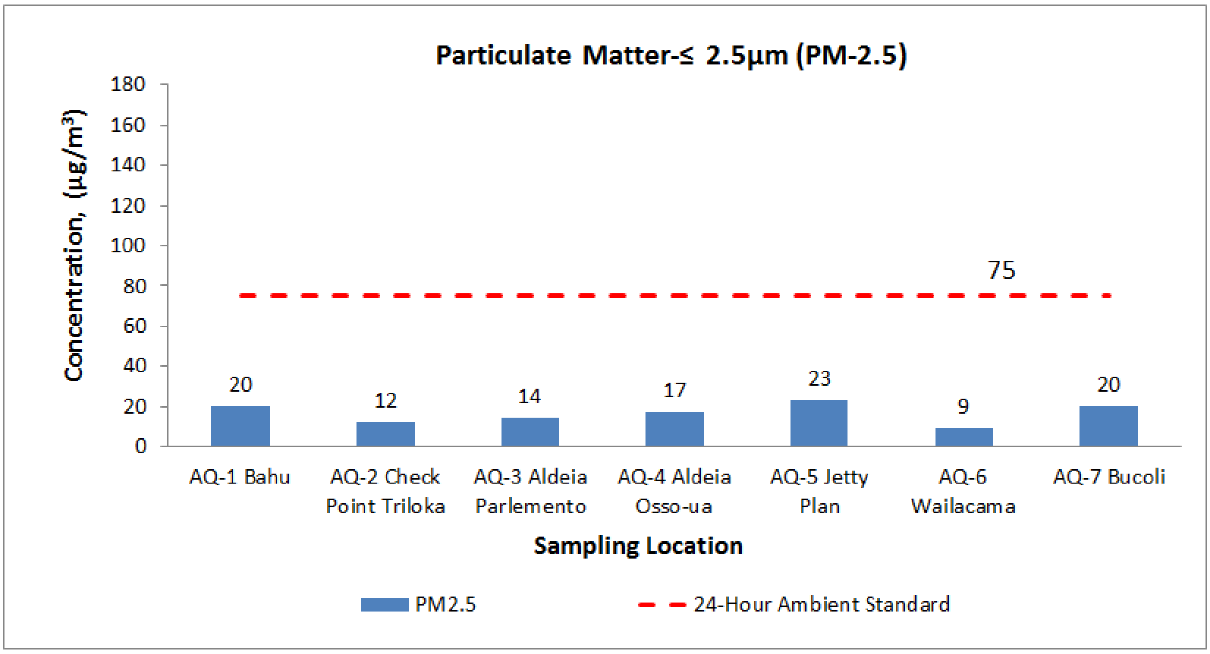


Figure 3.26 24 Hour-Ambient Concentration of $PM_{2.5}$

During the construction and operation phase of cement plant, there shall be an increase of particulate emission to the ambient air. Sources of particulate at cement plants include (1) quarrying and crushing, (2) raw material storage, (3) grinding and blending (in the dry process only), (4) clinker production, (5) finish grinding, and (6) packaging and loading. The largest emission source of particulate within cement plants is the pyro-processing system that includes the kiln and clinker cooler exhaust stacks. Often, dust from the kiln is collected and recycled into the kiln, thereby producing clinker from the dust. However, if the alkali content of the raw materials is too high, some or all of the dust is discarded or leached before being returned to the kiln. In many instances, the maximum allowable cement alkali content of 0.6 percent (calculated as sodium oxide) restricts the amount of dust that can be recycled. Bypass systems sometimes have a separate exhaust stack. Additional sources of PM are raw material storage piles, conveyors, storage silos, and unloading facilities. The magnitude of emission will be strongly influenced by the control during each stage of operation. Dust suppression facilities and actions such as road watering, stockpile covering, de-dusting mechanism using fabric filter or electrostatic precipitator, barrier installation, etc. will have significant influence in reducing the particulate emissions.

After being emitted to the atmosphere, PM_{10} and $PM_{2.5}$ shall undergo several processes such as dispersion and chemical or physical transformations in the atmosphere which are strongly influenced by the meteorology. Those particles may finally be removed by deposition from the atmosphere to the earth's surface. Deposition caused by precipitation is called wet deposition; and deposition processes which are not influenced by precipitation are summarized as dry deposition. A third kind of deposition, through which water droplets are deposited by interception of fog, mist, or clouds, is referred to as occult deposition. Since this process plays only a significant role in areas with frequent orographic cloud cover (Dollard et al. 1983), it can be neglected in most urban areas.

Wet deposition comprises processes in which particles are cooperated into droplets and subsequently transferred to the earth's surface. Particles might either serve as condensation nuclei for atmospheric water and be incorporated into the formed droplet or collide with an existing droplet. If these processes occur within a cloud, they are called in-cloud scavenging or rainout. If they take place below the cloud, they are named below-cloud scavenging or washout (Seinfeld and Pandis, 2006).

Wet deposition is a very effective way to remove particles from the atmosphere. In Baucau, wet deposition may occur during wet season which lasts from December to May.

The term dry deposition encompasses several mechanisms like turbulent diffusion, sedimentation, Brownian diffusion, interception, inertial forces, electrical migration, and etc. Deposition rates are governed by many factors, including meteorological variables such as wind velocity or relative humidity, properties of the particles (e.g., particle size and shape), and variables of the surface on which the particles are deposited. This dry deposition may occur mainly during dry season in Baucau which lasts from June to November. When considering particle dry deposition, a special focus is often laid on urban vegetation, since it provides a distinct larger surface area compared to the ground on which it stands. An optimized planting of vegetation along roads can also reduce re-suspension of particles by motorized traffic.

Carbon Monoxide

Carbon monoxide is a colourless, odourless, tasteless, and very stable gas which has lifetime between 2 until 4 months in the atmosphere. Naturally, CO is the second gas after CO_2 as the gas which has the highest concentration in the lower atmosphere (troposphere). Its natural sources originate from volcano and natural forest fire; cause the concentration around 0.2 ppm (229 µg/m^3). Anthropogenic sources of CO mostly come from the incomplete combustion of fossil fuel or combustion of fuel in motorized vehicles.

Results of CO measurements in seven locations are shown in **Figure 3.27**. One hour concentrations of CO in seven locations, were measured between 218 to 481 µg/Nm^3 far below the 1 hour standard (30.000 µg/m^3) according to WHO (2010). These concentrations are closer to the concentration of natural CO, which indicates that the current anthropogenic activities only slightly increase the ambient concentration of CO.

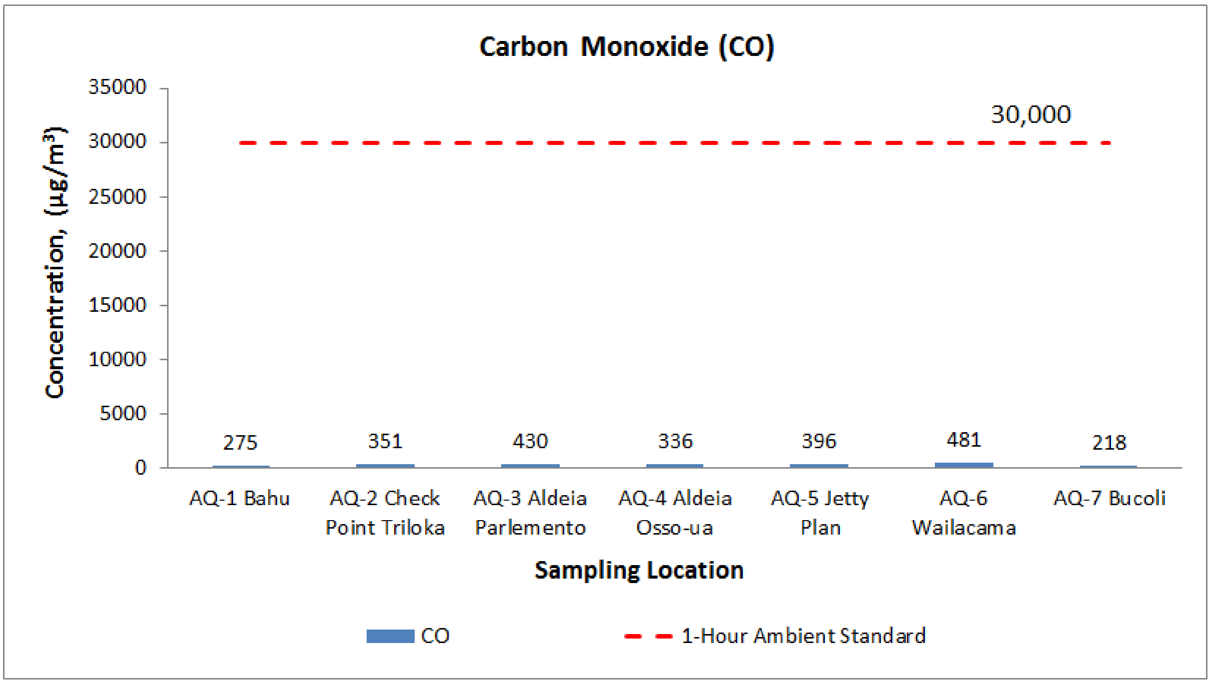


Figure 3.27 One Hour Ambient Concentration of CO

Emissions CO can occur in the primary steps of the kiln process (preheater, precalciner), when impurities (such as organic matter) that are present in the raw materials are volatized as the raw mix is heated. Elevated CO levels occur in cement kilns or a number of reasons. Calcinations, which is critical to the cement production process, results in CO by product, as does the decomposition of carbon dioxide due to extremely high moisture and metallic catalyst. Finally, partial oxidation of hydrocarbons present in raw materials may also produce CO.

Nitrogen Dioxides

Nitrogen dioxide (NO_2) and nitrogen monoxide (NO) are compound containing nitrogen in the atmosphere, and become very important indicator of air pollution. Naturally, NO_x can be formed in the atmosphere through lightning, oxidation of NO with the help of ozone, as well as activities in farming area. Anthropogenic sources originate from the process of combustion of fuel containing nitrogen (fuel NO_x) or from combustion condition at high temperature where reaction between N_2 and O_2 might occur (thermal NO_x).

One hour nitrogen dioxide concentrations in Baucau area which were measured in seven locations are still below the standard (200 µg/m^3) according to WO (2005) and European Union as shown in **Figure 3.28.** The measured concentration ranged between 7 to 28 µg/m^3.

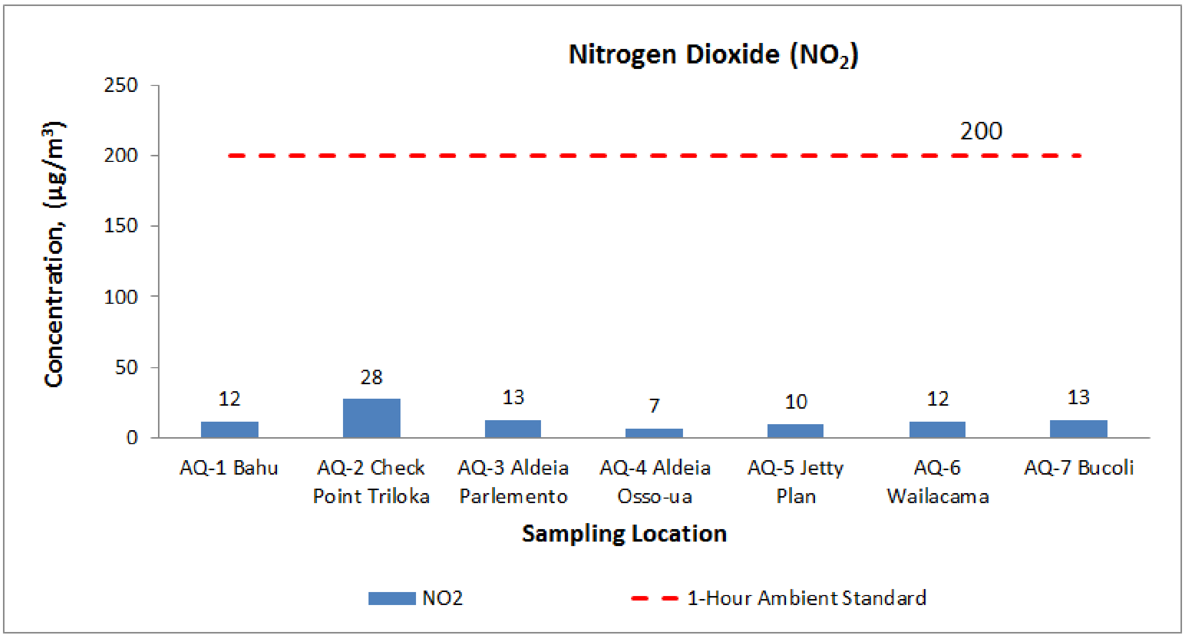


Figure 3.28 One Hour Ambient Concentration of NO_2

As it was illustrated before, NO_x are formed in the combustion process either by oxidation of the nitrogen in the combustion air (thermal NO_x), or by oxidation of the nitrogen compounds in the fuel (fuel NOx). Thermal NO_x is formed at temperatures above 1200˚C. Due to the very high temperatures in the cement kiln thermal NO_x dominate the composition of produced NO_x. Nitrogen monoxide accounts for about 95 % and nitrogen dioxide for about 5 %.

Sulphur Dioxide

Sulphur dioxide is a non-flammable gas, not explosive, colourless and can cause a sensational taste at concentration of 0.3 ppm (784 µg/Nm^3) until 1 ppm (2,612 µg/Nm^3). Sulphur dioxide can easily react with other component to form a dangerous compound such as sulphite acid, sulphate acid, and other sulphate particles. Natural resources of SO_2 originate from volcano, ocean, decomposition processes, and natural forest fire. 24 hour average concentration of SO_2 originates from natural sources is about 10 µg/Nm^3 (EMEP-MSC, 1995). Sulphur dioxide from anthropogenic sources is emitted from industrial activities which utilize coal as energy source, smelting process, sulphate acid production, pulp and paper, and incineration of waste containing sulphur.

Results of SO_2 measurements (**Figure 3.29**) in seven location show that SO_2 concentration are far below the standard (196 µg/m^3 and) according to WHO (2005). The measured concentrations range between <8.5 µg/m^3 to 18 µg/m^3, which are around the level of natural concentration.

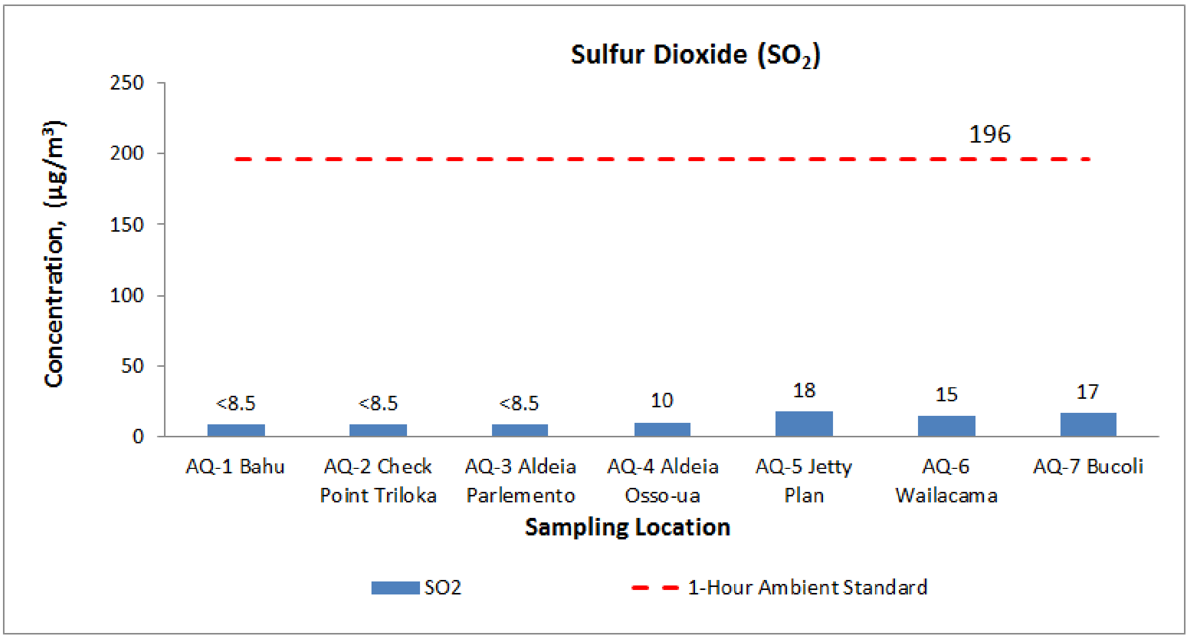


Figure 3.29 One Hour Ambient Concentration of Sulphur Dioxide (SO_2)

SO_2 emissions from cement plants are primarily determined by the content of volatile sulphur in the raw materials. This sulphur is emitted as SO_2 from the low temperature end of the kiln system. Sulphur present as sulphate in the raw materials is only partly decomposed at high temperatures and almost completely discharged from the kiln system with the clinker. Sulphur introduced into the kiln with the fuels is oxidized to SO_2 and will not lead to significant SO_2 emissions as SO_2 formed at the hot end of the kiln system reacts with the reactive, fine raw materials in the sintering zone, the pre-calciner and the hot part of the preheater.

Hydrocarbon

Hydrocarbon is the organic compound consists of carbon and hydrogen. The term of hydrocarbon can also be used for the functionalized organic compound (VOC) consists of atoms such as oxygen, hydrogen, halogen (chlorine, bromine, and Iodine), nitrogen, and phosphor. Hydrogen might exist in the atmosphere in two forms, depends on its volatility and its vapor pressure. If exist in the form of semi volatile compound (SVOC), the hydrocarbon are freely move in the atmosphere. If the hydrocarbon has a low vapor pressure, it can have a semi volatile condition. Hydrocarbon can also be differentiated as methane hydrocarbon (MHC) and non-methane hydrocarbon (NMHC).

Hydrocarbon as trace gases in the atmosphere has a very low concentration. Methane has the highest concentration, around 1.7 ppm (1,110 µg/m^3). Other types of hydrocarbon are measured in the very low concentration, e.g., isoprene (C_5H_8) is 0.6 – 2.5 ppb (2-7 µg/Nm^3) and terpene ($C_{10}H_{16}$) is 0,03 – 2 ppb (0,2 – 11 µg/Nm^3).

Results of measurement shows concentration of 3 hour ambient concentration of NMHC in seven locations are still below the standard (160 µg/m^3) according to US EPA. All measured concentration are below the detection of the method, i.e. less than 1 µg/m^3 as shown in **Figure 3.30**.

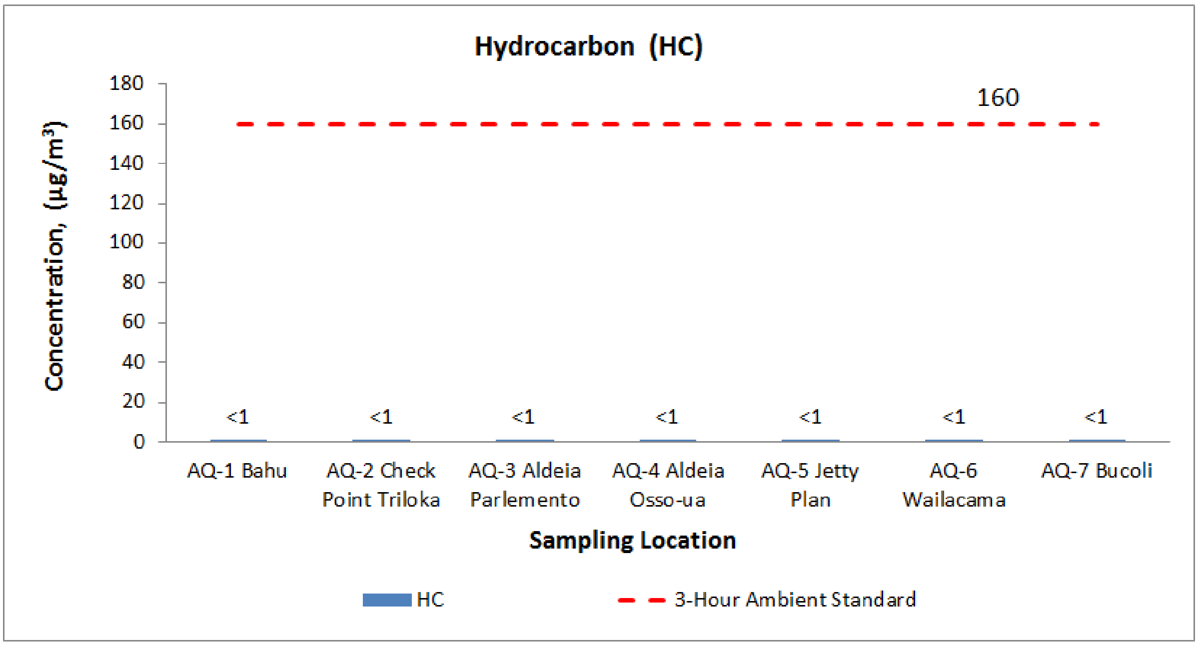


Figure 3.30 Three Hour Ambient Concentration of Hydrocarbon

Ozon (O_3)

Natural ozone in lower atmosphere (troposphere) has concentration of 20 ppb (40 µg/m^3). Additional ozone concentration might come from the chemistry reaction in troposphere and movement of ozone form stratosphere to troposphere. Ozone formation as the results of anthropogenic activities occur when hydrocarbon react with nitrogen oxide in the present of sunlight. Mixing between reactant and product related to hydrocarbon, nitrogen oxide, and sunlight is called as photochemical smog.

Results of ozone measurement in seven locations show the concentration far below the standard (235 µg/Nm^3) according to US EPA 1997 (see **Figure 3.31**). The measured ozone value is between < 2.5 µg/m^3 and 19 µg/m^3. The observation of ozone concentration is an important part of air quality monitoring, because ozone is a secondary pollutants which is not directly emitted from the source, but formed in the atmosphere due to photochemical reactions of primary air pollutants (NO_2 and hydrocarbon) in the present of sunlight.

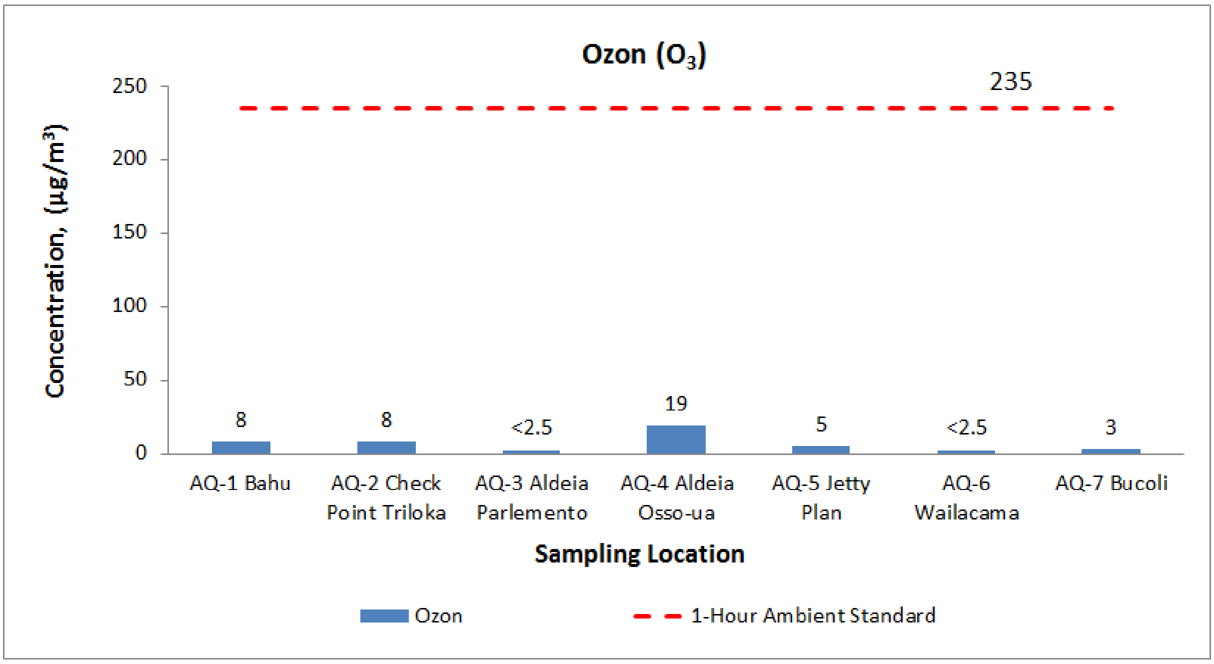


Figure 3.31 One Hour Ambient Concentration of Ozone

4. IMPACT ASSESSMENT

Impact assessment of cement TL activities was carried out quantitatively by using modelling tools, both during construction and operation phase. The impact assessment divided into two major parts, i.e.; the emission inventory and prediction of future ambient air quality. Emission rates from inventory calculation become the input for prediction of future ambient air quality combine with other supporting data such as Baucau meteorological data and topographical data. The results of prediction are presented in the form isopleth map to describe the dispersion of air pollutants over the project surrounding area and sensitive receptors.

4.1 Emission Inventory

Emissions during the construction of the project can be associated with site preparation and construction of a particular facility itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. The quantity of dust emissions from constructions and operations are proportional to the area of land being worked and to the level of construction activity. By analogy to the parameter dependence observed for other similar fugitive dust sources, one can expect emissions from heavy construction and operations to be correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [μm] in diameter), the speed and weight of the average vehicle, as well as the soil moisture content. Detail calculations of emission rates from particulate (dust) and gas generating activities in cement plant and jetty area, limestone mine, and clay mine are described in **Table 4.1** until **Table 4.5**.

Emissions during the operation phase can be classified into four major sources which are calculated according to area specific activities:

- Particulates and gases from cement plant operation

  There are five main point sources (kiln house stack, cooler electrostatic precipitation stack, cement mill bag house stack, coal mill bag house stack, and thermal power plant stack) which continuously emit air pollutants associated with the operation stage of the cement plant as described in **Table 4.6**.

- Particulate and gases from limestone mine and clay mine operation

  Emissions of particulates occur from a number of operations in material quarrying and processing. Activities such as bulldozing, truck loading/unloading, blasting, drilling, active storage pile (where wind erosion might occur) and vehicle movements are considered to be the main source of particulate generation. Other particulate generation also comes from the operation of main and ancillary equipment during the mine operation. The combustion of fuels during the operation of this equipment may also release gases to the ambient air. Detail calculations for the emission rates of air pollutants are described in **Table 4.7** until **Table 4.10** for limestone mine operation and **Table 4.11** until **Table 4.13** for clay mine operation.

- Particulate and gases from clay hauling from clay mine to cement plant

  Clay hauling from clay mine to cement plant has a long route on a paved road, passes several villages start from Bucoli – Triloca – Tirilolo – Laelesu, Parlemento, Osso-ua, until cement plant. Particulate emissions occur whenever vehicles travel over a paved surface such as a road. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and re-suspension of loose material on the road surface. In general terms, re-suspended particulate emissions from paved roads originate from, and result in the depletion of the loose material present on the surface (i.e., the surface loading).

Detail calculation for particulate and gases from clay hauling are shown in **Table 4.14** until **Table 4.16**.

Construction Phase

- *Particulates from site preparations*

Table 4.1 Activity Data of Site Preparation

No	Dust Generating Activities	Activity Supporting Data													
		Number of equipment			Silt content	Moisture Content	Operating hours	Mean Vehicle Speed	Wind Speed	Material	Active Storage Area	Vehicle km travel	Average Weight of the Vehicles	Mean number of wheels	number of days with at least 0.254 mm of precipitation per year
		Cement Plant and Jetty	Limestone Mine	Clay Mine											
					s	M		S	U	Mat	A	VKT	W	w	p
					%	%	hours/day	VKT		Mg/day	Ha	km/day	ton		days
1	Bulldozing (top soil)	1	1	1	6.2	10	5.5								
						10			8	10					
3	Active storage pile (emission due to wind erosion and maintenance										2				
4	Vehicle movement	21	7	4	6.2			25				40	15	8	130

Table 4.2 Emission Rate Calculation for Site Preparation

No	Dust Generating Activities	Emission Factor				Emission Rate					
						Cement Plant Area		Limestone Mine		Clay Mine	
		PM_{10}	$PM_{2.5}$	Unit	Source	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
		EF				E					
						g/s					
1	Bulldozing (top soil)	$0.75\,\frac{18.6\,(s)^{1.5}}{(M)^{1.4}}$	$0.022\,\frac{78.4\,(s)^{1.2}}{(M)^{1.3}}$	Kg/hour	AP.42 Sec.13.2, Table 13.2.3	E =R*1000*(EF*OH)/(24*3600)					
		9.034515535	1.824691436			6.E-01	1.E-01	6.E-01	1.E-01	6.E-01	1.E-01
2	Loading and unloading excavated material using trucks	$k * 0.0016 * \frac{(\frac{U}{2.2})^{1.3}}{(\frac{M}{2})^{1.4}}$ k=0.35 for PM10,& 0.053 for PM 2.5		Kg/Mg	Ap.42 Sec. 13.2.4	E =2*1000*(EF*Mat)/(24*3600)					
		0.000315	0.000048			7.E-05	1.E-05	7.E-05	1.E-05	7.E-05	1.E-05
3	Active storage pile (emission due to wind erosion and maintenance	*0.85 for TSP, multiplication factor for PM10: 0.75, and PM2.5: 0.105		Mg/hectare/ year	Ap.42 Sec.11.9, Table 11.9.2	E =1000*(EF*A)/(365*24*3600)					
		0.6375	0.08925			4.E-05	6.E-06	4.E-05	6.E-06	4.E-05	6.E-06
4	Vehicle movement	$E = k\,5.9\left(\frac{s}{12}\right)\left(\frac{S}{30}\right)\left(\frac{W}{3}\right)^{0.7}\left(\frac{w}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)$ K = 0.36 for PM_{10}, and 0.095 for $PM_{2.5}$		g/VKT		E = (R*VKT*EF)/(24*3600)					
		722.1526	190.5681			2.E-02	5.E-03	6.E-03	2.E-03	4.E-03	1.E-03
	Total					6.E-01	1.E-01	6.E-01	1.E-01	6.E-01	1.E-01

Table 4.3 Main Equipment Activities for Site Preparation

No	Equipment	Activities: Cement Plant and Jetty	Activities: Limestone Mine	Activities: Clay Mine	Capacity	Operating Hours	Emission Factor: PM_{10}	Emission Factor: $PM_{2.5}$	Emission Factor: CO	Emission Factor: NO_x	Emission Factor: SO_2
					P	OH					
					bhp	hours/day					
1	Water truck/fuel truck, MHDT	7	2	2		8	1.88	0.72	4.62	7.31	0.01
2	Crane	7			173	8	0.26	0.239	3.41	5.1	0.006
3	Low & Flat bed trailer, HHDT	7	2	1		8	2.3	0.72	10.14	7.31	0.03
4	Fork lift	3			173	8	0.249	0.229	3.353	4.32	0.006
5	Welding generators	5			49	8	0.525	0.483	6.028	5.549	0.007
6	Excavator	3	2	1	173	8	0.259	0.239	3.377	4.523	0.006
7	Bulldozer / Ripper	3	1	1	493	8	0.14	0.129	3.053	4.7	0.006
8	Dump Truck, HHDT	7	3	2		8	2.3	0.72	10.14	7.31	0.03
9	Motor Grader		1		173	8	0.26	0.239	3.369	5.1	0.006
10	Wheel Loader	5			247	8	0.109	0.1	1.194	2.8	0.006
11	Power generators	2	1	1	226	8	0.13	0.12	1.27	3.87	0.01

Table 4.4 Emission Rate Calculation for Main Equipment Activities during Construction Phase

No	Equipment	Emission														
		Cement Plant and Jetty					Limestone Mine					Clay Mine				
		PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
		g/s														
1	Water truck/fuel truck, MHDT	E = (R*EF*OH)/(24*3600)														
		1.2E-03	4.7E-04	3.0E-03	4.7E-03	6.5E-06	3.5E-04	1.3E-04	8.6E-04	1.4E-03	1.9E-06	3.5E-04	1.3E-04	8.6E-04	1.4E-03	1.9E-06
2	Crane	E = (R*EF*P*OH)/(24*3600)														
		2.9E-02	2.7E-02	3.8E-01	5.7E-01	6.7E-04										
3	Low & Flat bed trailer, HHDT	E = (R*EF*OH)/(24*3600)														
		1.5E-03	4.7E-04	6.6E-03	4.7E-03	1.9E-05	4.3E-04	1.3E-04	1.9E-03	1.4E-03	5.6E-06	2.1E-04	6.7E-05	9.4E-04	6.8E-04	2.8E-06
		E = (R*EF*P*OH)/(24*3600)														
4	Fork lift	1.2E-02	1.1E-02	1.6E-01	2.1E-01	2.9E-04										
5	Welding generators	1.2E-02	1.1E-02	1.4E-01	1.3E-01	1.6E-04										
6	Excavator	1.2E-02	1.1E-02	1.6E-01	2.2E-01	2.9E-04	8.3E-03	7.6E-03	1.1E-01	1.4E-01	1.9E-04	4.1E-03	3.8E-03	5.4E-02	7.2E-02	9.6E-05
7	Bulldozer / Ripper	1.9E-02	1.8E-02	4.2E-01	6.4E-01	8.2E-04	6.4E-03	5.9E-03	1.4E-01	2.1E-01	2.7E-04	6.4E-03	5.9E-03	1.4E-01	2.1E-01	2.7E-04
8	Dump Truck, HHDT	E = (R*EF*OH)/(24*3600)														
		1.5E-03	4.7E-04	6.6E-03	4.7E-03	1.9E-05	6.4E-04	2.0E-04	2.8E-03	2.0E-03	8.3E-06	4.3E-04	1.3E-04	1.9E-03	1.4E-03	5.6E-06
		E = (R*EF*P*OH)/(24*3600)														
9	Motor Grader	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.2E-03	3.8E-03	5.4E-02	8.1E-02	9.6E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
10	Wheel Loader	1.2E-02	1.1E-02	1.4E-01	3.2E-01	6.8E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
11	Power generators	5.4E-03	5.0E-03	5.3E-02	1.6E-01	4.2E-04	2.7E-03	2.5E-03	2.7E-02	8.1E-02	2.1E-04	2.7E-03	2.5E-03	2.7E-02	8.1E-02	2.1E-04
	Total	1.1E-01	9.6E-02	1.5E+00	2.3E+00	3.4E-03	2.3E-02	2.0E-02	3.3E-01	5.3E-01	7.9E-04	1.4E-02	1.3E-02	2.2E-01	3.7E-01	5.9E-04

Table 4.5 Emission Rate from Construction Phase

No	Source	Cement Plant and Jetty Construction					Limestone Plan Construction					Clay Mine Construction				
		PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
		$g/s/m^2$														
1	Site preparation	2.E-06	3.E-07				2.E-06	3.E-07				2.E-06	3.E-07			
2	Equipment activities during construction phase	3.0E-07	2.7E-07	4.2E-06	6.5E-06	9.6E-09	6.6E-08	5.8E-08		1.5E-06	2.2E-09	4.1E-08	3.6E-08	6.4E-07	1.1E-06	1.7E-09
	Total	2.0.E-06	6.E-07	4.E-06	6.E-06	1.E-08	1.7.E-06	3.9.E-07	9.5E-07	1.5E-06	2.2E-09	1.69.E-06	3.7.E-07	6.E-07	1.E-06	2.E-09

Note: Calculation was made based on an assumption concentrated area of the construction activities about 35 Ha

Operation Phase

- *Particulates and gases from cement plant operation*

Table 4.6 Emission from Cement Plant Operation - Main Point Sources

No.	Point Source	Stack Diameter	Stack Height	Gas Stack Temperature	Velocity	Output concentration				Cross Section Area	Gas Flowrate	Emission rate				
						PM_{10}	SO_2	NO_2	C0			PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO
		D	H	T	v	C				A_{cross} = 0.25 □ D	Q = A_{cross}*v	E = (Q*C)/1000				
		m	m	Celsius	m/s	mg/Nm^3				m^2	m^3/s	g/s				
1	Kiln/Raw mill bag House stack	4	120	120	18	30	200	800	500	12.57	226.29	6.79	0.95	45.26	181.03	113.14
2	Cooler ESP stack	3.4	35	110	18	30				9.08	163.49	4.90	0.69			
3	Cement Mill bag House Stack	1.5	55	90	18	30				1.77	31.82	0.95	0.13			
4	Coal Mill Bag House Stack	2	65	77.5	18	30				3.14	56.57	1.70	0.24			
5	Thermal Power plant Stack	2.5	90	140	18	30	200	800	500	4.91	88.39	2.65	0.37	17.68	70.71	44.20

- *Particulate and gases from limestone mine operation*

Table 4.7 Activity Data of Limestone Mine Operation

No	Activity	Material	Activity Supporting Data															
			Pro-duction	Overbur-den & Inter-burden handling	Effective working hour per day	Mine Working Days	Number of blasting	Blasting area	Water Content	Opera-tion Hour	Silt Content	Vehicle Km Travel	average weight of the vehicles travelling the road	mean num-ber of wheels	Ave-rage wind speed	Mean vehicle speed	number of days with at least 0.254 mm of precipitation/year	Storage pile area
			C				B	A	M	OH	s	VKT	W	w	U	S	p	A
			ton/ year	ton/hour	hours/ day	days/ year	Blasting /year	m^2	%	hour/ year	%	VKT/year	tone		m/sec	km/hour		Hectare
1	Bulldozing	Overburden							10	1,650	6.2							
2	Truck Loading	Overburden	854,700	259	11.0	300												

No	Activity	Material	Pro-duction	Overbur-den & Inter-burden handling	Effective working hour per day	Mine Working Days	Number of blasting	Blasting area	Water Content	Opera-tion Hour	Silt Content	Vehicle Km Travel	average weight of the vehicles travelling the road	mean num-ber of wheels	Ave-rage wind speed	Mean vehicle speed	number of days with at least 0.254 mm of precipitation/year	Storage pile area
			C				B	A	M	OH	s	VKT	W	w	U	S	p	A
			ton/ year	ton/hour	hours/ day	days/ year	Blasting /year	m^2	%	hour/ year	%	VKT/year	tone		m/sec	km/hour		Hectare
3	Truck unloading	Overburden	854,700															
4	Blasting	Limestone / Overburden					20	9,498										
5	Drilling	Limestone	2,095,432															
6	Truck Loading	Limestone	2,095,432															
7	Truck unloading		2,095,432															
8	Active storage pile (wind erosion and maintenance)	Lime-stone or overburden																20.0
9	Dump truck movement	Unpaved road									6.20	59,400	3	8	8	25	15.5	

Table 4.8 Emission Rate Calculation for Limestone Mine Operation

No	Mining Activities		Emission Factor Calculation			Emission Rate Calculation			
	Activity	Material	PM_{10}	$PM_{2.5}$	Unit	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
			EF			E		E2	
						kg/year		g/s	
1	Bulldozing	Overburden	$((0{,}45*s^{1{,}5})/M^{1{,}4}))*0.75$	$((2{,}6*s^{1{,}2})/M^{1{,}3}))*0.105$	kg/jam	E = OH*EF		E2=(E*1000)/(365*24*3600)	
			0.2074	0.1222	kg/jam	342.25	201.61	1.1E-02	6.4E-03
2	Truck Loading	Overburden				C*EF			
			0.00036	0.0002	kg/Mg, kg/ton	307.69	170.94	9.8E-03	5.4E-03
			0.00036	0.0002	kg/t	307.69	170.94	9.8E-03	5.4E-03
4	Blasting	Limestone or Overburden	$(0{,}00022*A^{1{,}5})*0{,}52$	$(0{,}00022*A^{1{,}5})*0{,}03$	kg/blasting	B*EF			
			106	6	kg/blasting	2,118	122	6.7E-02	3.9E-03

No	Mining Activities		Emission Factor Calculation			Emission Rate Calculation			
	Activity	Material	PM_{10}	$PM_{2.5}$	Unit	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
			EF			E		E2	
						kg/year		g/s	
5	Drilling	Limestone				C*EF			
			0.00004		kg/ton	67		2.1E-03	3.0E-04
			0.000008		kg/ton	16.76		5.3E-04	7.4E-05
			0.000008		kg/ton	13		4.3E-04	6.0E-05
8	Active storage pile (wind erosion and maintenance)	Limestone or overburden				A*EF			
			0.41	0.0041	ton/(hectare*yr)	8,200	82	2.6E-01	2.6E-03
9	Dump truck movement	Unpaved road	0.36*5.9(s/12)*(S/30)*(W/3)0.7 *w/4)^0.5*((365-p)/365)*281.11	0.095*5.9(s/12)*(S/30)*(W/3)0.7*w/4)^0.5*((365-p)/365)*281.12	g/VKT	VKT*EF			
			836	221		49,643	13,100	1.6E+00	4.2E-01
						Total with 30 % Suppression		1.4E+00	3.1E-01

Table 4.9 Emission Rate Calculation for Main and Ancillary Equipment during Limestone Mine Operation

No	Activity Data (A)						Emission Factor (EF)						Emission Rate				
	Equipment	Specification	Require-ment	Capa-city	Operating hours	Vehicle Mile Travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
			R		OH	VMT	EF						E				
				bhp	hours/ year	Mile/year							g/s				
1	Main Mining Equipment												E = (EF*Cap*OH*R)/(365*24*3600)				
	Drilling machine	385 Hp	3	379.61	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]	3.E-02	3.E-02	4.E-01	5.E-01	7.E-04
	Excavator with rock breaker	40 ton class, 175 Hp	1	172.55	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]	5.E-03	4.E-03	6.E-02	8.E-02	1.E-04
2	Loading												E = (EF*Cap*OH*R)/(365*24*3600)				
	Hydraulic excavator	4.5 m^3 bucket cap., 450 Hp	3	172.55	3300		0.259	0.239	3.377	4.523	0.006	g/bhp-hr[a]	1.E-02	1.E-02	2.E-01	2.E-01	3.E-04
	Loader	4 m^3 bucket, 350 Hp	1	246.5	3300		0.109	0.100	1.194	2.800	0.006	g/bhp-hr[a]	3.E-03	3.E-03	3.E-02	7.E-02	2.E-04
3	Transportation												E = (EF*OH*R)/(365*24*3600)				

No	Equipment	Specification	Require-ment	Capa-city	Operating hours	Vehicle Mile Travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
	Activity Data (A)						Emission Factor (EF)						Emission Rate				
			R		OH	VMT	EF						E				
				bhp	hours/ year	Mile/year							g/s				
	Off highway dump truck, HHDT	36 ton payload cap., 450 Hp	2		330		0.760	0.700	45.960	114.93	0.060	g/hr[a]	2.E-05	1.E-05	1.E-03	2.E-03	1.E-06
			8		2970		2.300	0.720	10.140	19.56	0.030	g/hr[a]	2.E-03	5.E-04	8.E-03	1.E-02	2.E-05
4	Ancillaries												E = (EF*Cap*OH*R)/(365*24*3600)				
	Bulldozer with ripper	300 – 350 Hp	1	345.1	3300		0.14	0.129	3.053	4.7	0.006	g/bhp-hr[a]	5.E-03	5.E-03	1.E-01	2.E-01	2.E-04
	Grader	140 – 150 hp	1	147.9	3300		0.26	0.239	3.369	5.1	0.006	g/bhp-hr[a]	4.E-03	4.E-03	5.E-02	8.E-02	9.E-05
													E = (0.45*1000*VMT*EF*R)/(365*24*3600)				
	Jeeps - Double Axle drive		2			36,828	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]	5.E-04	4.E-04	1.E-02	1.E-02	3.E-05
	Water sprinkler (truck chassis mounted)		1			17,820	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]	3.E-04	2.E-04	6.E-03	7.E-03	1.E-05
	Fuel tanker (truck chassi mounted)		1			17,820	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/mile[b]	3.E-04	2.E-04	6.E-03	7.E-03	1.E-05
	Mobile service van		1			36,828	9.3E-05	6.0E-05	6.1E-03	6.0E-04	1.E-05	pounds/mile[b]	5.E-05	3.E-05	3.E-03	3.E-04	6.E-06
					Total								6.E-02	6.E-02	9.E-01	1.E+00	2.E-03

Table 4.10 Emission Rate from Limestone Operation

No	Limestone Mine Operation	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
		Emission Rate									
		E					E2 = E / 500000				
		g/s					$g/s/m^2$				
1	Mining Activities (**Table 4.3**)	1.4E+00	3.1E-01				2.4E-06	5.4E-07			
2	Main and Ancillary Equipment (**Table 4.4**)	0.064	0.058	0.876	1.231	0.002	1.1E-07	1.0E-07	1.5E-06	2.1E-06	3.0E-09
						Total	2.5E-06	6.4E-07	1.5E-06	2.1E-06	3.0E-09

- *Particulate and gases from clay mine operation*

Table 4.11 Emission Rate Calculation for Clay Mine Operation

No	Activity								Emission Factor		Emission Rate	
	Activity Generating Particulate	Silt Con-tent	Vehicle Km Travelled	average weight of the vehicles	Mean number of wheels	Average wind speed	Mean vehicle speed	Number of days with at least 0.254 mm of precipitation per year	PM, £ 10mm	PM, £ 2,5mm	PM, £ 10mm	PM, £ 2,5mm
		s	VKT	W	w	U	S	p				
		%	VKT/year	ton		m/sec	km/hour				g/s	
1	Truck movement (limestone hauling)								$E = k\ 5.9\left(\frac{s}{12}\right)\left(\frac{S}{30}\right)\left(\frac{W}{3}\right)^{0.7}\left(\frac{w}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)$ K = 0.36 for PM_{10}, and 0.095 for $PM_{2.5}$			
		6.20	59,400	20.0	8	8	25	128	142	37	1.9E-01	4.9E-02
										Total with 30% Suppression	1.3E-01	3.4E-02

Table 4.12 Emission Rate Calculation for Main and Ancillary Equipment during Clay Mine Operation

No	Activity Data						Emission Factor (EF)						Emission Rate				
	Main and ancillary equipment	Cap	Requi-rement	Capa-city	Operating Hour	Vehicle mile travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
			R	Cap	OH	VMT	EF						E				
				BHP	hour/year	mile/year							g/s				
1	Hydraulic excavator												E = (EF*Cap*OH*R)/(365*24*3600)				
		3 m^3	1	172.55	3300		3.E-01	2.E-01	3.E+00	5.E+00	6.E-03	g/bhp-hr[a]	5.E-03	4.E-03	6.E-02	8.E-02	**1.E-04**
													E = (0.45*1000*VMT*EF*R)/(365*24*3600)				
2	Tippers	10 ton	20			41,450	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/ mile	6.E-03	5.E-03	1.E-01	2.E-01	3.E-04

No	Activity Data						Emission Factor (EF)						Emission Rate				
	Main and ancillary equipment	Cap	Requi-rement	Capa-city	Operating Hour	Vehicle mile travel	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
			R	Cap	OH	VMT	EF						E				
				BHP	hour/year	mile/year							g/s				
3	Water sprinkler (truck chassis mounted)		1			12,435	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/ mile	9.E-05	7.E-05	2.E-03	2.E-03	5.E-06
4	Fuel tanker (truck chassi mounted)		1	175		12,435	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/ mile	9.E-05	7.E-05	2.E-03	2.E-03	5.E-06
						Total							1.E-02	9.E-03	2.E-01	2.E-01	4.E-04

Table 4.13 Emission Rate from Clay Mine Operation

No	**Clay Mine Operation**	**Emission Rate**									
		PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
		E					E2 =E/400633				
		g/s					$g/s/m^2$				
1	Mining activities (**Table 3.6**)	1.3E-01	3.4E-02				3.3E-07	8.6E-08			
2	Main and ancillary equipment (**Table 3.7**)	1.1E-02	9.3E-03	2.0E-01	2.4E-01	4.4E-04	2.7E-08	2.3E-08	5.1E-07	5.9E-07	1.1E-09
						Total	3.5E-07	1.1E-07	5.1E-07	5.9E-07	1.1E-09

- *Particulate and gases from clay hauling (clay mine to cement plant)*

Table 4.14 Emission Rate Calculation for Clay Hauling from Clay Mine to Cement Plant

No.	Activity Data					Emission Factor		Emission Rate			
	Tripper's Route	Road surface silt loading	Vehicle kilometre travelled	Average vehicle weight	Area	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
		sL	VKT	W	A	EF		E		E2	
		gram/m^2	km	ton	m^2	g/km/year		g/s		g/s/m2	
						$0,62*(sL)^{0.91}*(W)^{1.02}$	$0,15*(sL)^{0.91}*(W)^{1.02}$	E = (EF*VKT)/(365*24*3600)		E2=E/A	
1	Tripper's Route from Clay Mine to Cement Plant	50	32,145	10	122,507	228.3	55.2	0.2327	0.0563	5.E-07	4.E-12

Table 4.15 Emission Rate Calculation for Tipper's Fuel Combustion

No	Activity Data					Emission Factor (EF)						Emission Rate				
	Equipment	Cap	Require-ment	Vehicle mile travel (for all truck)	Area	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	Unit	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2
			R	VMT	A	EF						E				
		ton		mile/year	m^2							g/s/m2				
												E = (0.45*1000*VMT*EF)/(365*24*3600)/A				
2	Tippers' fuel combustion	10	20	19,930	122,507	5.0E-04	4.1E-04	1.2E-02	1.3E-02	3.E-05	pounds/ mile	1.2E-09	9.6E-10	2.7E-08	3.0E-08	6.4E-11

Table 4.16 Emission Rate From Clay Hauling

No	Activity	Emission				
		PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2
		g/s/m2				
1	Tripper's Route from Clay Mine to Cement Plant (**Table 3.9**)	5.E-07	4.E-12			
2	Tippers' fuel combustion (**Table 3.10**)	1.2E-09	9.6E-10	2.7E-08	3.0E-08	6.4E-11
	Total	5.E-07	1.E-09	2.7.E-08	3.0E-08	6.E-11

4.2 Prediction of Impacts on Air Quality

Prediction of impacts on air quality can be basically done by calculating the atmospheric air pollutants dispersion which depends on many interrelated factors, such as physical and chemical nature of effluents, meteorological characteristics of the environment, location of the source with relation to obstructions to air motion, and nature of the terrain downwind from the source. Therefore the availability of reliable and complete data shall produce a refined air dispersion modelling. Prediction of impacts on air quality due to construction and operation phase of cement plant was modelled by using the AERMOD VIEW software. Two major parts related to modelling can be classified into modelling input and modelling output.

4.2.1 Modelling Input

Important points for the modelling input area:

- Emission rates from each sources and their supporting physical descriptions

  Emission rates of particulates in the form of PM_{10} and $PM_{2.5}$, and emission rates of gases in the form of CO, NO_2, and SO_2 for each source were derived from previous inventory calculation

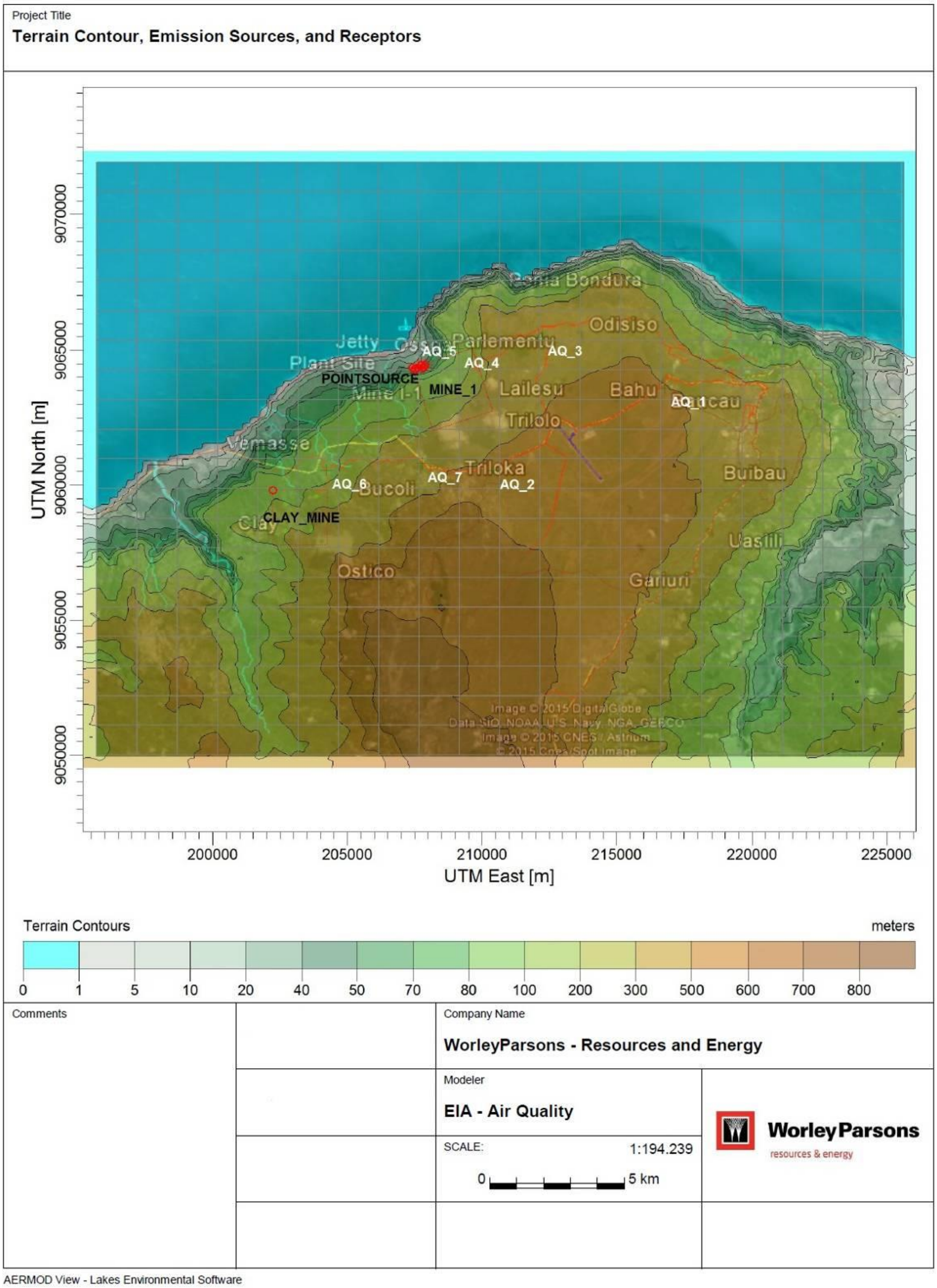
  - **Table 4.5** for construction phase
  - **Table 4.6**, **Table 4.10**, **Table 4.13**, and **Table 4.16** for operation phase.

- Location of sources, receptors including sensitive receptors, and topographical data of the model area. Main sources during the construction phase are located in cement plant and jetty area, limestone mine and clay mine. During the operation phase, the same main sources are also located in these areas, with additional line source of clay hauling (road route) from clay mine to cement plant area. Receptors are located up to 15 km from the source, with sensitive receptor denoted as AQ sign as already shown in **Table 3.1** and **Figure 4.1**. Receptors are denoted by grid for the uniform Cartesian grid (total: 448 receptors), and AQ sign for the discrete Cartesian receptors (total: 7 receptors).
- The map of the location uses the imagery map from Google earth which is directly connected with ISC AERMOD Software. The topographical map of the modelled area was extracted from *www.webgis.com*. This data was collected during the Shuttle Radar Topography Mission (SRTM) and contains global coverage from 56 degrees south latitude to 60 degrees north latitude in 1 by 1 degree blocks with an approximate resolution of 90 by 90 meters. The extracted topographical data in the form of the Shuttle Radar Topography Mission (SRTM) are divided into one by one degree latitude and longitude tiles in "geographic" projection. Heights are in meters referenced to the WGS84/EGM96 geoid. The file was then preprocessed using the AERMAP software to produce the calculated terrain elevation and scale height for each specified receptor as shown in **Figure 4.1.**
- Hourly meteorological data of temperature, pressure, humidity, and wind speed and wind direction, cloud cover.

  The surface and upper air meteorological data (hourly meteorological data of wind speed, wind direction, cloud cover, pressure, and temperature) for the modelled area were derived from lakes environmental software with the information shown in **Figure 3.5.**

- Background concentration, derived from baseline study

  The background concentrations were determined based on the baseline study before the operation of future cement plant. The predicted ground level concentration from the model results should be added with the background concentration to reflect the cumulative effect of emission from various sources within the study area.



Source of terrain data: www.webgis.com

Figure 4.1 Emission Sources, Receptors, and Terrain Contour – Surrounding Project Area

4.2.2 Modelling output

Results of prediction are presented in the form of isopleth of each concentration over the receptor area. An isopleth map generalizes and simplifies a continuous distribution data. The data was presented as a third dimension map, which is indicated by series of lines called isopleths which connect points of equal value of concentration. The averaging time was chosen to be 1 hour (except for particulates), 24 hour and annual averaging time, since generally the air pollutant has the standard in this averaging time. Calculated concentration by the model shows the concentration that is merely caused by the construction activities, not include the background concentration (concentration before the activity begins, i.e. air quality baseline data). Therefore to approximate accumulative ambient impacts, background concentration has to be added to the predicted concentration.

Construction Phase

PM_{10} and $PM_{2.5}$

Construction phase is a source of dust emissions that may have substantial temporary impact on local air quality. Emissions during the construction can be associated with site preparation and operation of main and ancillary equipment, and construction the facilities. Construction works relates to earth moving during site preparation has the highest contribution to the particulate emission rates.

Isopleth **in Figure 4.2** and **Figure 4.3** shows PM_{10} tends to disperse to the north west direction from the construction area, the opposite direction from where the prevailing winds blow (**see Figure 3.5**, prevailing winds blows mostly blow from south east direction). Higher topographical level south east of mining and plant area also give contribution to hinder the dispersion to south east direction. A high concentration of PM_{10} will be concentrated in the mining area (limestone and clay construction work area) and cement-jetty plant area. The 24 hour average concentration of PM_{10} caused by construction activities is predicted to be as high as 114 µg/Nm^3 (**Figure 4.2**) about 4 times higher than its background concentration (PM_{10} concentration from baseline data: 21 up to 31 µg/Nm^3). The highest probable concentration due to cumulative impacts of 24 hour average concentration of PM_{10} is 145 µg/Nm^3. **Figure 4.3** shows the highest annual average concentration of PM_{10} is predicted to be 17 µg/Nm^3. Both averaging time concentration is lower than the standard (150 µg/Nm^3 for 24 hour average concentration and 70 µg/Nm^3 for annual average concentration).

Similar dispersion pattern shows in **Figure 4.4** and **Figure 4.5** for $PM_{2.5}$. The highest 24 average concentration for $PM_{2.5}$ is calculated to be 25 µg/Nm^3; slightly higher than its background (9 - 23 µg/Nm^3) which will give the highest cumulative impacts of 48 µg/Nm^3. The annual average of $PM_{2.5}$ concentration is calculated to be about 4 µg/Nm^3. All calculated and cumulative ambient concentration is predicted to be lower than the standard, 75 µg/Nm^3 for 24 hour average and 35 µg/Nm^3 for annual average. It should be noted that these predicted level of concentrations might be observed if construction works applied the control techniques to reduce the emission of particulates. Higher level of particulates may occur if particulate emission control is neglected.

Figure 4.2 until **Figure 4.4** also indicate that the sensitive receptors which might undergo higher level of concentrations than other sensitive receptors are located in AQ5 (around the jetty plant area, scattered small cluster of fisherman village close to this plant area), AQ4 (Aldeia Osso-ua, settlement close plant area), and AQ6 Wailacama (settlement area north east of clay quarry).

CO, NO_2, and SO_2

During construction phase, gases (CO, NO_2, and SO_2) might be emitted from the operation of heavy equipment and vehicle movement. Incomplete combustion in internal engine may emit certain amount of these pollutants. Dispersion estimates for these gases can be seen in **Figure 4.6 to 4.8** (for CO), **Figure 4.9** to **4.11**(for NO_2) and **Figure 4.12** to **4.14** ($SO_{2)}$). Similar to particulates, pollutants tend to disperse to North West of the sources, and higher concentrations are identified in cement-jetty plant area. Construction activities which emit these pollutants are concentrated in cement-jetty plant area. Therefore higher concentration might happen close to this area. The highest 1 hour average concentrations of CO, NO_2, and SO_2 are 287 µg/Nm^3, 109 µg/Nm^3, and 0.7 µg/Nm^3 respectively, all are below their ambient standards (CO: 40000 µg/Nm^3 , NO_2: 200 µg/Nm^3, and SO_2: 350 µg/Nm^3). Background concentration for CO, NO_2, and SO_2 are 218-418 µg/Nm^3, 7 - 28 µg/Nm^3, and 8.5 – 18 µg/Nm^3 respectively, which give the highest cumulative ambient concentrations of 705 µg/Nm^3 for CO, 137 µg/Nm^{3}for NO_2, and 18.7 µg/Nm^3 for SO_2. These cumulative ambient concentrations are also below the ambient standard for each pollutant. The summary of predicted 1st high 1 hour, 24 hour and annual concentration for each pollutant is presented in **Table 4.17** for construction phase and **Table 4.18** for operation phase.

Operation Phase

PM_{10} and $PM_{2.5}$

During the operation phase of cement plant, the main sources of dust are the stacks of the kiln system, cooler ESP, cement mill, coal mill, and thermal power plant. The emission rate of particulates from main stack sources will be maintained not more than 30 µg/Nm^3, using particulate control with very high reduction efficiency (up to 99%) such as bag filter and electrostatic precipitator. In addition some channelled dust emissions occur in connection with the various grinding processes (raw materials, cement), and diffuse dust emission may arise from storage and handling of raw materials, fuels, clinker and cement, as well as from vehicle traffic used at the manufacturing site. Other sources come from the mining activities, and clay hauling from clay mine to cement plant storage area. Dispersion estimates for PM_{10} are shown in **Figure 4.15** and **Figure 4.16,** while for PM $_{2.5}$ are shown in **Figure 4.17** and **Figure 4.18.** The dispersion direction is still similar to the construction phase, i.e. tends to the North West direction. Predicted 24 hour ambient concentration of PM_{10} and $PM_{2.5}$ are 30 µg/Nm^3 and 13 µg/Nm^3 respectively, which would lead to cumulative ambient concentration of 61 µg/Nm^3 for PM_{10} and 36 µg/Nm^3 for $PM_{2.5}$.These values are below the 24 hour average standard for each respective pollutant.

Maintaining the PM_{10} and $PM_{2.5}$ ambient concentration is very important because PM_{10} or $PM_{2.5}$ may contain microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing. People with heart or lung diseases, children and older adults are the most likely to be affected by particle pollution exposure.

CO, NO_2, and SO_2

The main source of gases comes from the combustion process in cement plant, power plant, and also in internal engine of heavy equipment and vehicle traffic. The specific sources may come from the following processes:

- CO can occur in the primary steps of the kiln process (preheater, precalciner), when impurities (such as organic matter) that are present in the raw materials are volatised as the raw mix is heated.
- NO_x are formed in the combustion process either by oxidation of the nitrogen in the combustion air (thermal NO_x), or by oxidation of the nitrogen compounds in the fuel (fuel NOx). Thermal NO_x form at temperatures above 1200˚C. Due to the very high temperatures in the cement kiln thermal NO_x dominate.
- SO_2 emissions from cement plants are primarily determined by the content of volatile sulphur in the raw materials. This sulphur is emitted as SO_2 from the low temperature end of the kiln system. Sulphur present as sulphates in the raw materials is only partly decomposed at high temperatures and almost completely discharged from the kiln system with the clinker. Sulphur introduced into the kiln with the fuels is oxidised to SO_2 and will not lead to significant SO2 emissions as SO2 formed at the hot end of the kiln system reacts with the reactive, fine raw materials in the sintering zone, the precalciner and the hot part of the preheater.
- Dispersion estimate during operation phase are shown in **Figure 4.19** to **Figure 4.21** for CO, **Figure 4.22** to **Figure 4.25** for NO_2, and **Figure 4.26** and **Figure 4.28** for SO_2.. The isopleth patterns show the tendency of pollutants to disperse to North West direction. During the operation phase, the gases seem to be able to disperse farther than during construction phase. The reason is because the dominant sources for these gases come from the cement plant operation (stack's sources) which has a higher height of discharge level (stack height itself). The predicted highest 1 hour average concentrations for these gases are: 659 µg/Nm^3 for CO, 222 µg/Nm^3 for NO_2, and 265 µg/Nm^3 for SO_2. Addition by background concentration would give cumulative ambient concentration of 1140 µg/Nm^3 for CO, 250 µg/Nm^3 for NO_2, and 283 µg/Nm^3 for SO_2. Cumulative ambient concentration of CO and SO_2 are still below the standard (CO:40000 µg/Nm^3 and SO2:350 µg/Nm^3). For NO_2 there is a probability exceedance (25 times) within a year, as shown in the output modelling which may violate the standard (see **Table 4.19.**)
- Maintaining CO, NO_2, and SO_2 concentration below the standard is very important, because high concentration of these pollutants may risk the human health. Higher concentration of these pollutants may occur during the dry season which last from July to November, because during these months wet deposition rarely happens.
  - The highest predicted 1 hour CO concentration (i.e., 1140 µg/Nm^3) is far lower than the harmful concentration. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death. Exposure to CO can reduce the oxygen-carrying capacity of the blood. As CO levels increase and remain above 50 ppm (57000 µg/Nm^3), symptoms may become noticeable. At levels approaching 200 ppm (230000 µg/Nm^3), symptoms become more severe. A concentration of 400 ppm (467000 µg/Nm^3) will further intensify symptoms and is life threatening after three hours of exposure while 800 ppm (915000 µg/Nm^3) results in unconsciousness within two hours and death within two to three hours. Exposure to about 13,000 ppm of CO can cause death after one to three minutes.
  - The highest predicted 1 hour NO_2 concentration (i.e., 250 µg/Nm^3) is also lower than the harmful concentration. The main effect of breathing in raised levels of NO_2 the increased likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk. Available data from animal

toxicology experiments rarely indicate the effects of acute exposure to NO_2 concentrations of less than 1880 µg/Nm^3 (1 ppm). Normal healthy people exposed at rest or with light exercise for less than 2 hours to concentrations of more than 4700 µg/Nm^3 (2.5 ppm) experience pronounced decrements in pulmonary function; generally, such people are not affected at less than 1880 µg/Nm^3 (1 ppm). One study showed that the lung function of people with chronic obstructive pulmonary disease is slightly affected by a 3.75-hour exposure to 560 µg/Nm^3 (0.3 ppm). A wide range of findings in asthmatics has been reported; one study observed no effects from a 75-minute exposure to 7520 µg/Nm^3 (4 ppm), whereas others showed decreases in FEV1 after 10 minutes of exercise during exposure to 560 µg/Nm^3 (0.3 ppm). Asthmatics are likely to be the most sensitive subjects, although uncertainties exist in the health database. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30–110 minutes to 560 µg/Nm^3 (0.3 ppm) during intermittent exercise. However, neither of these laboratories was able to replicate these responses with a larger group of asthmatic subjects. One of these studies indicated that nitrogen dioxide can increase airway reactivity to cold air in asthmatics. At lower concentrations, the pulmonary function of asthmatics was not changed significantly (WHO, 2000)

- The highest predicted 1 hour SO_2 concentration (i.e., 283 µg/Nm^3) is also lower than the harmful concentration. Scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms. Asthmatic individuals are especially sensitive to SO_2 (Baxter, 2000) and may respond to concentrations as low as 0.2-0.5 ppm (525 – 1306 µg/Nm^3). Studies also show a connection between short-term exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations including children, the elderly, and asthmatics. Sulfur dioxide affects human health when it is breathed in. It irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 or 15 minutes after breathing it in. Those most at risk of developing problems if they are exposed to sulfur dioxide are people with asthma or similar conditions.

Table 4.17 Predicted 1st High Air Pollutant Concentration for One Hour, 24 Hours, and Annual Average Concentration during Construction Phase

No.	Parameter	Averaging time	Standard	Modelling Output				
				1st High Concentration	Coordinate Location		Description Area	Figure Number
			µg/Nm³	µg/Nm³	Easting	Northing		
1	PM_{10}	24 hours	150	114	203171.72	9058782,81	Mining and cement plant area, north west of sources	Figure 3.2
		Annual	70	17	203171.72	9058782,81		Figure 3.3
2	$PM_{2.5}$	24 hours	75	25	203171.72	9058782,81		Figure 3.4
		Annual	35	3.81	203171.72	9058782,81		Figure 3.5
3	CO	1 hour	40000	287	207662,54	9065361,09	Plant and Jetty area, north west of sources	Figure 3.6
		24 hours		73	207662,54	9065361,09		Figure 3.7
		Annual		4.67	207662,54	9065361,09		Figure 3.8
4	NO_2	1 hour	200	109	207662,54	9065361,09		Figure 3.9
		24 hours		28	207662,54	9065361,09		Figure 3.10
		Annual	40	1.96	207662,54	9065361,09		Figure 3.11
5	SO_2	1 hour	350	0.7	207662,54	9065361,09		Figure 3.12
		24 hours	125	0.2	207662,54	9065361,09		Figure 3.13
		Annual		0.012	207662,54	9065361,09		Figure 3.14

Note: Predicted ambient concentration was calculated based on controlled emission rate (reduced emission rate by pollutant control from specified activities)

Table 4.18. Predicted 1st High Air Pollutant Concentration for One Hour, 24 Hours, and Annual Average Concentration during Operation Phase

No.	Parameter	Averaging time	Standard	Modelling Output				
				1st High Concentration µg/Nm³	Coordinate Location		Distance from the Source	Figure Number
					Easting	Northing		
1	PM_{10}	24 hour	150	30	209159.48	9064264.71	Inside mining area, north west of emission source	Figure 3.15
		Annual	70	5	209159.48	9064264.71		Figure 3.16
2	$PM_{2.5}$	24 hours	75	13	209159.48	9064264.71		Figure 3.17
		Annual	35	1,11	203171.72	9058782.81		Figure 3.18
3	CO	1 hour	40000	659	207662.54	9062071.64	Area between clay and limestone mine, north west of line source area	Figure 3.19
		24 hours		100	207662.54	9062071.64		Figure 3.20
		Annual		6	207662.54	9062071.64		Figure 3.21
4	NO_2	1 hour	200	222	209159.48	9064264.71		Figure 3.22 Figure 3.23
		24 hours		44	209159.48	9064264.71		Figure 3.24
		Annual	40	6	203171,72	9058782,81		Figure 3.25
5	SO_2	1 hour	350	265	207662.54	9062071.95		Figure 3.26
		24 hours	125	40	207662.54	9062071.95		Figure 3.27
		Annual		1,66	206165.60	906657.47		Figure 3.28

Note: Predicted ambient concentration was calculated based on controlled emission rate (reduced emission rate by pollutant control from specified activities)

Table 4.19 Predicted 1 Hour NO_2 Concentration Exceed the Ambient Standard (Modelling Output)

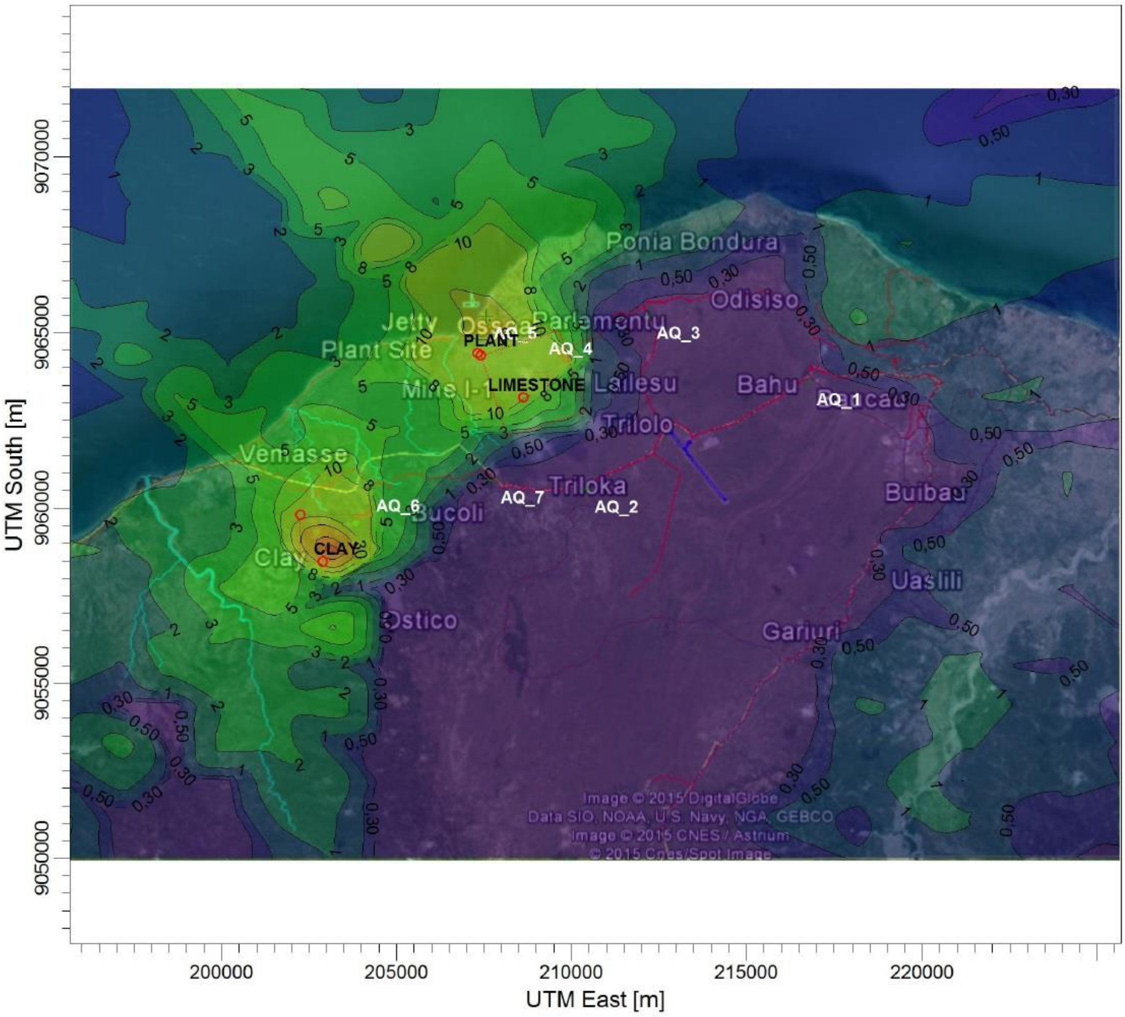
MAXI-FILE FOR 1-HR VALUES >= A THRESHOLD OF 200.0
FOR SOURCE GROUP: ALL
FORMAT: (1X,I3,1X,A8,1X,I8.8,2(1X,F13.5),3(1X,F7.2),1X,F13.5)

AVE	GRP	X	Y	AVERAGE CONC
1	ALL	209159.48000	9064264.71000	222.51581
1	ALL	209159.48000	9064264.71000	213.56789
1	ALL	209159.48000	9064264.71000	216.79533
1	ALL	209159.48000	9064264.71000	216.77803
1	ALL	209159.48000	9064264.71000	221.27082
1	ALL	209159.48000	9064264.71000	221.55026
1	ALL	209159.48000	9064264.71000	219.84058
1	ALL	209159.48000	9064264.71000	204.79724
1	ALL	209159.48000	9064264.71000	220.38416
1	ALL	209159.48000	9064264.71000	216.21911
1	ALL	207662.54000	9062071.95000	214.35220
1	ALL	209159.48000	9064264.71000	216.99620
1	ALL	209159.48000	9064264.71000	217.80108
1	ALL	209159.48000	9064264.71000	212.02078
1	ALL	209159.48000	9064264.71000	216.91408
1	ALL	207662.54000	9062071.95000	213.34014
1	ALL	209159.48000	9064264.71000	214.94832
1	ALL	209159.48000	9064264.71000	203.56191
1	ALL	209159.48000	9064264.71000	215.40348
1	ALL	209159.48000	9064264.71000	211.43419
1	ALL	209159.48000	9064264.71000	219.18460
1	ALL	209159.48000	9064264.71000	213.12281
1	ALL	209159.48000	9064264.71000	210.04060
1	ALL	207662.54000	9062071.95000	203.20043
1	ALL	209159.48000	9064264.71000	209.94019

CONCUNIT ug/m^3

Project Title

PM10 - 1st High 24 Hour Ambient Concentration (Construction Phase)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

0,01 0,30 0,50 1,00 2,00 3,00 5,00 8,00 10,00 30,00 50,00 80,00 100,00 114,00

Comments Construction Phase		Company Name **WorleyParsons - Resources and Energy**
		Modeler **EIA - Air Quality**
	Output Type **Concentration**	SCALE: 1:188.674 0 5 km
	Maximum Concentration **114,25073 ug/m^3**	

WorleyParsons resources & energy

AERMOD View - Lakes Environmental Software

Figure 4.2 PM_{10} - 1st High 24 Hour Ambient Concentration (Construction Phase)

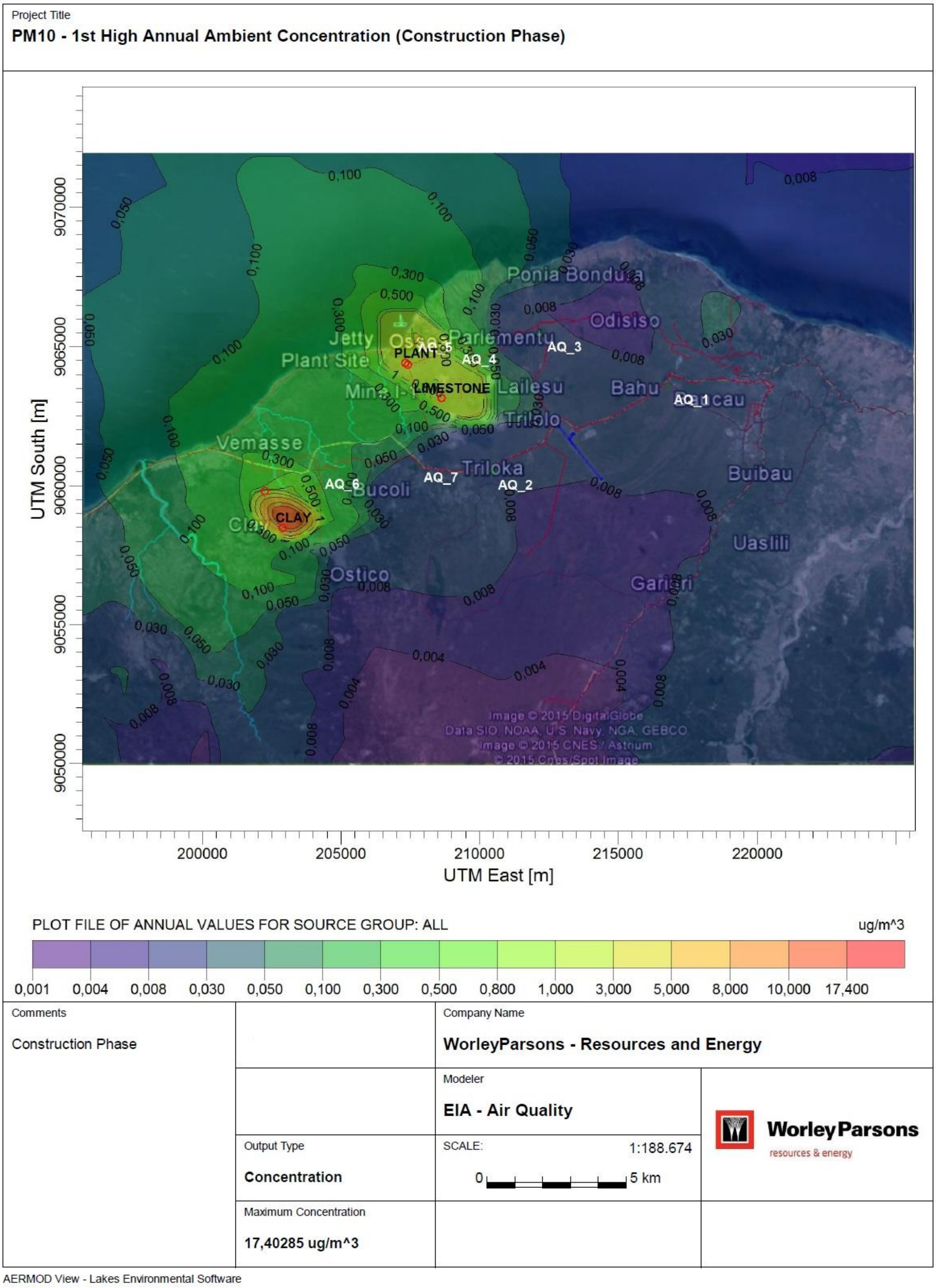
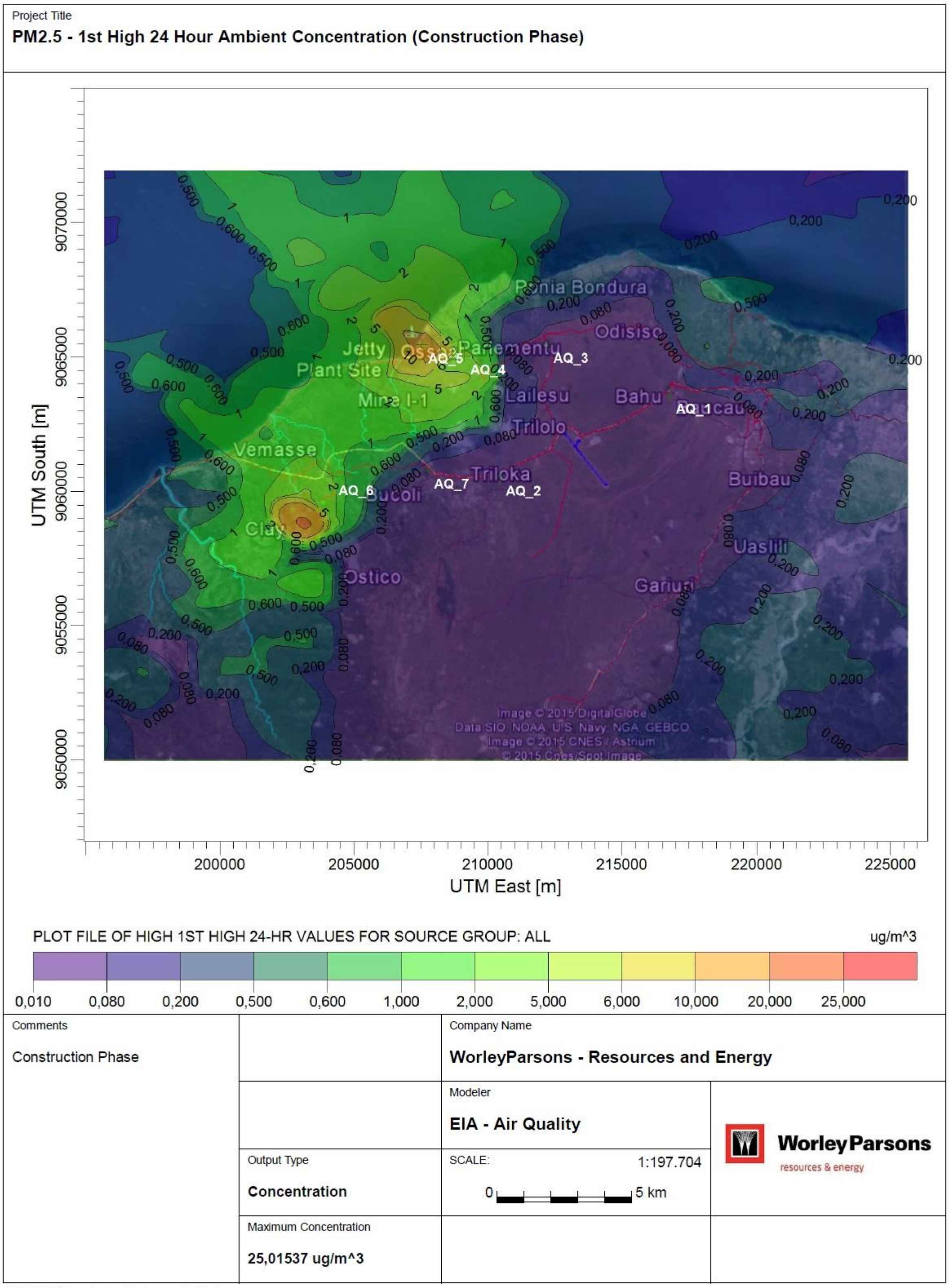


Figure 4.3 PM_{10} - 1st High Annual Ambient Concentration

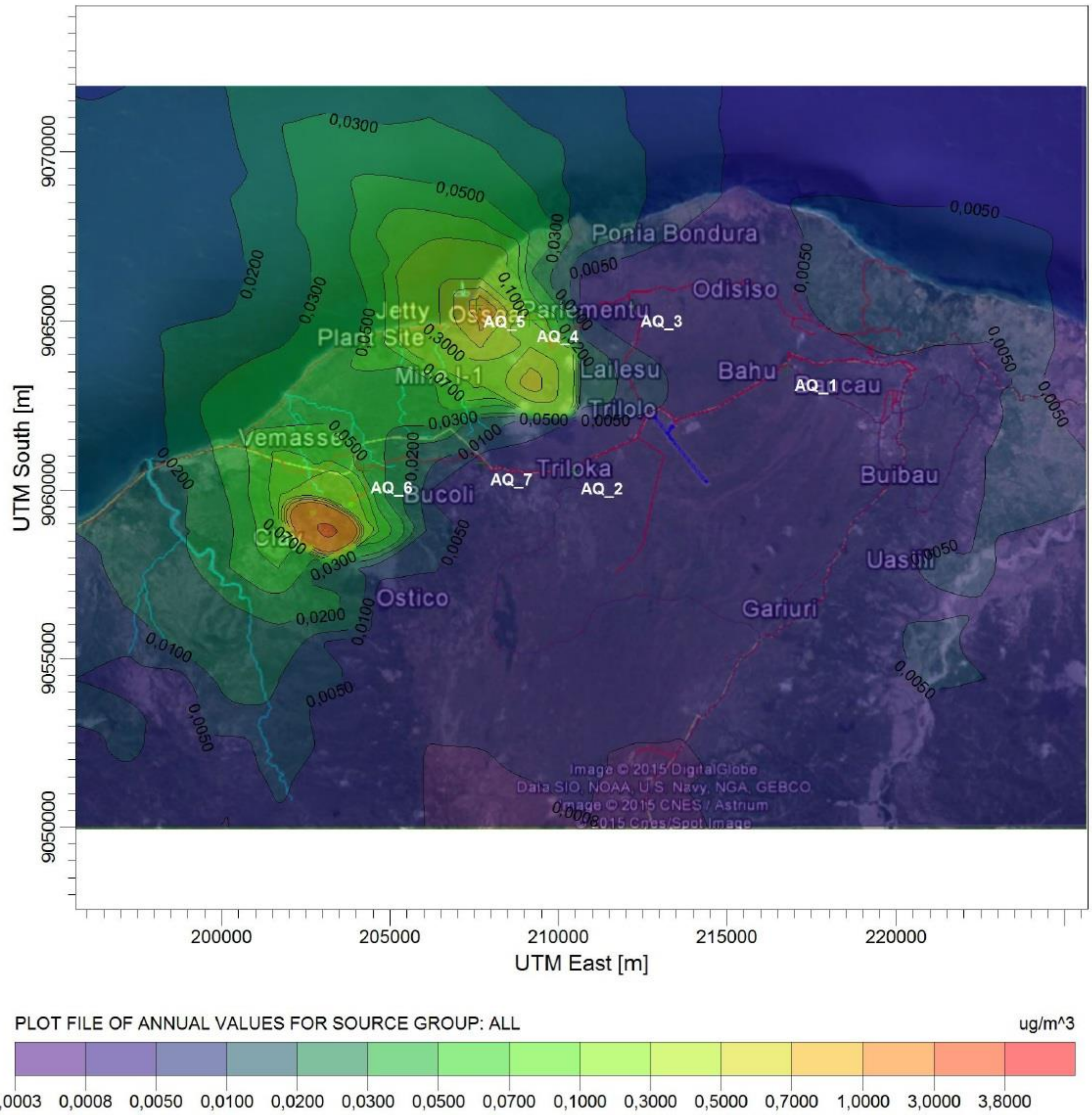


AERMOD View - Lakes Environmental Software

Figure 4.4 $PM_{2.5}$ - 1st High 24 Hour Ambient Concentration (Construction Phase)

Project Title

PM2.5 - 1st High Annual Ambient Concentration (Construction Phase)



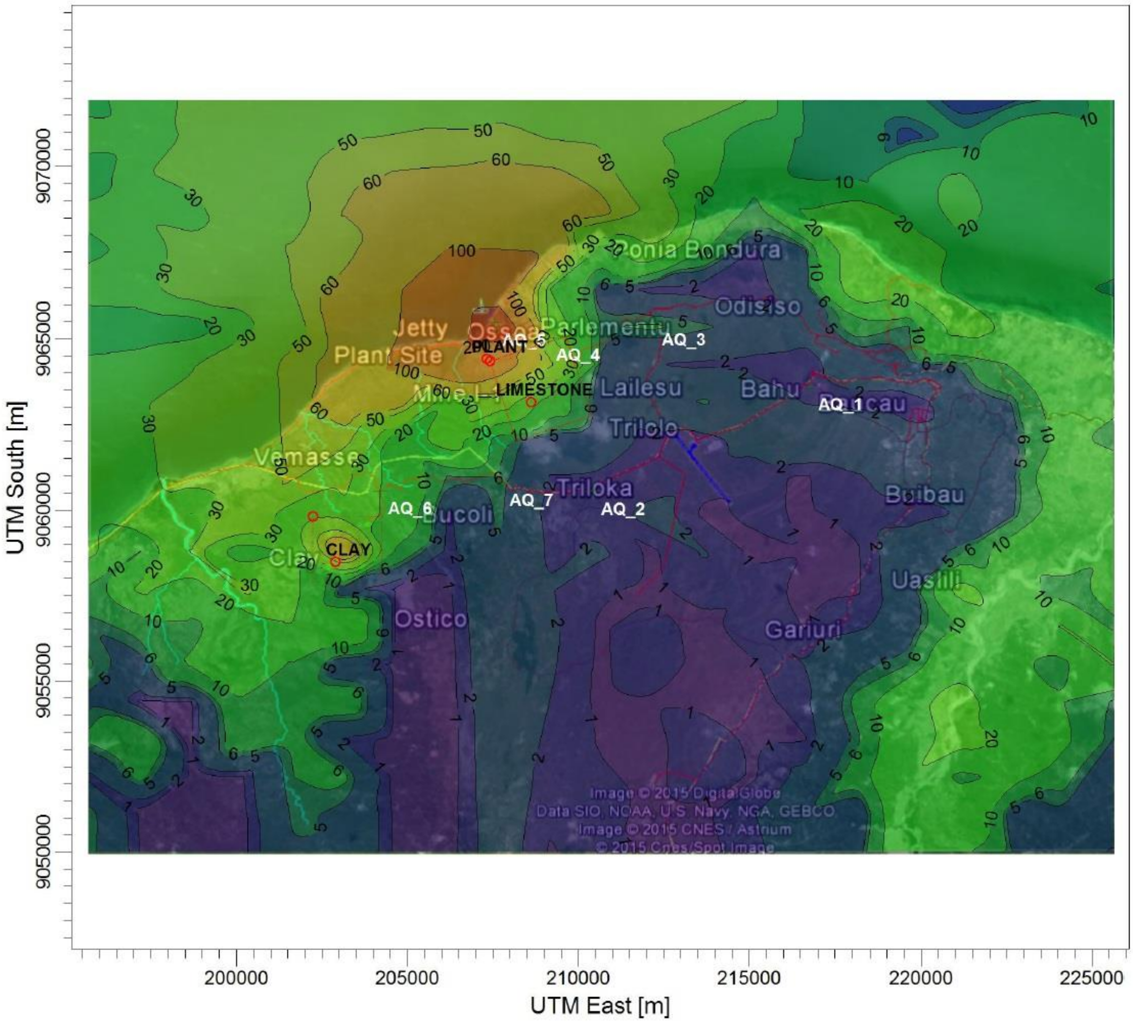
Comments Construction Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:188.674 0 — 5 km	
	Maximum Concentration **3,81064 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.5 $PM_{2.5}$ - 1st High Annual Ambient Concentration (Construction Phase)

Project Title

CO - 1st High 1 Hour Ambient Concentration (Construction Phase)



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

0,10 1,00 2,00 5,00 6,00 10,00 20,00 30,00 50,00 60,00 100,00 200,00 287,00

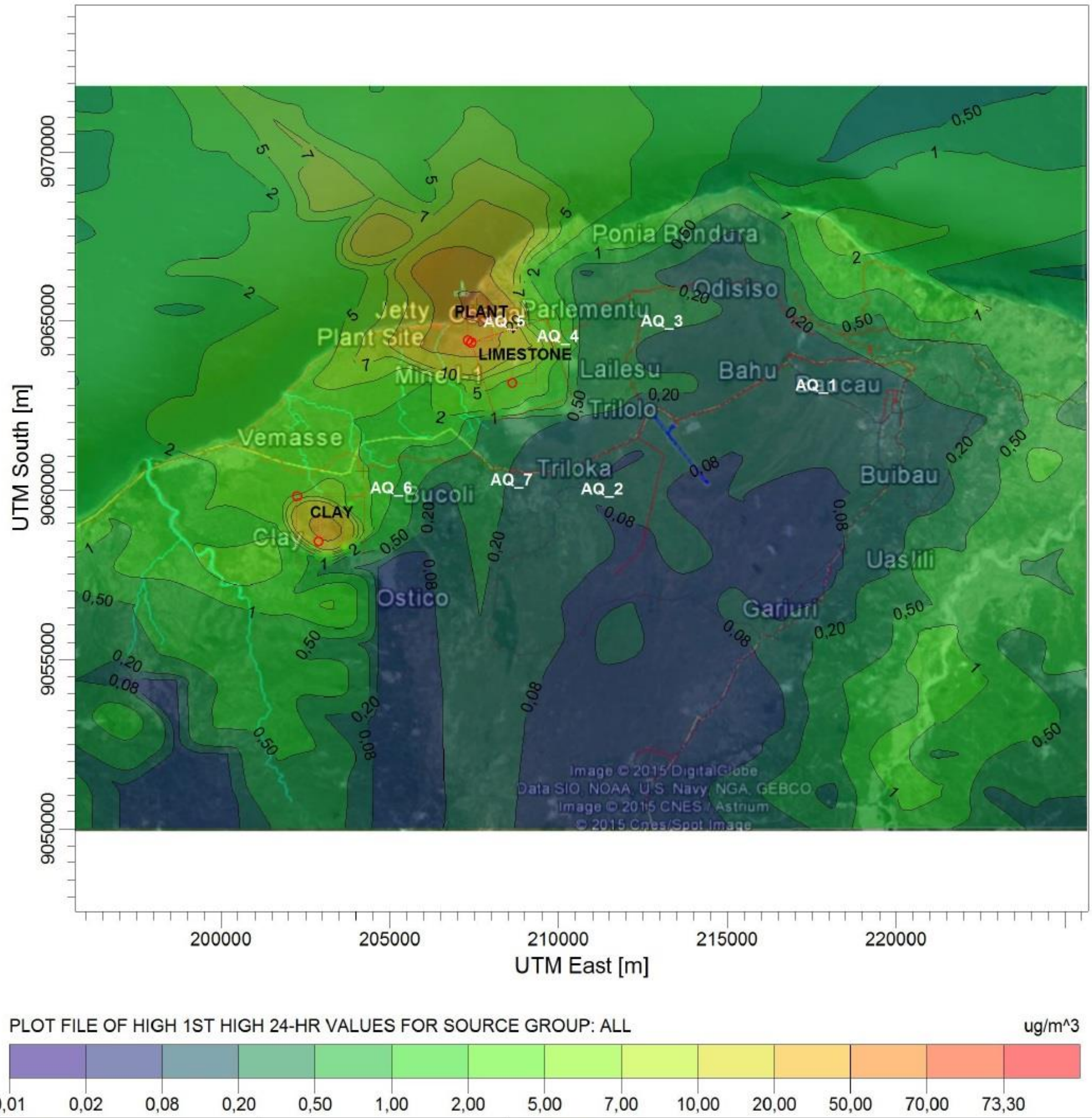
Comments Construction Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:194.239 0 5 km	
	Maximum Concentration **287,36301 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.6 CO - 1st 1 High Hour Ambient Concentration (Construction Phase)

Project Title

CO - 1st High 24 Hour Ambient Concentration (Construction Phase)



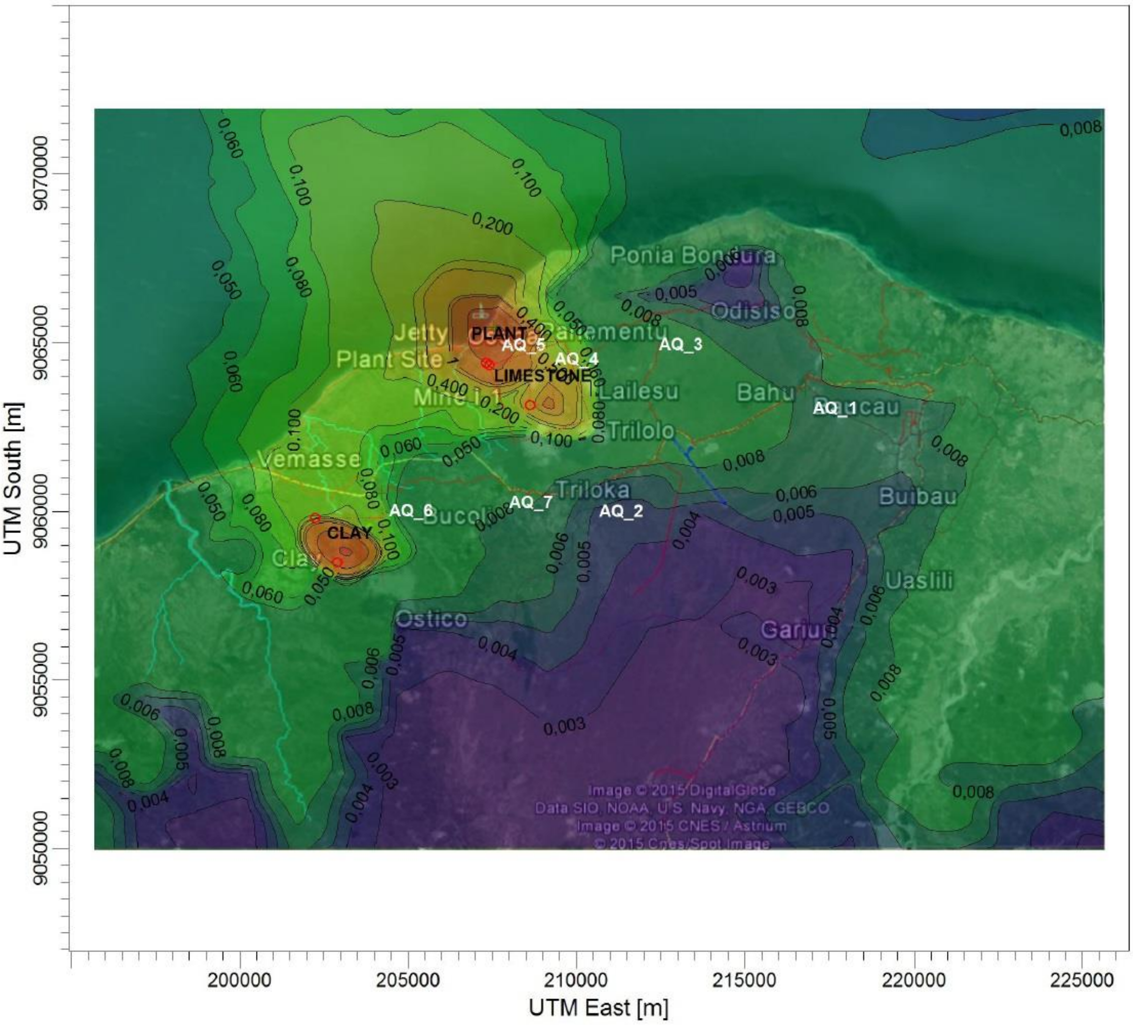
Comments		Company Name	
Construction Phase		WorleyParsons - Resources and Energy	
		Modeler: EIA - Air Quality	WorleyParsons resources & energy
	Output Type: Concentration	SCALE: 1:188.674 (0 — 5 km)	
	Maximum Concentration: 73,33923 ug/m^3		

AERMOD View - Lakes Environmental Software

Figure 4.7 CO - 1st 24 High Hour Ambient Concentration (Construction Phase)

Project Title

CO - 1st High Annual Ambient Concentration (Construction Phase)



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL ug/m^3

0,001 0,003 0,004 0,005 0,006 0,008 0,050 0,060 0,080 0,100 0,200 0,400 0,500 0,800 1,000 2,000 4,000 4,700

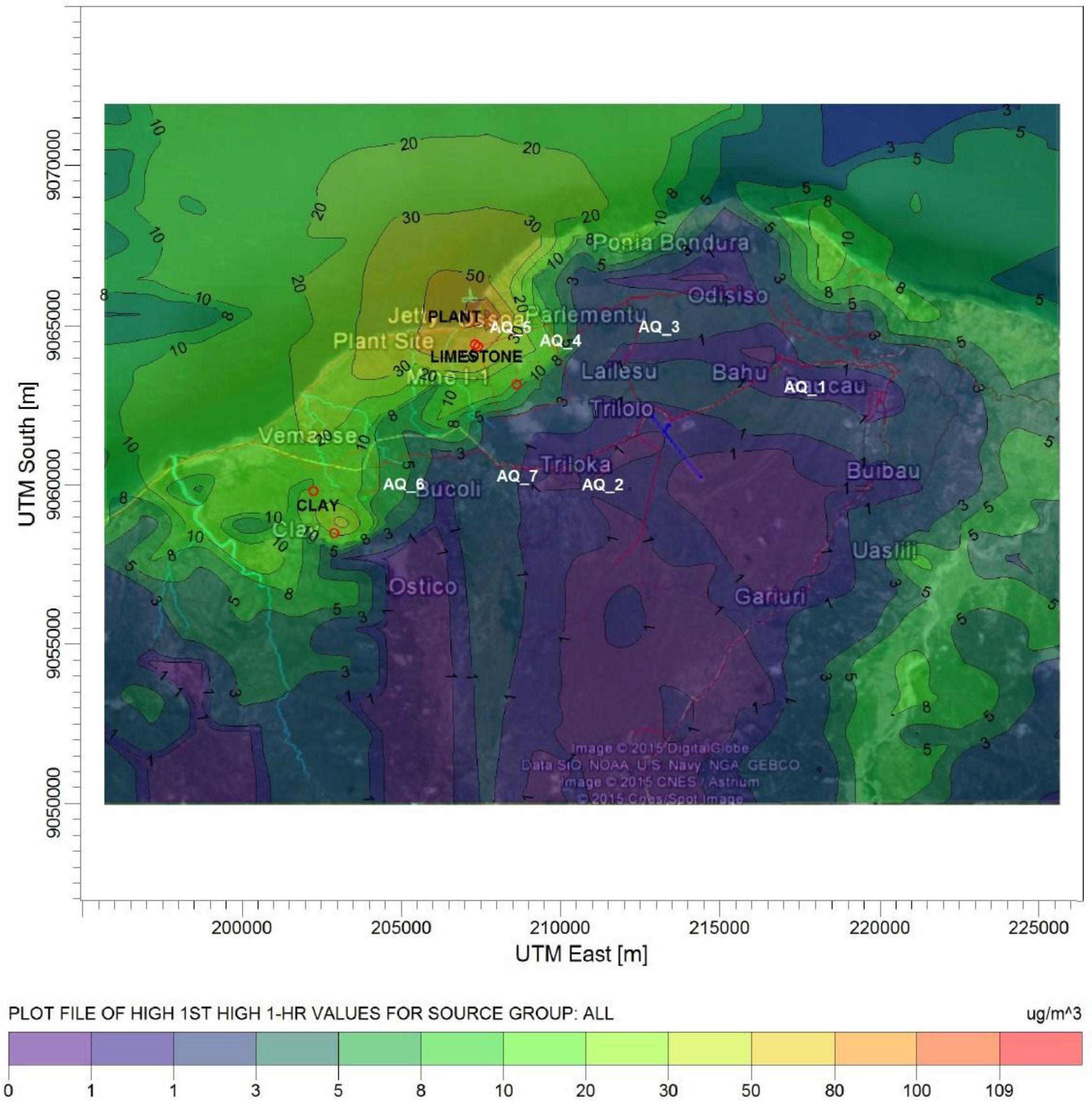
Comments: Construction Phase		Company Name: **WorleyParsons - Resources and Energy**
		Modeler: **EIA - Air Quality**
	Output Type: **Concentration**	SCALE: 1:197.704 (0 — 5 km)
	Maximum Concentration: **4,67284 ug/m^3**	

AERMOD View - Lakes Environmental Software

Figure 4.8 CO - 1st High Annual Ambient Concentration (Construction Phase)

Project Title

NO2 - 1st High 1 Hour Ambient Concentration



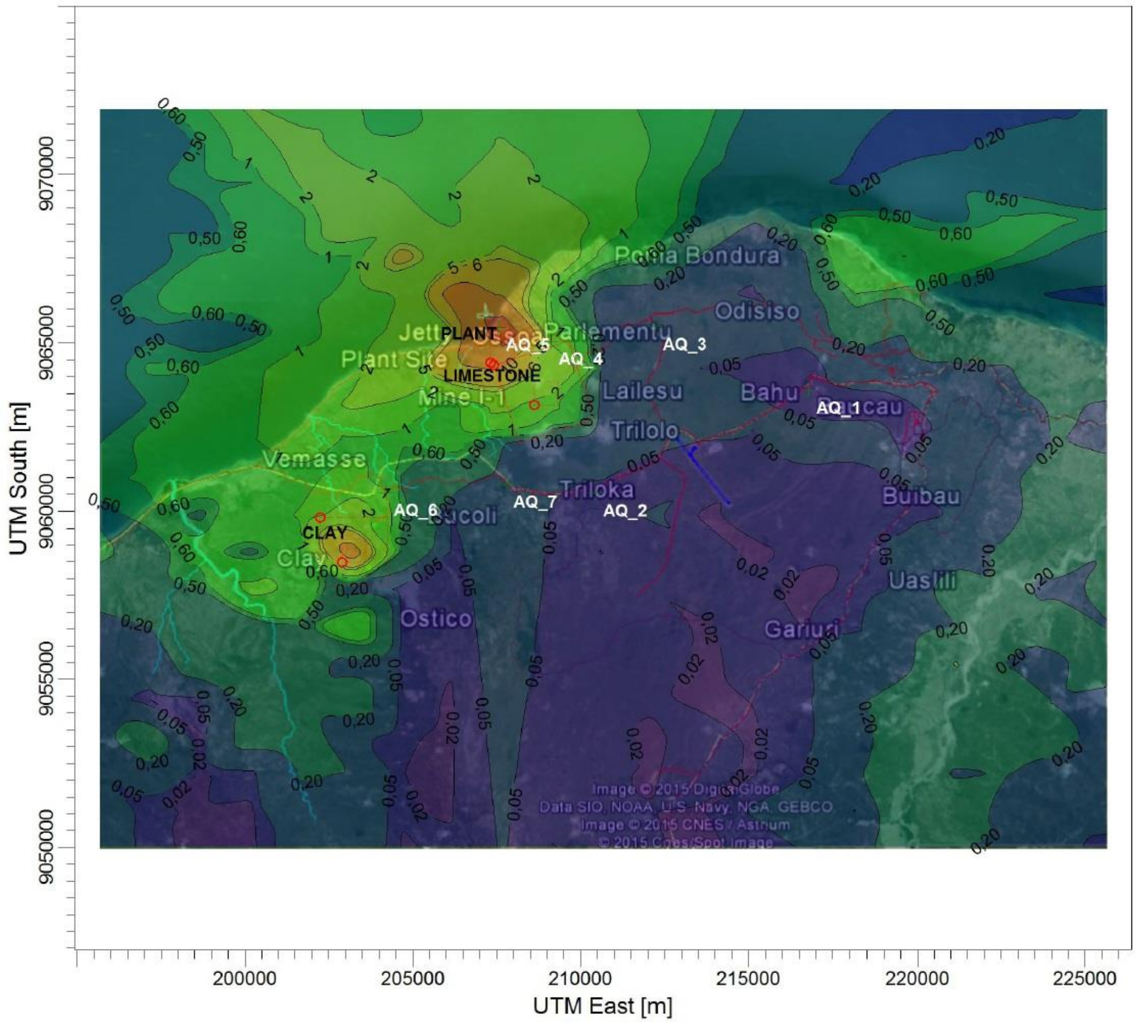
Comments		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:197.704 0 5 km	
	Maximum Concentration **108,99976 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.9 NO_2 - 1st High 1 Hour Ambient Concentration (Construction Phase)

Project Title

NO2 - 1st High 24 Hour Ambient Concentration (Construction Phase)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL — ug/m^3

0,01 | 0,02 | 0,05 | 0,20 | 0,50 | 0,60 | 1,00 | 2,00 | 5,00 | 6,00 | 10,00 | 20,00 | 28,00

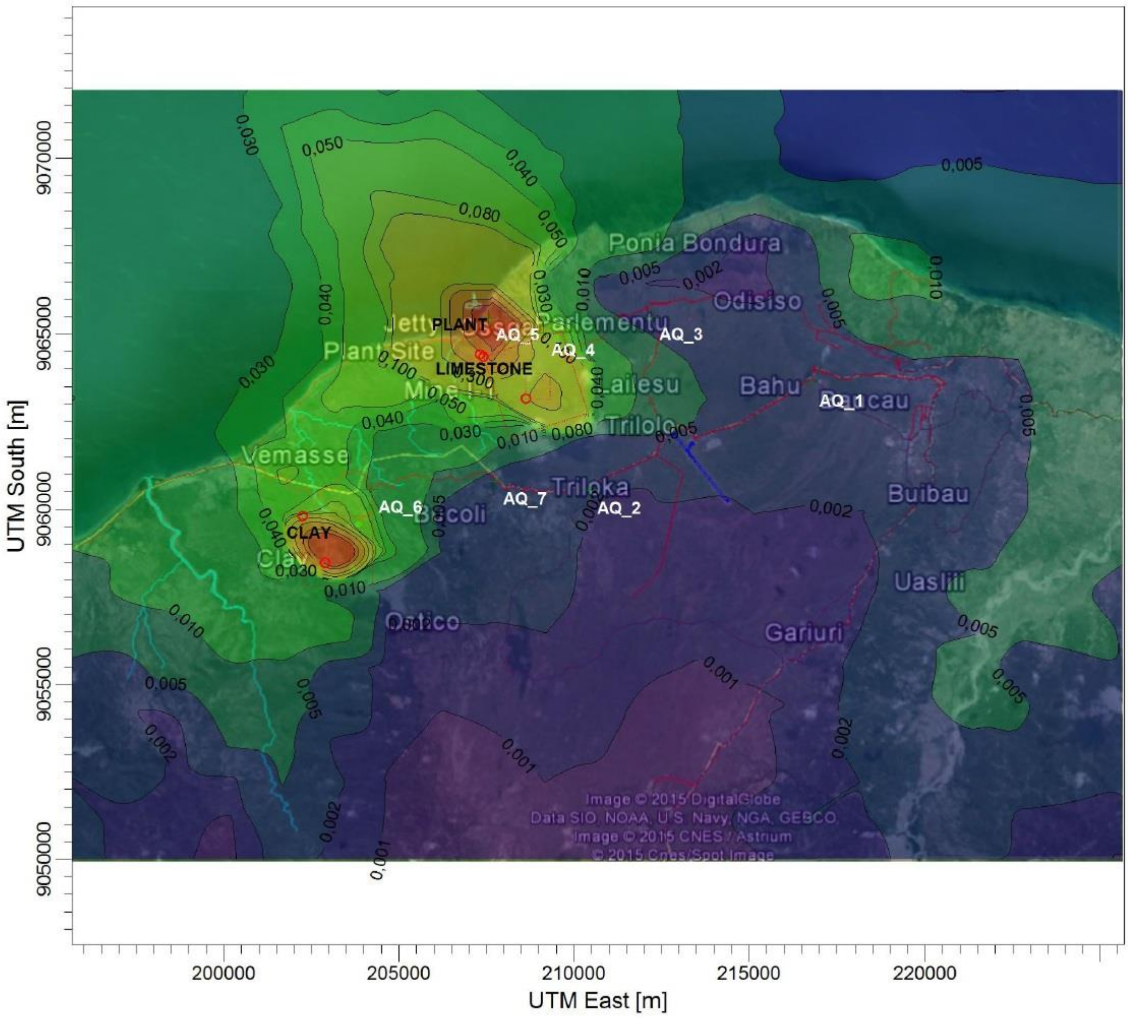
Comments		Company Name	
Construction Phase		WorleyParsons - Resources and Energy	
		Modeler: EIA - Air Quality	WorleyParsons resources & energy
	Output Type: Concentration	SCALE: 1:197.704 (0 – 5 km)	
	Maximum Concentration: 27,81857 ug/m^3		

AERMOD View - Lakes Environmental Software

Figure 4.10 NO_2 - 1st High 24 Hour Ambient Concentration (Construction Phase)

Project Title

NO2 - 1st High Annual Ambient Concentration (Construction Phase)



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL ug/m^3

0,0005 0,0010 0,0020 0,0050 0,0100 0,0300 0,0400 0,0500 0,0800 0,1000 0,3000 0,5000 0,8000 1,0000 2,0000

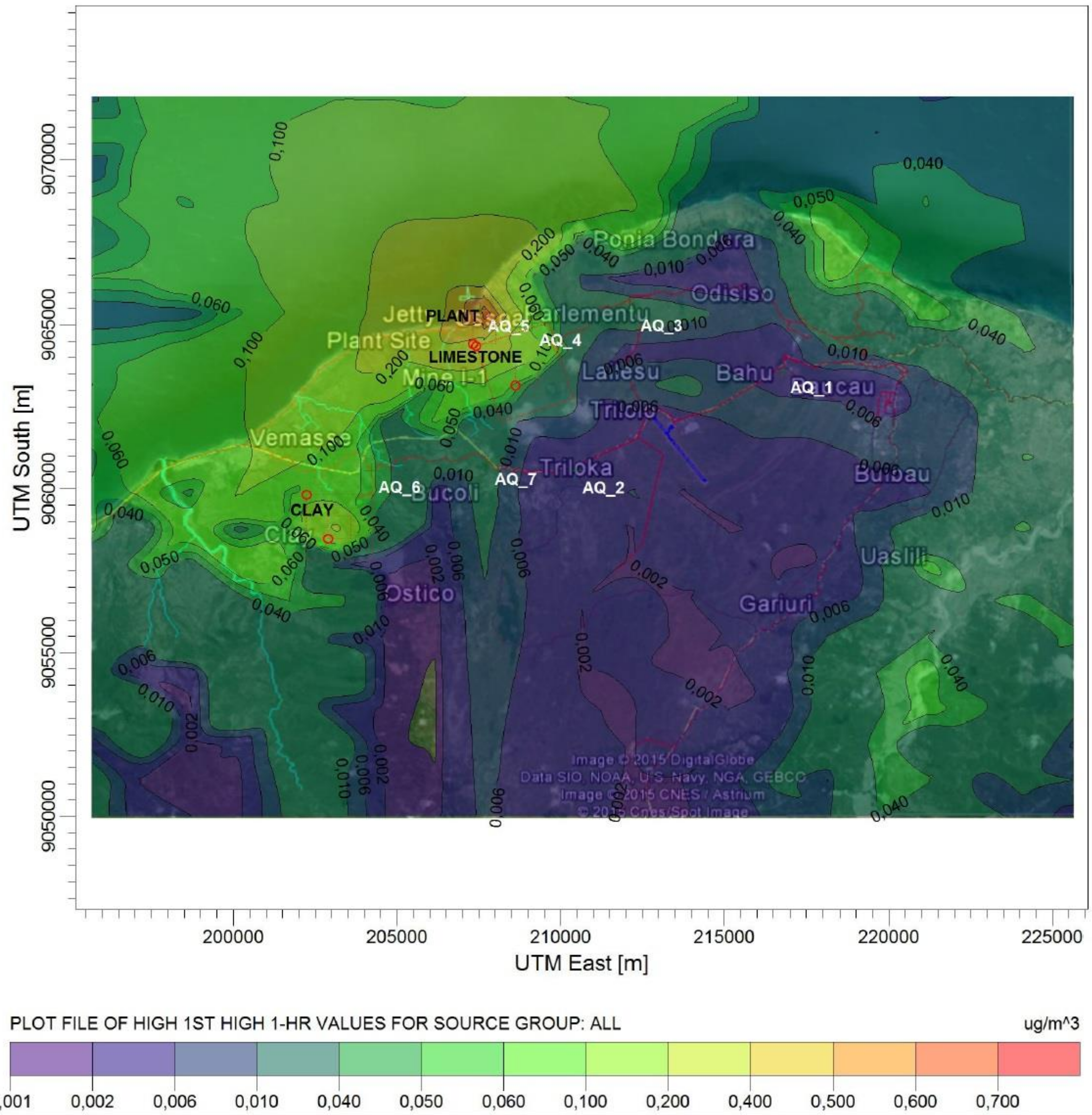
Comments		Company Name	
Construction Phase		**WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:188.674 0 5 km	
	Maximum Concentration **1,95905 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.11 NO_2 - High 1st Annual Ambient Concentration (Construction Phase)

Project Title

SO2 - 1st High 1 Hour Ambient Concentration (Construction Phase)



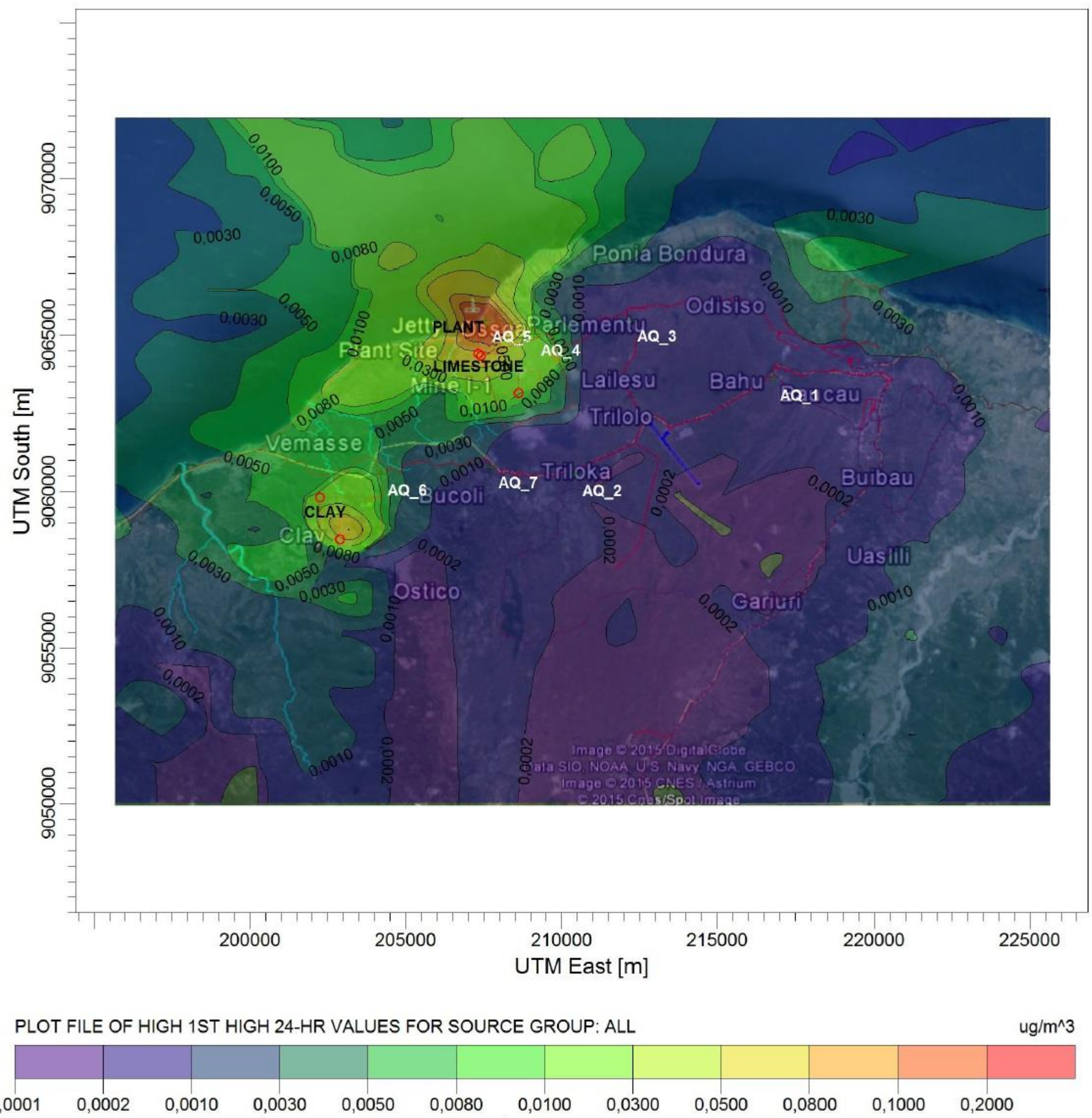
Comments		Company Name	
Construction Phase		WorleyParsons - Resources and Energy	
		Modeler: EIA - Air Quality	WorleyParsons resources & energy
	Output Type: Concentration	SCALE: 1:194.239 (0 – 5 km)	
	Maximum Concentration: 0,67382 ug/m^3		

AERMOD View - Lakes Environmental Software

Figure 4.12 SO_2 - 1st High 1 Hour Ambient Concentration (Construction Phase)

Project Title

SO2 - 1st High 24 Hour Ambient Concentration (Construction Phase)



Comments		Company Name	
Construction Phase		**WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:203.952 0 — 5 km	
	Maximum Concentration **0,17197 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.13 SO_2 - 1st High 24 Hour Ambient Concentration (Construction Phase)

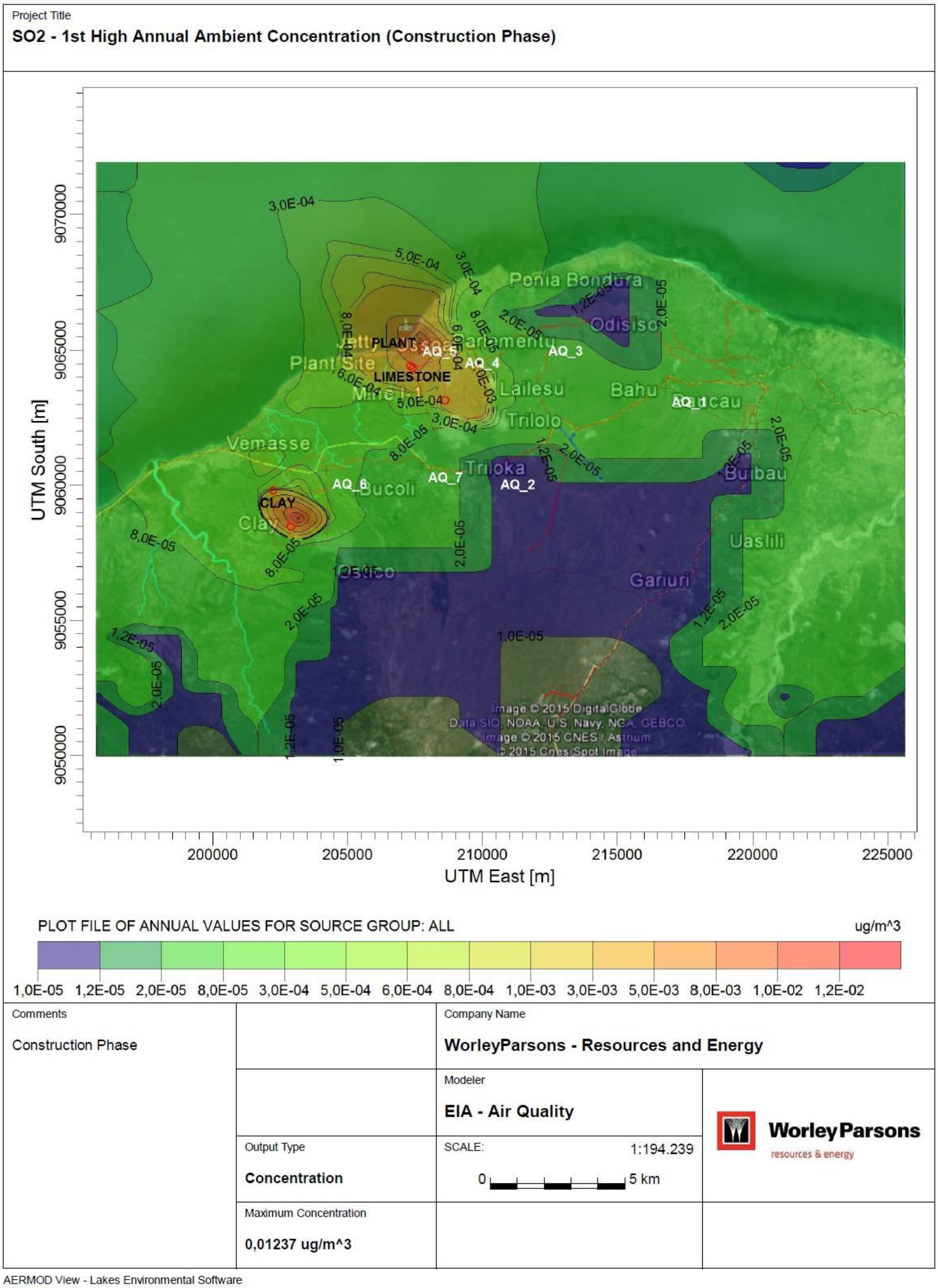
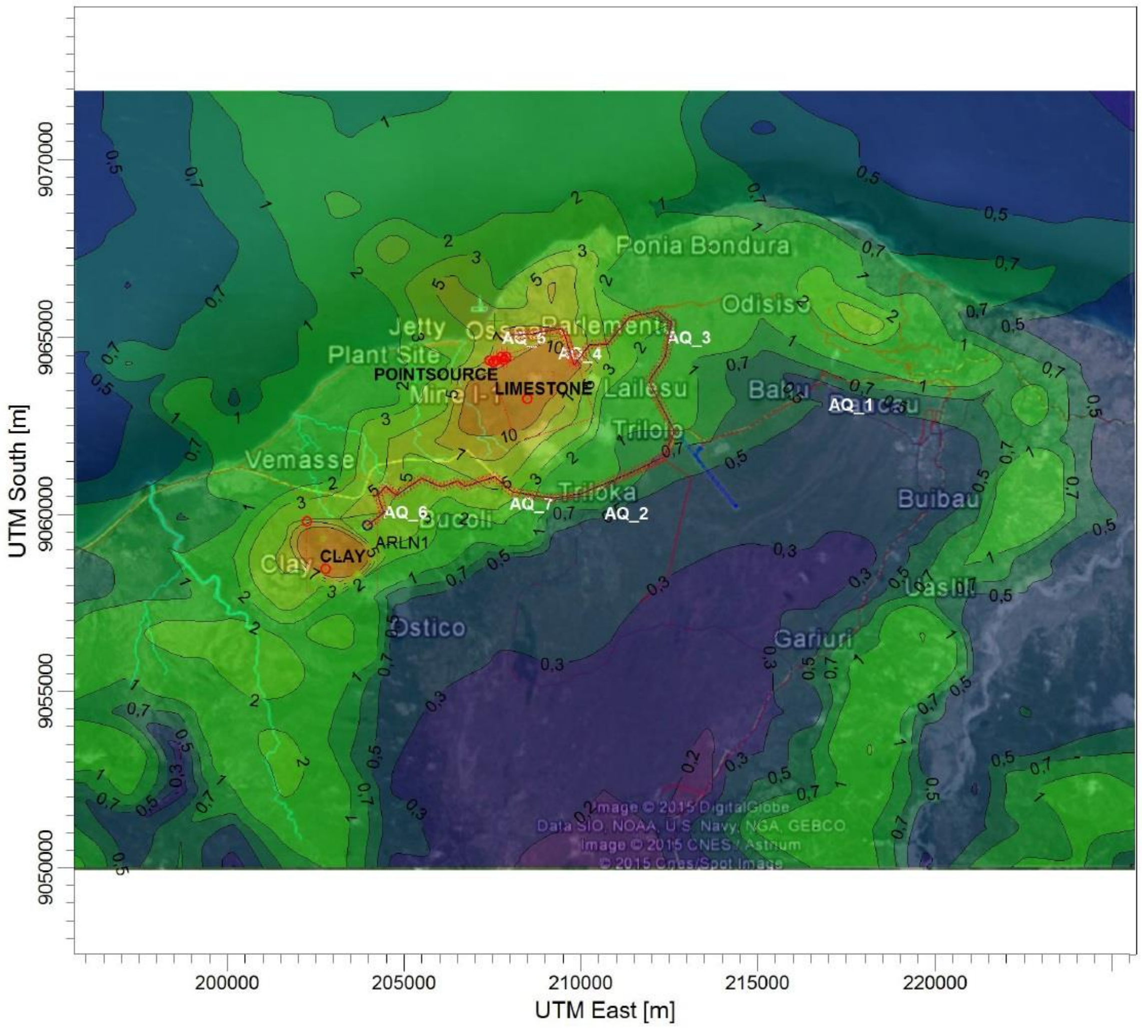


Figure 4.14 SO_2 - 1st High Annual Ambient Concentration (Construction Phase)

Project Title

PM10 - 1st High 24 Hour Ambient Concentration (Operation Phase)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

0,1 0,2 0,3 0,5 0,7 1,0 2,0 3,0 5,0 7,0 10,0 30,0

Comments

Operation Phase

Company Name

WorleyParsons - Resources and Energy

Modeler

EIA - Air Quality

Output Type

Concentration

SCALE: 1:188.674

0 5 km

Maximum Concentration

30,46069 ug/m^3

AERMOD View - Lakes Environmental Software

Figure 4.15 PM_{10} - 1st High 24 Hour Ambient Concentration Operation Phase)

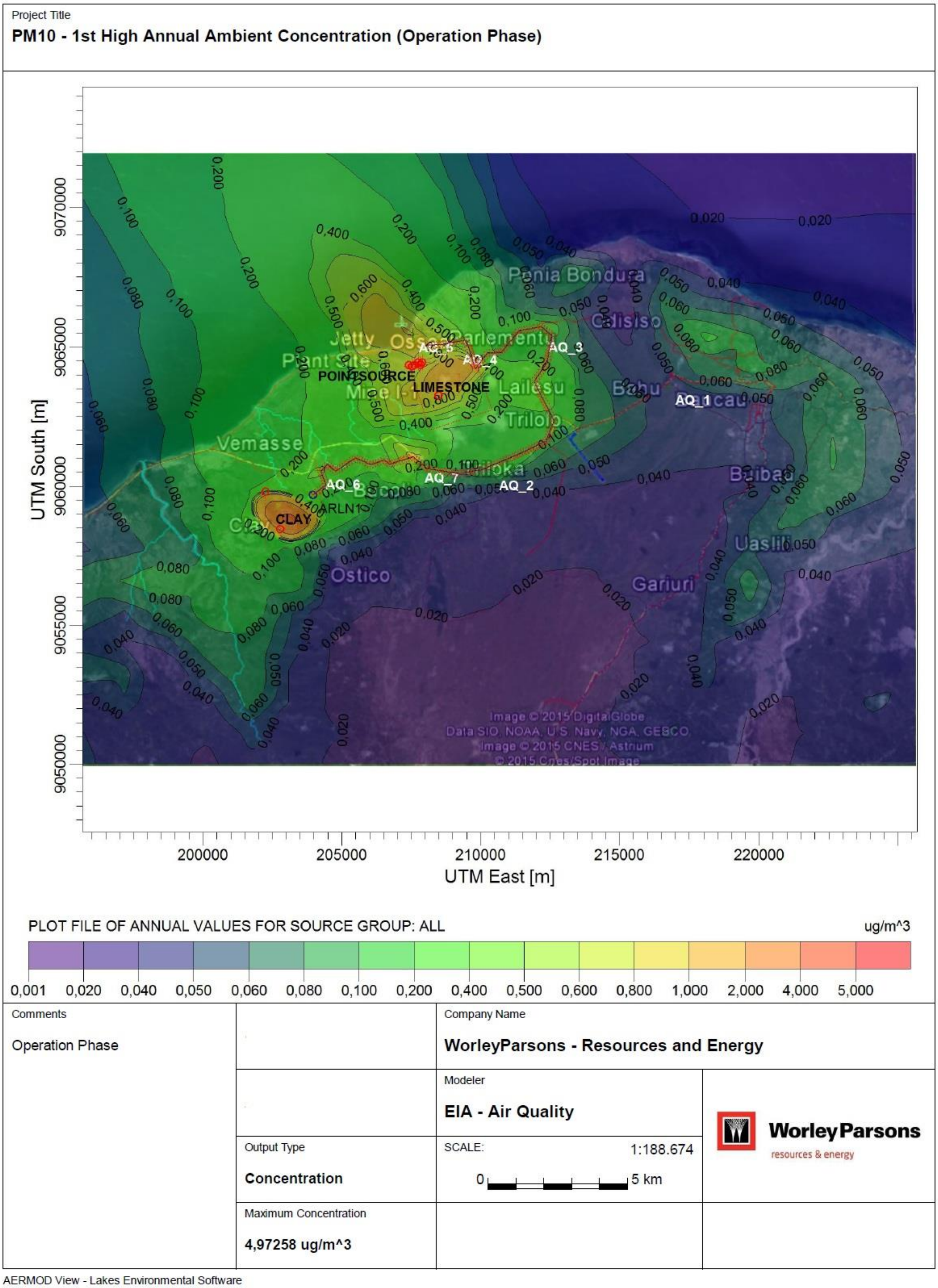
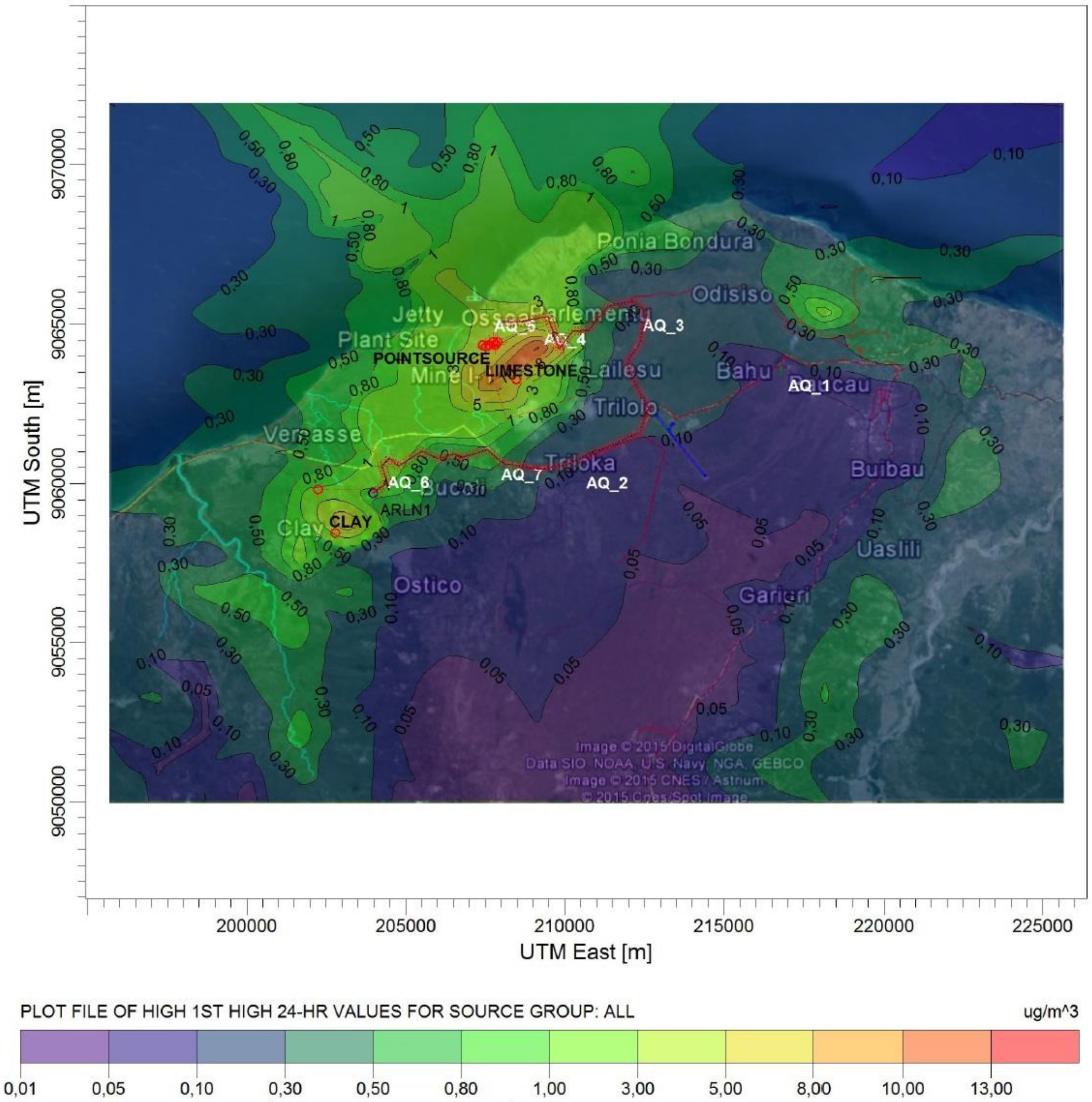


Figure 4.16 PM_{10} - 1st High Annual Ambient Concentration (Operation Phase)

Project Title

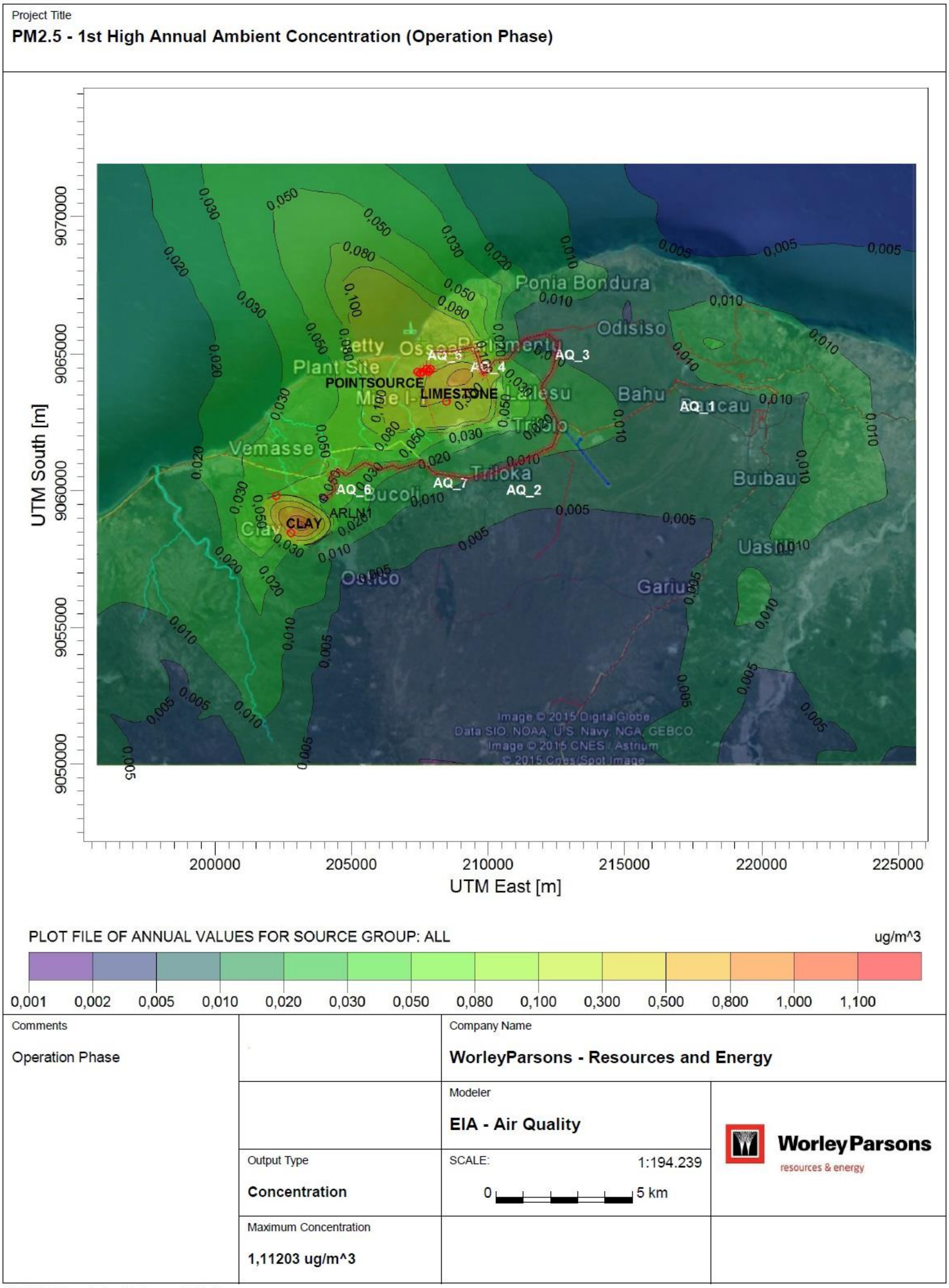
PM2.5 - 1st High 24 Hour Ambient Concentration (Operation Phase)



Comments Operation Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:197.704 0 5 km	
	Maximum Concentration **13,36986 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.17 $PM_{2.5}$ - 1st High 24 Hour Ambient Concentration (Operation Phase)

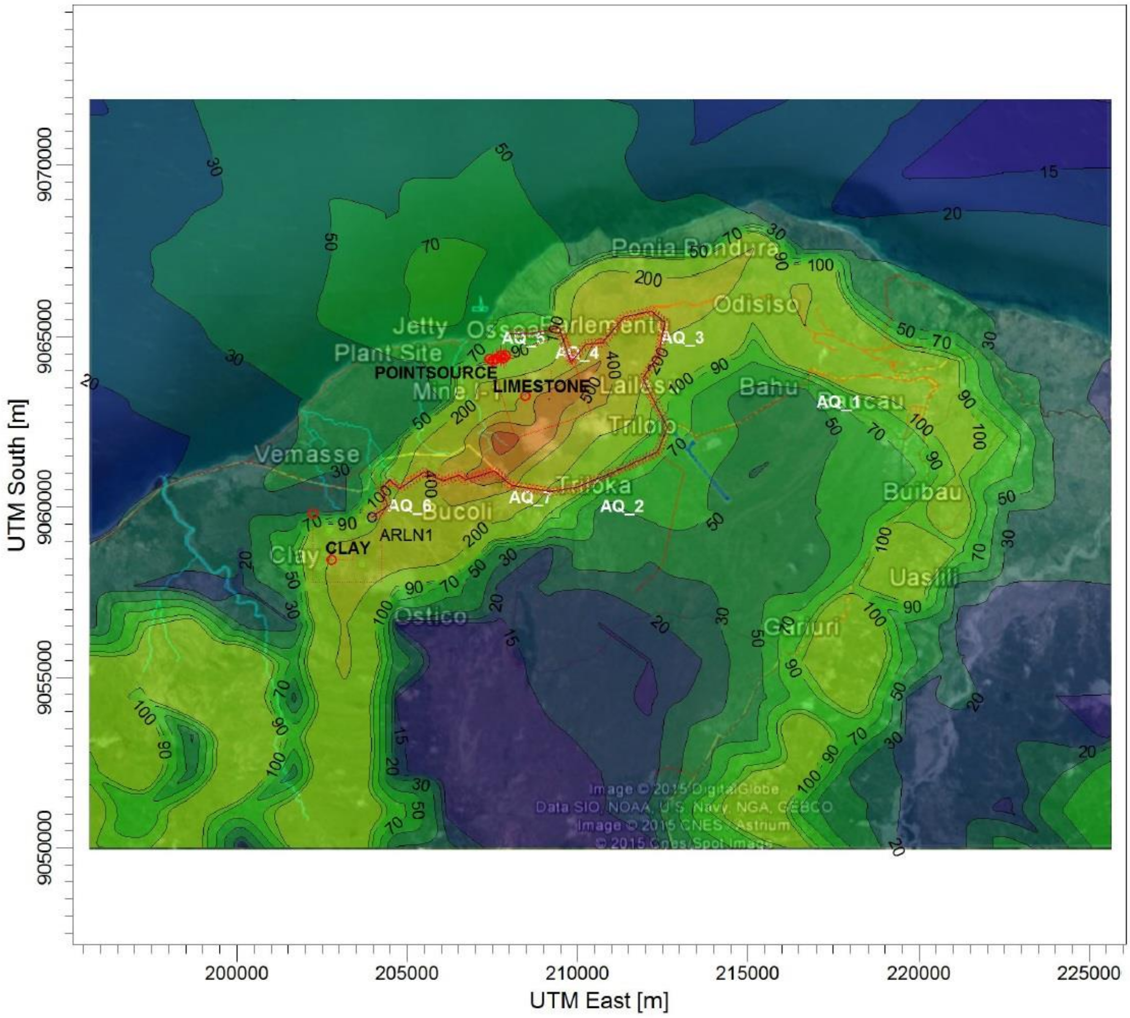


AERMOD View - Lakes Environmental Software

Figure 4.18 $PM_{2.5}$ - 1st High Annual Ambient Concentration (Operation Phase)

Project Title

CO - 1st High 1 Hour Ambient Concentration (Operation Phase)



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

8 10 15 20 30 50 70 90 100 200 400 500 600 659

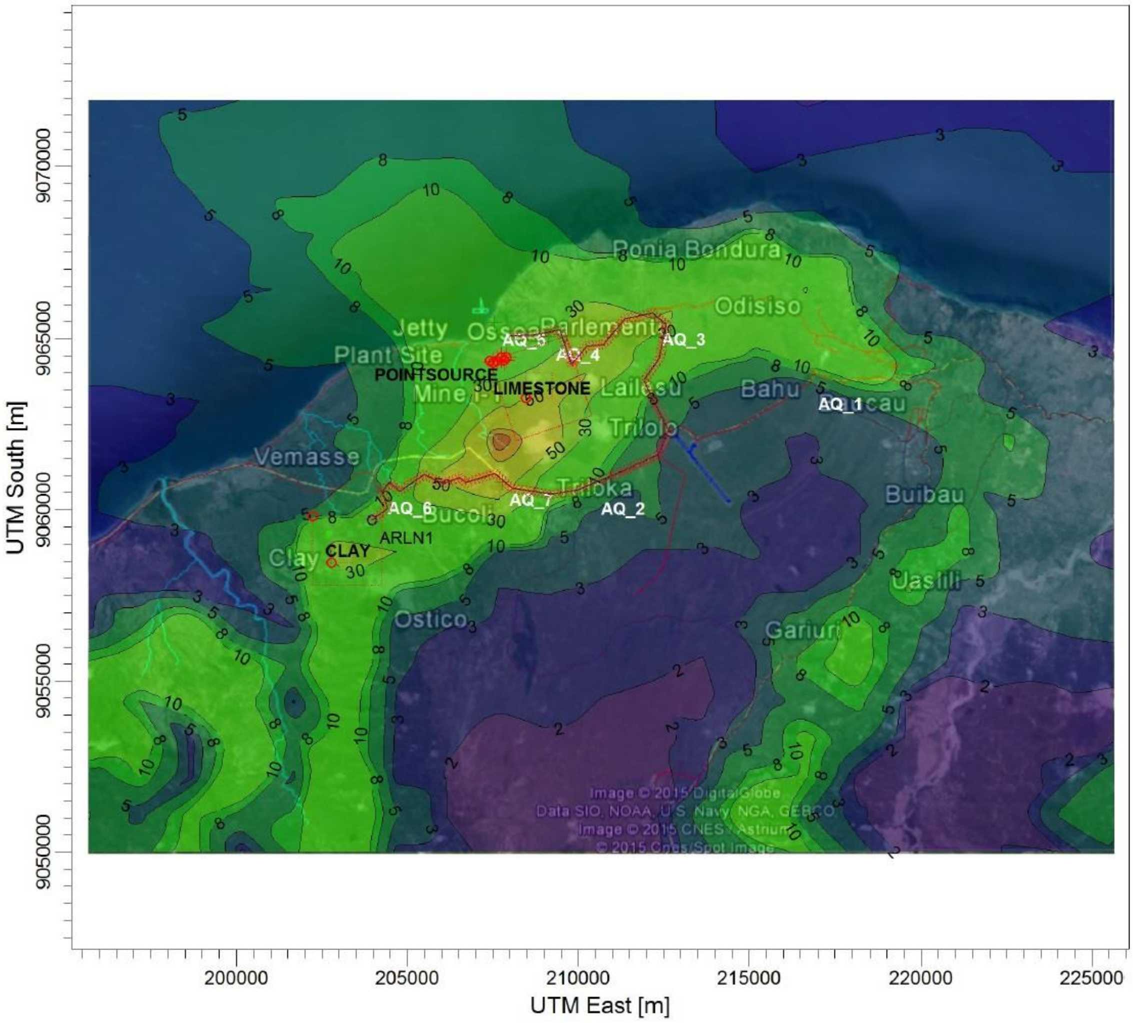
Comments		Company Name	
Operation Phase		**WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:194.239 0 5 km	
	Maximum Concentration **658,67683 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.19 CO - 1st High 1 Hour Ambient Concentration (Operation Phase)

Project Title

CO - 1st High 24 Hour Ambient Concentration (Operation Phase)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL — ug/m^3

1,0 | 2,0 | 3,0 | 5,0 | 8,0 | 10,0 | 30,0 | 50,0 | 80,0 | 90,0 | 100,0

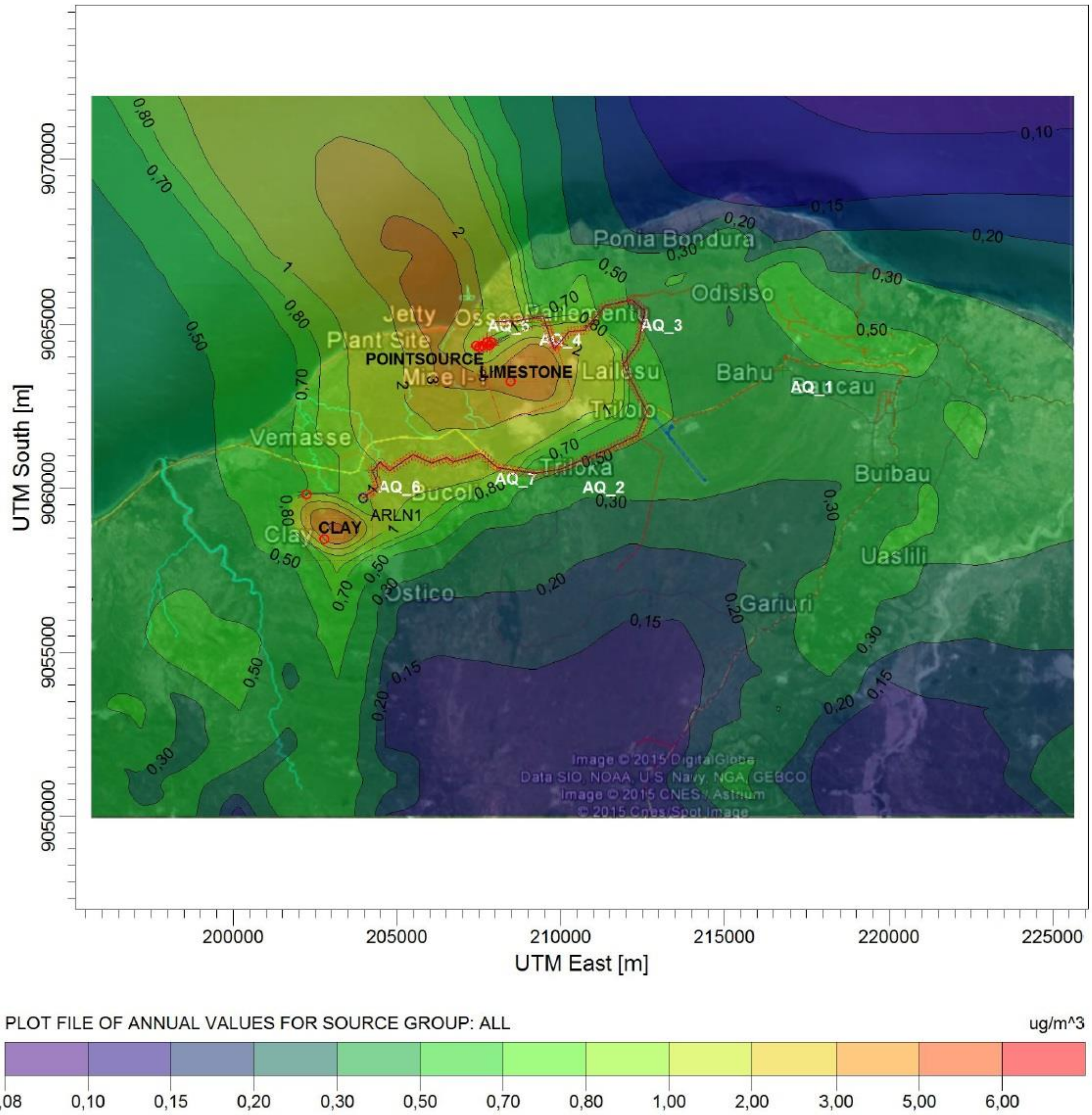
Comments Operation Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:194.239 0 — 5 km	
	Maximum Concentration **100,14775 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.20 CO - 1st High 24 Hour Ambient Concentration (Operation Phase)

Project Title

CO - 1st High Annual Ambient Concentration (Operation Phase)



Comments		Company Name
Operation Phase		**WorleyParsons - Resources and Energy**
		Modeler: **EIA - Air Quality**
	Output Type: **Concentration**	SCALE: 1:194.239 (0 – 5 km)
	Maximum Concentration: **5,88445 ug/m^3**	

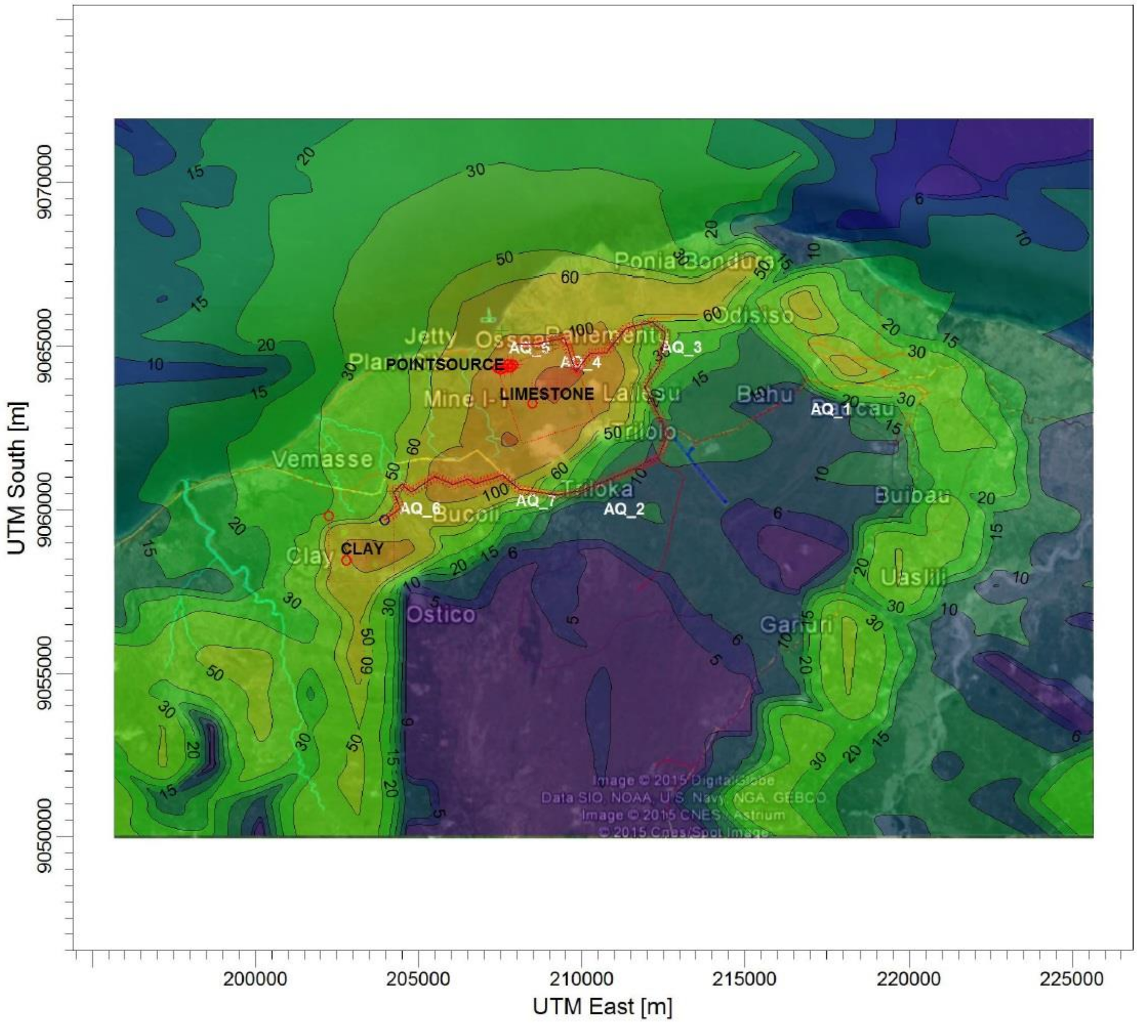
WorleyParsons resources & energy

AERMOD View - Lakes Environmental Software

Figure 4.21 CO - 1st High Annual Ambient Concentration (Operation Phase)

Project Title

NO2 - 1st High 1 hour Ambient Concentration (Operation Phase)



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: ALL — ug/m^3

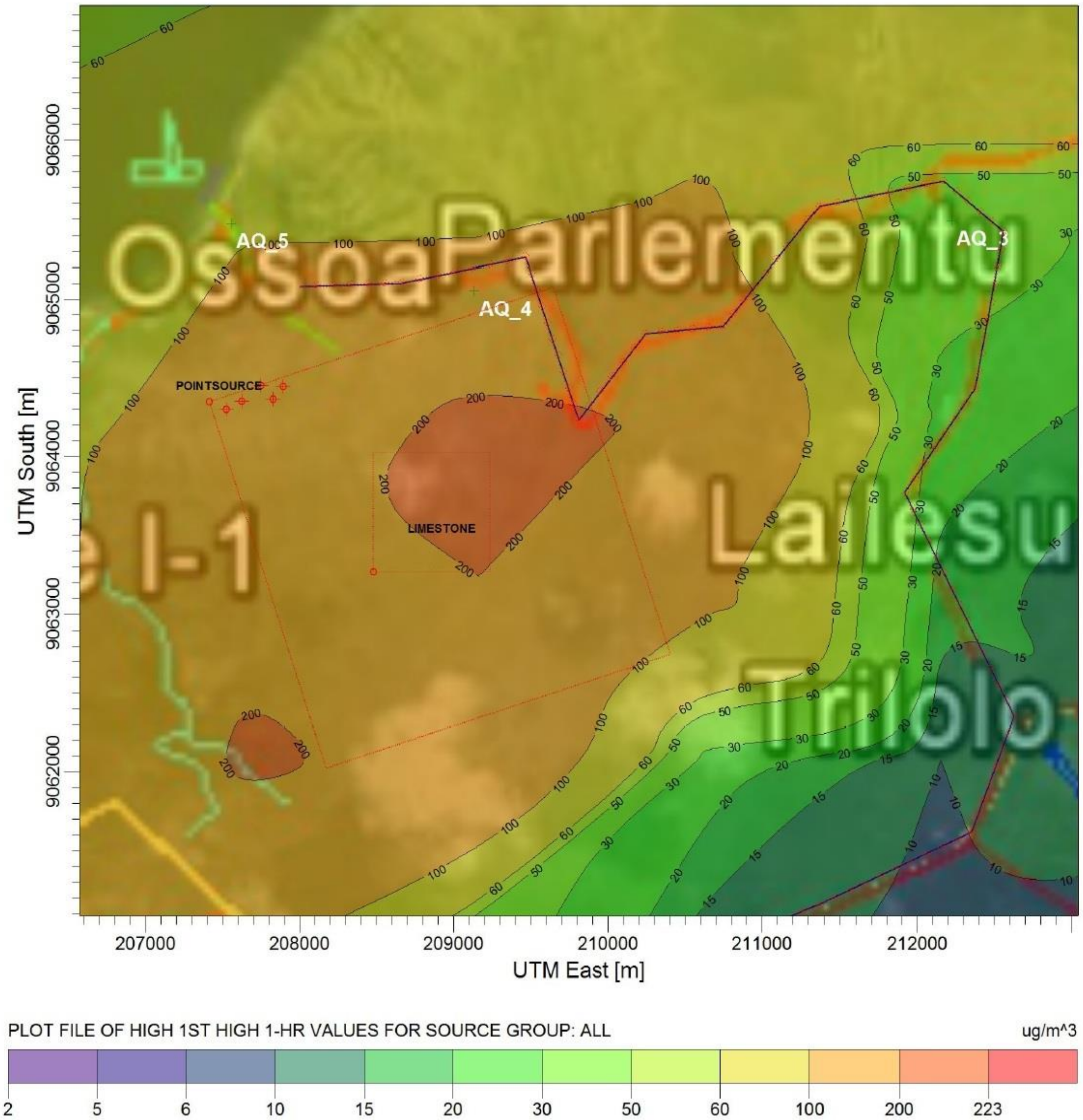
2 | 5 | 6 | 10 | 15 | 20 | 30 | 50 | 60 | 100 | 200 | 223

Comments Operation Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:203.952 0 — 5 km	
	Maximum Concentration **222,51581 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.22 NO_2 - 1st High 1 Hour Ambient Concentration (Operation Phase)

Project Title
NO2 - 1st High 1 Hour Ambient Concentration (Operation Phase)



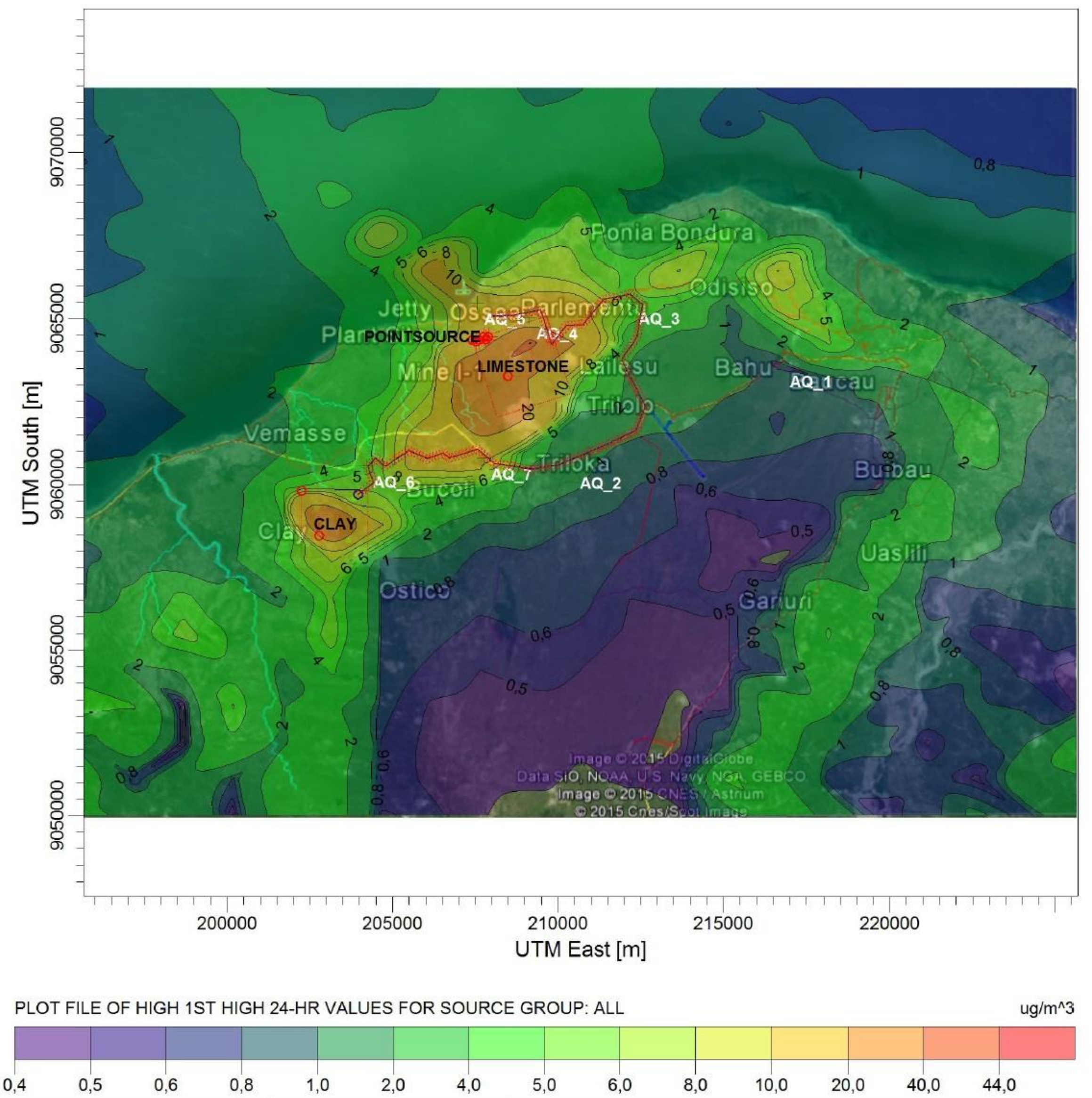
Comments		Company Name	
Operation Phase		WorleyParsons - Resources and Energy	
		Modeler: EIA - Air Quality	WorleyParsons resources & energy
	Output Type: Concentration	SCALE: 1:40.672 (0 – 1 km)	
	Maximum Concentration: 222,51581 ug/m^3		

AERMOD View - Lakes Environmental Software

Figure 4.23 NO_2 - 1[st] High 1 Hour Ambient Concentration – Closer View (Operation Phase)

Project Title

NO2 - 1st High 24 hour Ambient Concentration (Operation Phase)



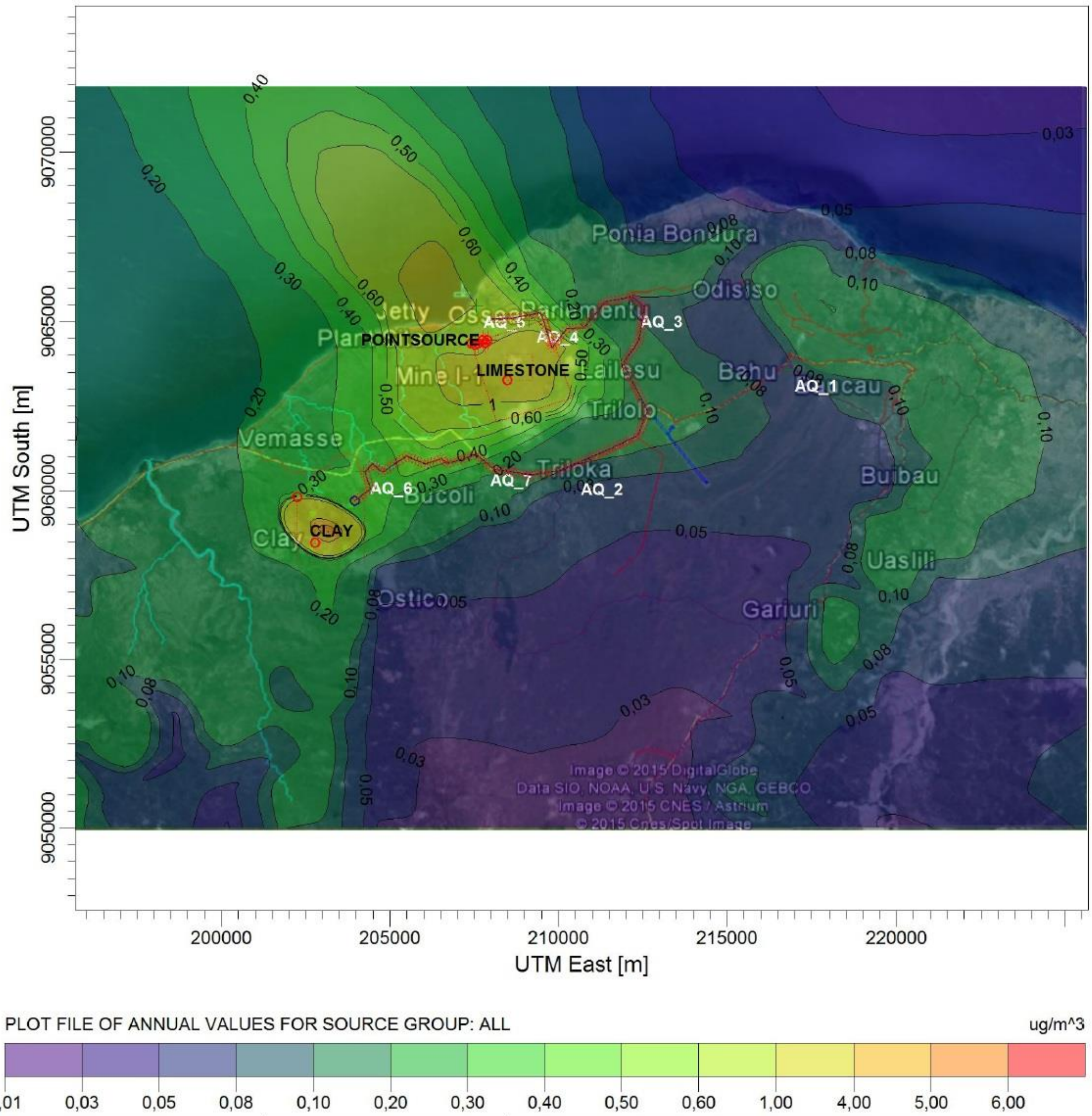
Comments Operation Phase		Company Name **WorleyParsons - Resources and Energy**
		Modeler **EIA - Air Quality**
	Output Type **Concentration**	SCALE: 1:188.674 0 — 5 km
	Maximum Concentration **44,22981 ug/m^3**	

AERMOD View - Lakes Environmental Software

Figure 4.24 NO_2 - 1st High 24 Hour Ambient Concentration (Operation Phase)

Project Title

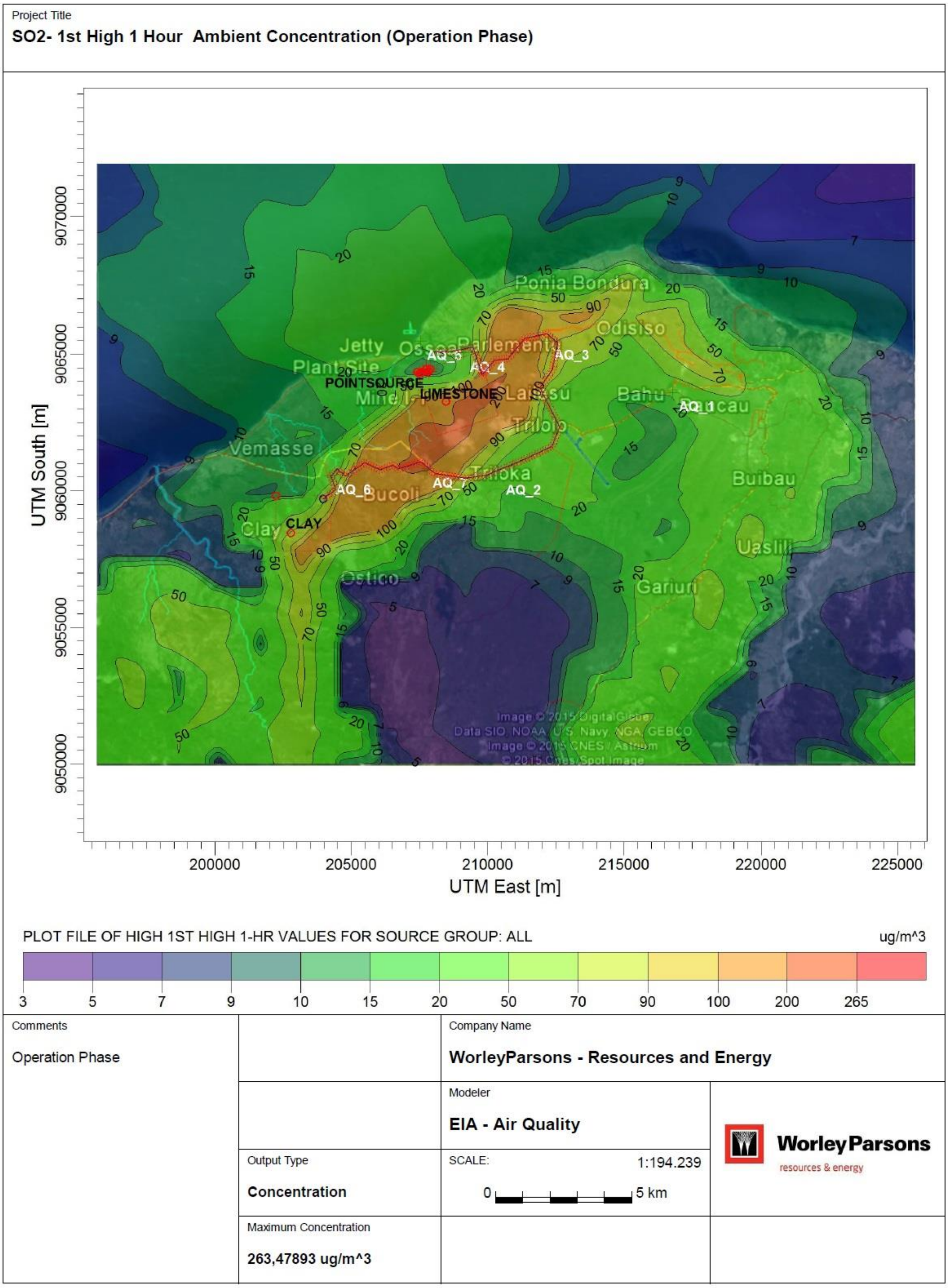
NO2 - 1st High Annual Ambient Concentration (Operation Phase)



Comments		Company Name	
Operation Phase		**WorleyParsons - Resources and Energy**	
		Modeler: **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type: **Concentration**	SCALE: 1:188.674 (0 — 5 km)	
	Maximum Concentration: **6,07035 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.25 NO_2 - 1st High Annual Ambient Concentration (Operation Phase)

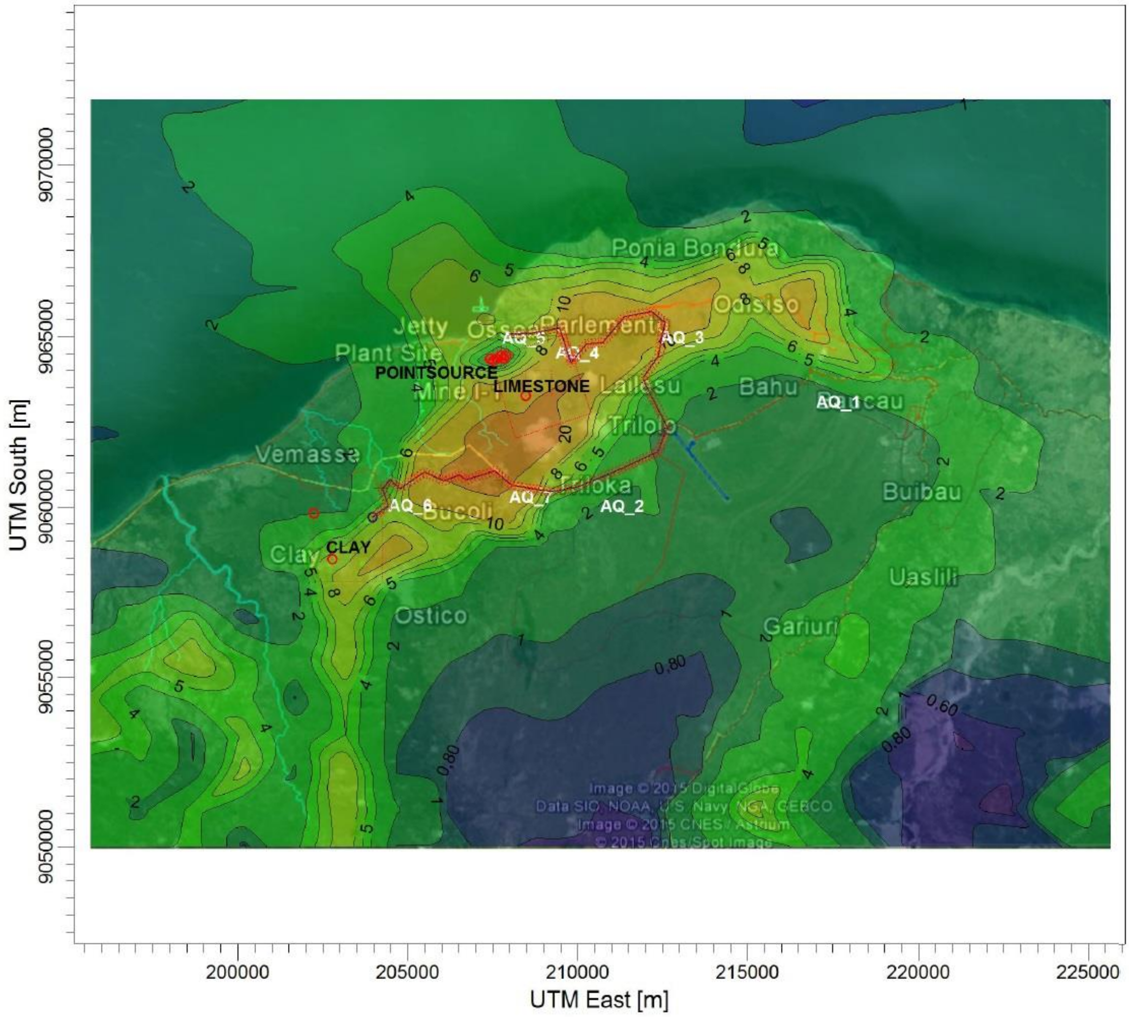


AERMOD View - Lakes Environmental Software

Figure 4.26 SO_2 - 1st High 1 Hour Ambient Concentration (Operation Phase)

Project Title

SO2- 1st High 24 Hour Ambient Concentration (Operation Phase)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL ug/m^3

0,40 0,50 0,60 0,80 1,00 2,00 4,00 5,00 6,00 8,00 10,00 20,00 40,00

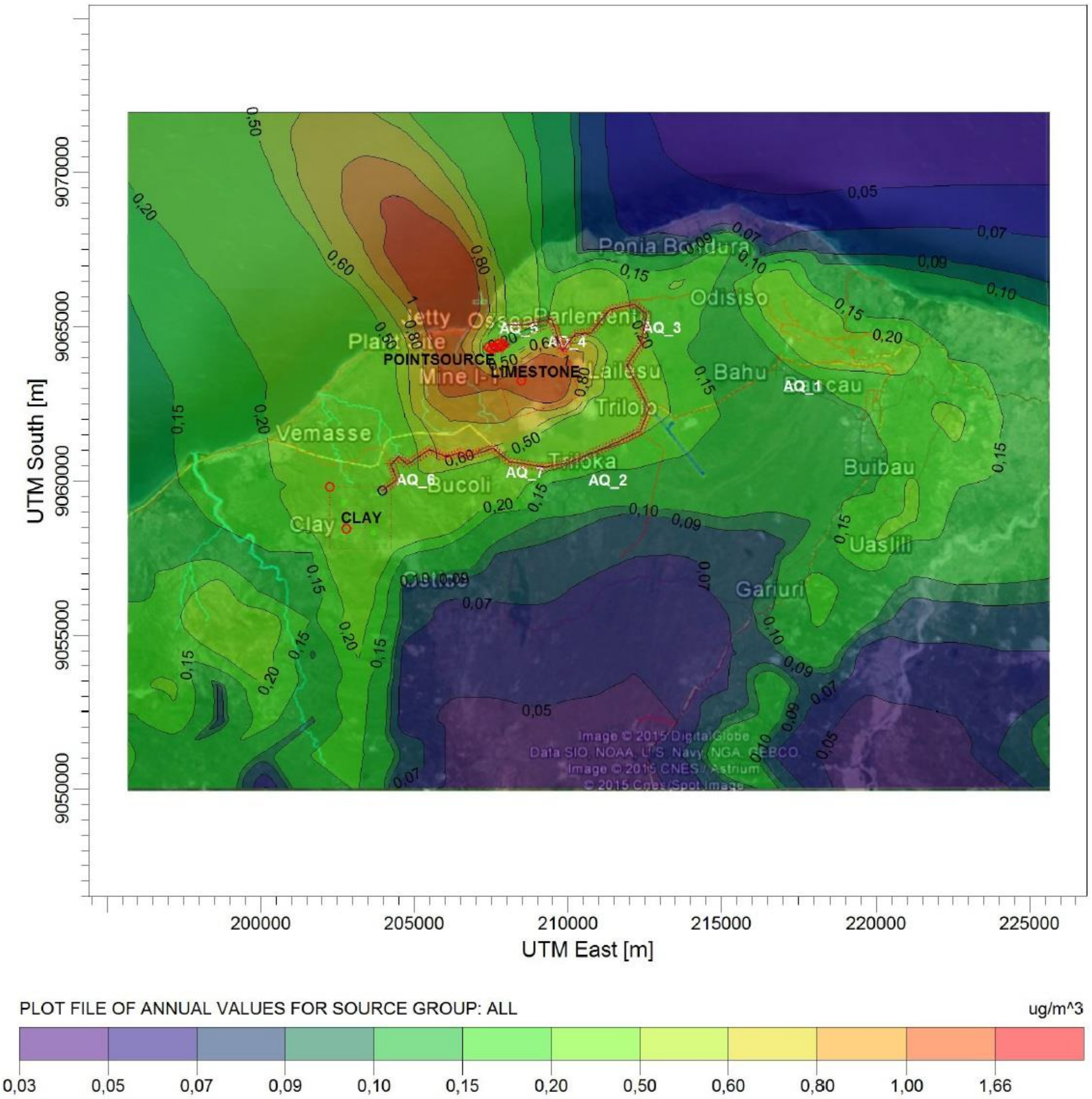
Comments Operation Phase		Company Name **WorleyParsons - Resources and Energy**	
		Modeler **EIA - Air Quality**	WorleyParsons resources & energy
	Output Type **Concentration**	SCALE: 1:194.239 0 5 km	
	Maximum Concentration **40,03219 ug/m^3**		

AERMOD View - Lakes Environmental Software

Figure 4.27 SO_2 - 1st High 24 Hour Ambient Concentration (Operation Phase)

Project Title

SO2- 1st High Annual Ambient Concentration (Operation Phase)



Comments		Company Name	
Operation Phase		WorleyParsons - Resources and Energy	
		Modeler: EIA - Air Quality	WorleyParsons resources & energy
	Output Type: Concentration	SCALE: 1:203.952 (0 – 5 km)	
	Maximum Concentration: 1,65708 ug/m^3		

AERMOD View - Lakes Environmental Software

Figure 4.28 SO_2 - 1st High Annual Ambient Concentration (Operation Phase)

4.2.3 Summary of the Modelling Output

The summary of predicted 1st high concentration for each pollutant is presented in **Table 4.17** for construction phase and **Table 4.18** for operation phase**.** The 1st high concentration is the highest concentration which occurs in each receptor for certain averaging time. During the construction phase, the highest concentration might occur less than 500 m away from the construction activities. During the operation phase, the highest concentrations generally occur farther at 1 up to 3 km away from the main sources (such as stacks). Although these highest concentrations are below the standards, people will undergo results of dispersion for a very long time (as long as the operation phase of the project), therefore mitigation measures during the construction and operation phase must be properly applied.

The dispersion patterns are presented by isopleth map as shown in **Figure 4.2** until **Figure 4.28.** In general, in can be concluded that highest concentrations are located in the mining area, cement plant and jetty area. Pollutants tend to disperse to the North West direction from the sources, in the opposite direction from where the prevailing winds blow (prevailing winds blow mostly from south east direction). Moreover, the area located in the south east direction from the sources (plant and mining area) has a higher level, which is capable of preventing pollutant dispersion by topographic barrier.

During the construction phase, predicted ambient concentration for all averaging time and all air pollutant parameters are below the ambient standard. While during operation phase, predicted ambient concentration for PM_{10}-$PM_{2.5}$ (24 hour and annual averaging time), CO-SO_2 (1 hour, 24 hour, and annual averaging time) and NO_2 (annual averaging time) are also below the ambient standard. Only 1 hour NO_2 concentrations (highest concentration: 222 µg/Nm^3) are predicted to be slightly above the standard (200 µg/Nm^3 according to WHO standard), with occurrence frequency shown in **Table 4.19**. Total number of 1 hour NO_2 calculated data are 3,924,480 data (derived from 448 receptors x 8760 hour in a year), and total number of exceedance (data above ambient standard) are 25 data only, therefore the exceedance percentage is only 0.0006%. The location which will undergo probable exceedance is located inside the limestone mining area, and shall not reach the sensitive receptor in AQ4 (illustrated in **Figure 4.23**). The 1 hour NO_2 concentration in AQ4 is predicted to be 100 to 150 µg/Nm^3.

The dispersed pollutants are predicted to be able to reach the sensitive areas, but the concentration level reaching these areas are all below the standard for each averaging time. Sensitive receptors which may experience higher dispersed concentration than other receptors are located in:

- AQ5, around the jetty plant area, scattered small cluster of fisherman village close to the plant area.
- AQ4, Aldeia Osso-ua, settlement close to the plant area.
- AQ6 Wailacama, settlement area at north east of clay quarry.

5. MITIGATION

The cement plant project will have negative impacts to the air quality, not only during construction phase but also during operation phase. Direct impact is indicated by the increase of certain air pollutant in the ambient air, caused by emission of significant amount of air pollutants due to air pollutant generating activities. Although the impact assessment using modelling tool has shown that the future ambient concentration generally below the ambient standard, mitigation must be implemented to keep the concentration of air pollutants in the ambient air is in allowable level.

5.1 Mitigation during Construction Phase

A relative high concentration of particulates will be emitted to the ambient air, therefore the mitigation should include, but not limited to the followings:

General Mitigation

- Ensuring that all adequate dust control measures are implemented in a timely manner during all phases of construction development.
- For all sites with areas of open ground that are close to sensitive receptors, construction works should follow best practice to prevent dust and other pollutant emissions from being carried outside the boundary;
- Provide a control zone around the site boundary to protect sensitive receptors (this could include an area of hard-standing, or by erecting effective barriers around dusty activities or the site boundary);
- Machinery, fuel and chemical storage and dust generating activities should not be located close to boundaries and sensitive receptors if at all possible.
- All workers onsite will undertake environmental awareness training to highlight potential issues specific to this construction project.
- The contractor will provide the need based safety measures by providing personal protective equipment (PPE) to the workers based on the nature of the work e.g., providing helmets and goggles for the workers working with the installation of roofs, providing ear plugs or ear muff for workers who works using power machinery, ear protection will help protect the important sense of hearing.
- Ensure correct working methods are employed during construction process to avoid.

Mitigation during Site Preparation

Site preparation related to earth moving works. Excavation and earthwork activities can be a potential source of dust outside the site if they are not properly controlled;

- All material excavated, stockpiled, or graded shall be sufficiently watered, treated, or covered to prevent fugitive dust from leaving the property boundaries and causing a public nuisance or a violation of an ambient air standard.
- Watering should occur at least twice daily, with complete site coverage.
- All land clearing, grading, earth moving, or excavation activities on a project should be suspended as necessary to prevent excessive windblown dust when winds are expected to exceed 20 mph.
- All areas with vehicle traffic shall be watered or have dust palliative applied as necessary for regular stabilization of dust emissions.

- All on-site vehicle traffic shall be limited to a speed of 15 mph on unpaved roads.
- All material transported off-site shall be either sufficiently watered or securely covered to prevent public nuisance, and there must be a minimum of six (6) inches of freeboard in the bed of the transport vehicle.

Mitigation during Construction of Facilities

Construction works should carry out the following controls to reduce particulates and gases associated with vehicles - such as that from exhaust emissions, the contact of tires on the road surface or dust blowing from materials carried.

- ***Vehicle operation***
  - No vehicles or plant will be left idling unnecessarily;
  - Reduce the number of vehicle movements through better planning;
  - Set an appropriate speed limit on haul routes;
  - Clearly label all vehicles associated with the contract.
- ***Vehicle certification***
  - All heavy duty vehicles should meet certain emission regulation from local Environmental Protection Agency.
- ***Emission abatement***
  - Use a good quality of fuel (e.g. with low sulphur content)
  - Engines and exhaust systems should be regularly serviced according to manufacturer's recommendations and maintained to meet statutory limits/opacity tests.

  Construction works also use heavy equipment which can emit pollutants from internal combustion of fuel in their machines. The followings should prevent the emissions:

  - All heavy equipment should meet certain emission regulation from local Environmental Protection Agency.
  - Equipment should not be left idling unnecessarily.
  - Non Road Mobile Machinery (vehicles and plant) should be well maintained. Should any emissions of dark smoke occur (except during start up) then the relevant machinery should be stopped immediately and any problem rectified before being used.

Mitigation Monitoring and Reporting

A mitigation monitoring and reporting program should be developed and should include the following components:

- Monitor the air quality in sensitive receptors, especially AQ5 (representing the construction area), AQ4 (settlement area in Aldeia Osso-ua), AQ6 (settlement area in Wailacama), once every six month to ensure the air quality parameters do not violate the standard. Parameters which should be measured area:
  - PM_{10}, $PM_{2.5}$, CO, NO_2, and SO_2 : representing the primary air pollutant.
  - Ozone: representing the secondary air pollutant.

- Monitoring results and mitigation activities should be reported to the local environmental agency

5.2 Mitigation during Operation Phase

The main sources of dust from the cement production process are kilns, raw materials mills, clinker coolers, and cement mills. In all these processes, large volumes of gases flow through dusty material.

Cement manufacturing involves the movement of dusty or pulverized materials from quarrying the limestone to loading the finished product for shipment, and fugitive dust emissions can arise during the storage and handling of materials and solid fuels, and also from road surfaces. Particulate releases from the packing and dispatch of clinker/cement can also be significant.

Mitigation in Cement Plant Area

Emission from stacks due to activities in crusher, raw mill, coal mill, clinker cooler, cement mill, packing plant, should use the following mitigation measures:

Related to Stack's Emission

- Ensure maximum efficiency of combustion in kiln.
- Performance guarantee of suitably designed Bag filters/ ESP will limit the dust concentration to 30 mg/ Nm^3 in all emissions.
- In the event of failure of any pollution control equipment, automatic tripping in the control system should be provided.
- Efficiency of each air pollution control equipment will be ensured to more than 99%.
- Continuous dust monitor should be installed on kiln stack.
- Performance guarantee of SO_2, NO_x, and CO emissions from stacks is within the norms of 200 mg/ Nm^3, 800 mg/ Nm^3, and 500 mg/ Nm^3 respectively as specified.
- A well-designed low NO_x burner system will limit the core flame temperature to ensure a low value of $NO_{x.}$
- Regular preventive maintenance of pollution control equipment.
- All vehicles and their exhausts will be well maintained and regularly tested for emission concentration.

Related to fugitive emission

- Drop distances will be minimized by adjusting the conveyors.
- Dust suppression system by water sprinkler at dump hopper of raw materials.
- Regular dust suppression on the haul roads.
- Plant roads & approach roads will be made of bitumen/ concrete & mechanical vacuum cleaner shall be used for cleaning of dust on internal roads.
- Open areas within the plant premises/ along boundaries of the plant premises will be covered under green belt.
- Raw Materials/ products will be fully covered during transportation to/ from the site by road.

Mitigation in Mining Area

The following corrective measures are proposed for prevention of pollution of air and to maintain it well within the prescribed limits, in the limestone and clay mining area:

- Water spray on haulage roads shall be continuous process & proper maintenance of haul roads shall be done.
- Dust suppression systems (water spraying) will be adopted at faces/ sites before and after blasting and while loading.
- Dust generated due to blast hole drilling will be suppressed by using water injecting system of dust collectors, Proper maintenance of vehicles shall be done to limit gaseous emissions.
- A speed limit will be defined for the trucks/ dumpers moving within the mining area.
- Use of sharp drill bits for drilling holes and drills with water flushing systems (wet drilling) to reduce dust generation
- Mitigation measures for blasting in limestone mine:
    - All blasting will be done by a person who holds license
    - Blasting will be conducted in a manner that prevents injury to persons and damage to public or private property outside the project area
    - Timing of blasting will avoid high wind speeds and when workers are away from the mining face (for example: lunchtime).

Mitigation for Workers

- All workers onsite will undertake environmental awareness training to highlight potential issues specific to this operation project.
- The contractor will provide the need based safety measures by providing personal protective equipment (PPE) to the workers based on the nature of the work.

  Ensure correct working methods are employed during operation process.

Mitigation Monitoring and Reporting

A mitigation monitoring and reporting program should also be developed in operation phase, and should include the following components:

- Monitor the ambient air quality in sensitive receptors: AQ1 (settlement area in Bahu, east-south east of cement plant), AQ3 (School area in Aldeia Parlemento, east of cement plant and north east of limestone mine) AQ4 (settlement area in Aldeia Osso-ua), AQ6 (settlement area in Wailacama, north east of clay quarry) every six month to ensure the air quality parameters do not violate the standard. Parameters which should be measured are:
    - PM_{10}, $PM_{2.5}$, CO, NO_2, and SO_2 : representing the primary air pollutant
    - Ozone: representing the secondary air pollutant
- Monitoring the emission from stacks every six month:
    - Kiln stack and Thermal power plant stack; measured parameters are: particulates (PM_{10}, $PM_{2.5}$), CO, SO_2, and NO_2.

  - Cooler ESP stack, cement mill bag house stack, coal mill bag house stack; measured parameter is only particulate (PM_{10},and $PM_{2.5}$).
  - Analysing data from CEMS (Continuous Emission Monitoring Systems) installed in Kiln Stack.

- Monitoring results and mitigation activities should be reported to the local environmental agency

6. REFFERENCE

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3). Rood A.S, Performance Evaluation of AERMOD, CALPUFF and Legacy air Dispersion Models Using The Winter Validation Tracer Study Dataset, Atmospheric Environment, Volume 89, 2014

4). Standard Test Method for Nitrogen Dioxide Content of the Atmosphere (Reaction). Active Standard ASTM D1607 | Developed by Subcommittee: D22.03, Book of Standards Volume: 11.07

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APPENDIX

Technical Manual for Modelling of Air Quality using AERMOD

AERMOD is a regulatory steady-state plume modelling system with three separate components: AERMET (AERMOD Meteorological Pre-processor), AERMAP (AERMOD Terrain Pre-processor), and AERMOD (AERMIC Dispersion Model). The AERMOD model includes a wide range of options for modelling air quality impacts of pollution sources, making it a popular choice among the modelling community for a variety of applications.

Figure 1 shows the flow and processing of information in AERMOD. The modelling system consists of one main program (AERMOD) and two pre-processors (AERMET and AERMAP). The major purpose of AERMET is to calculate boundary layer parameters for use by AERMOD. The meteorological INTERFACE, internal to AERMOD, uses these parameters to generate profiles of the needed meteorological variables. In addition, AERMET passes all meteorological observations to AERMOD.

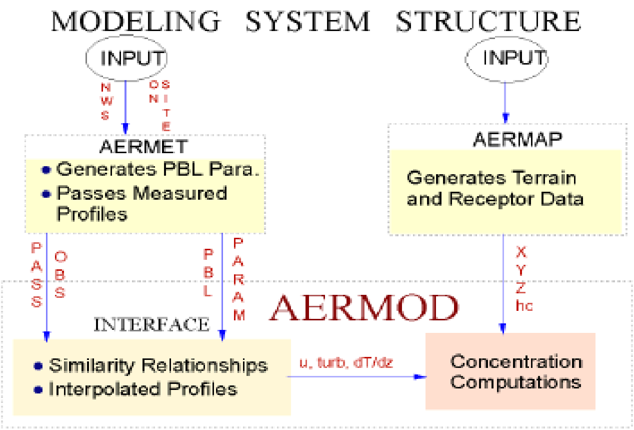


Figure 1 Data Flow in the AERMOD Modelling System

AERMOD Meteorological Processor (AERMET)

One of the major improvements that AERMOD brings to applied dispersion modelling is its ability to characterize the Planetary Boundary Layer (PBL)[2] through both surface and mixed layer scaling. AERMOD constructs vertical profiles of required meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using available meteorological observations. The AERMET program is a meteorological pre-processor which prepares hourly surface data and upper air data for use in the AERMOD short-term air quality dispersion model. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms. AERMET processes meteorological data in three stages and from this process two files are generated for use with the AERMOD model (see **Figure 2**):

1. A Surface File of hourly boundary layer parameters estimates;
2. A Profile File of multiple-level observations of wind speed, wind direction, temperature, and standard deviation of the fluctuating wind components.

[2] Planetary Boundary Layer (PBL) or Atmospheric Boundary Layer: the bottom layer of the troposphere that is in contact with the surface of the earth.

Flow sheet depicting the AERMET processing stages is shown below.

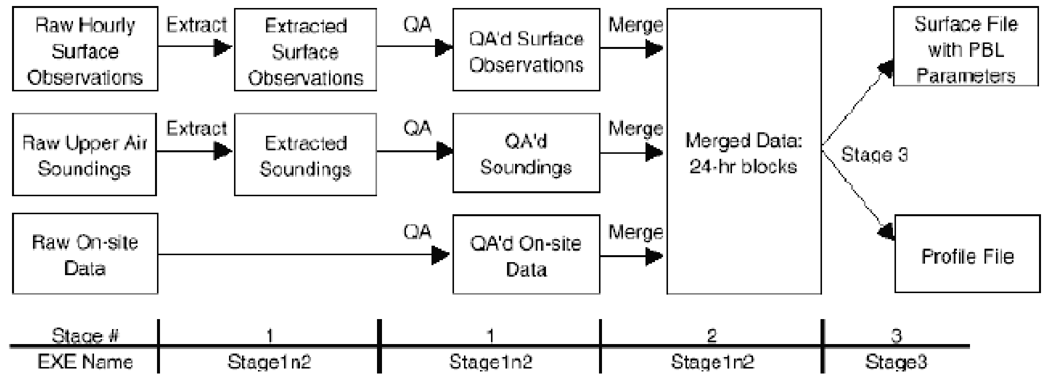


Figure 2 AERMET Processing Stages
(Source: U.S. EPA User's Guide for AERMET – DRAFT)

Surface characteristics in the form of albedo[3], surface roughness and Bowen ratio[4], plus standard meteorological observations (wind speed, wind direction, temperature, and cloud cover), are input to AERMET. AERMET then calculates the PBL parameters (see **Figure 3**): friction velocity (u_*), Monin-Obukhov length (L), convective velocity scale (w_*), temperature scale (θ_*), mixing height (z_i), and surface heat flux (H). These parameters are then passed to the INTERFACE (which is within AERMOD) where similarity expressions (in conjunction with measurements) are used to calculate vertical profiles of wind speed (u), lateral and vertical turbulent fluctuations (σ_v, σ_w), potential temperature gradient ($d\theta/dz$), and potential temperature (θ).

AERMET defines the stability of the PBL by the sign of H (convective for $H > 0$ and stable for $H < 0$). Although AERMOD is capable of estimating meteorological profiles with data from as little as one measurement height, it will use as much data as the user can provide for defining the vertical structure of the boundary layer. In addition to PBL parameters, AERMET passes all measurements of wind, temperature, and turbulence in a form AERMOD needs.

[3] Albedo: the fraction of the incident sunlight that is reflected
[4] Bowen ratio: the ratio of heat used for "Sensible Heat" (conduction and convection) to heat used for "Latent Heat" (vaporization of water) expressed in percent.

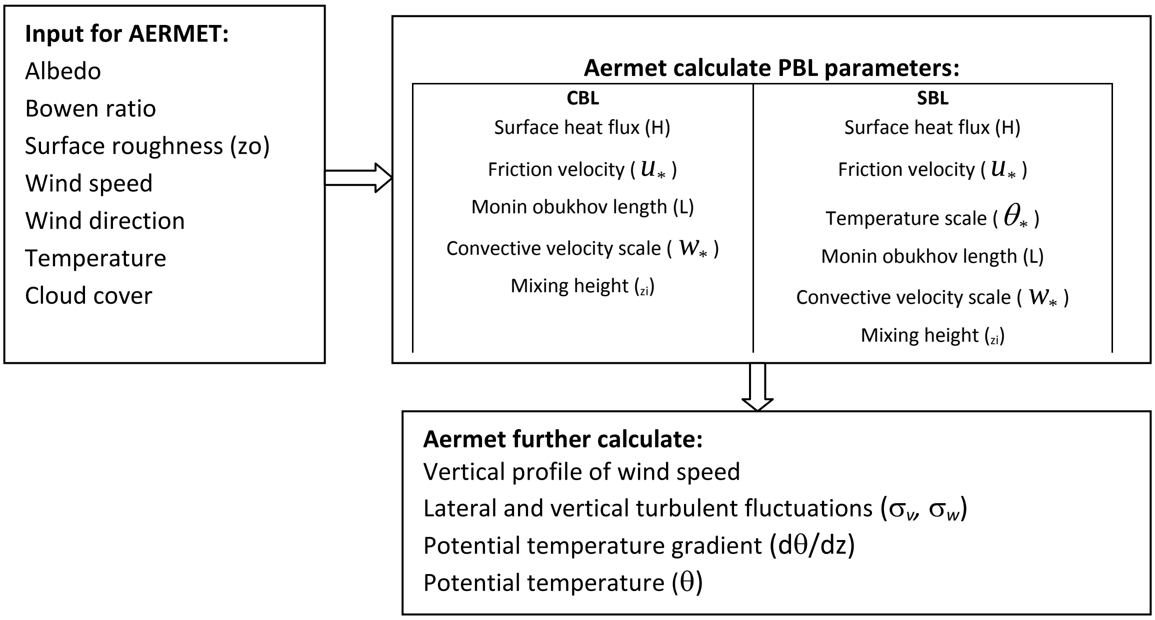


Figure 3 Flow of AERMET Estimating PBL Parameters

AERMOD Terrain Pre-processor (AERMAP)

Using a relatively simple approach, AERMOD incorporates current concepts about flow and dispersion in complex terrain. Where appropriate the plume is modelled as either impacting and/or following the terrain. This approach has been designed to be physically realistic and simple to implement while avoiding the need to distinguish among simple, intermediate and complex terrain, as required by other regulatory models. As a result, AERMOD removes the need for defining complex terrain regimes. All terrain is handled in a consistent and continuous manner while considering the dividing streamline concept (Snyder et al. 1985) in stably stratified conditions.

The AERMIC terrain pre-processor AERMAP uses gridded terrain data to calculate a representative terrain-influence height (h_c), also referred to as the terrain height scale. The terrain height scale h_c, which is uniquely defined for each receptor location, is used to calculate the dividing streamline height. The gridded data needed by AERMAP is selected from Digital Elevation Model (DEM) data. AERMAP is also used to create receptor grids. The elevation for each specified receptor is automatically assigned through AERMAP. For each receptor, AERMAP passes the following information to AERMOD: the receptor's location (x_r , y_r), its height above mean sea level (z_r), and the receptor specific terrain height scale (h_c).

AERMIC Dispersion Model (AERMOD)

AERMOD is a steady-state plume model, which assumes that concentrations at all distances during a modelled hour are governed by the temporally averaged meteorology of the hour. The steady state assumption yields useful results since the statistics of the concentration distribution are of primary concern rather than specific concentrations at particular times and locations.

In the stable boundary layer (SBL)[5], AERMOD assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL)[6], the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). This behaviour of the concentration distributions in the CBL was demonstrated by Willis and Deardorff (1981) and Briggs (1993). Additionally, in the CBL, AERMOD treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. For sources in both the CBL and the SBL AERMOD treats the enhancement of lateral dispersion resulting from plume meander.

In general, AERMOD models a plume as a combination of two limiting cases: a horizontal plume (terrain impacting) and a terrain-following plume. Therefore, for all situations, the total concentration, at a receptor, is bounded by the concentration predictions from these states. In flat terrain the two states are equivalent. By incorporating the concept of the dividing streamline height, in elevated terrain, AERMOD's total concentration is calculated as a weighted sum of the concentrations associated with these two limiting cases or plume states (Venkatram et al. 2001).

The general concentration equation, which applies in stable or convective conditions, is given by:

$$C_T\{x_r,y_r,z_r\} = f \cdot C_{c,s}\{x_r,y_r,z_r\} + (1-f)\,C_{c,s}\{x_r,y_r,z_p\} \qquad \textbf{Eq. 1}$$

where $C_T\{x_r, y_r, z_r\}$ is the total concentration, $C_{c,s}\{x_r, y_r, z_r\}$, is the contribution from the horizontal plume state (subscripts c and s refer to convective and stable conditions, respectively), $C_{c,s}\{x_r, y_r, z_p\}$ is the contribution from terrain-following state, f is the plume state weighting function, $\{x_r, y_r, z_r\}$ is the coordinate representation of a receptor (with z_r defined relative to stack base elevation), $z_p=z_r-z_t$ is the height of a receptor above local ground, and z_t is the terrain height at a receptor. **Figure 4** illustrates the relationship between the actual plume and AERMOD's characterization of it.

[5] Stable Boundary Layer (SBL): a cool layer of air adjacent to a cold surface of the earth, where temperature within that layer is statically stably stratified.

[6] Convective Boundary Layer (SBL): a type of atmospheric boundary layer characterized by vigorous turbulence tending to stir and uniformly mix, primarily in the vertical, quantities such as conservative tracer concentrations, potential temperature, and momentum or wind speed.

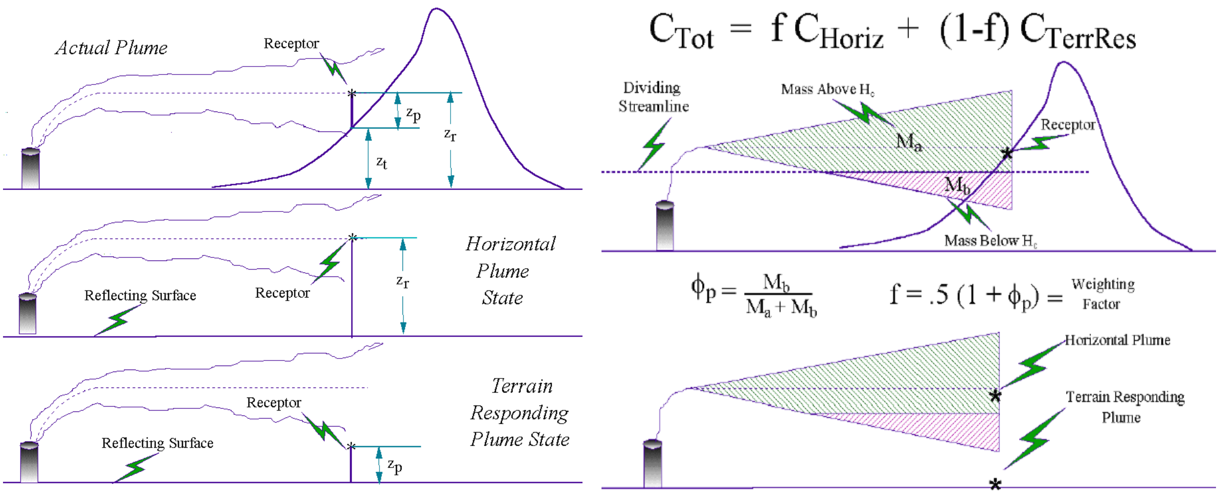


Figure 4 AERMOD Two State Approach.

(The total concentration predicted by AERMOD is the weighted sum of the two extreme possible plume states).

The general form of the expressions for concentration in each term of **eq. 1** for both the CBL and the SBL can be written as follows

$$C\{x,y,z\} = \left(Q/\tilde{u}\right) P_y\{y;x\}\, P_z\{z;x\} \qquad \textbf{Eq. 2}$$

here Q is the source emission rate, u is the effective wind speed, and P_y and P_z are probability density functions (pdf) which describe the lateral and vertical concentration distributions, respectively.

Concentration Predictions in the CBL

In AERMOD, the dispersion formulation for the convective boundary layer (CBL) represents one of the more significant model advances by comparison with existing regulatory models. One assumes that plume sections are emitted into a travelling train of convective elements – updrafts and downdrafts - that move with the mean wind. The vertical and lateral velocities in each element are assumed to be random variables and characterized by their probability density functions (pdf). The mean concentration is found from the pdf of the position of source-emitted “particles”; this position pdf in turn is derived from the pdf of the lateral and vertical velocities as described by Weil et al. (1997); also see Misra (1982), Venkatram (1983), and Weil (1988a).

In the CBL, the pdf of the vertical velocity (*w*) is positively skewed and results in a non-Gaussian vertical concentration distribution, F_z (Lamb 1982). The positive skewness is consistent with the higher frequency of occurrence of downdrafts than updrafts; for an elevated non-buoyant source the skewness also leads to the decent of the plume centreline, as defined by the locus of maximum concentration (Lamb 1982; Weil 1988a).

Figure 5 presents a schematic representation of an instantaneous plume in a convective boundary layer and its corresponding ensemble average. The base concentration prediction in AERMOD is representative of a one hour average.

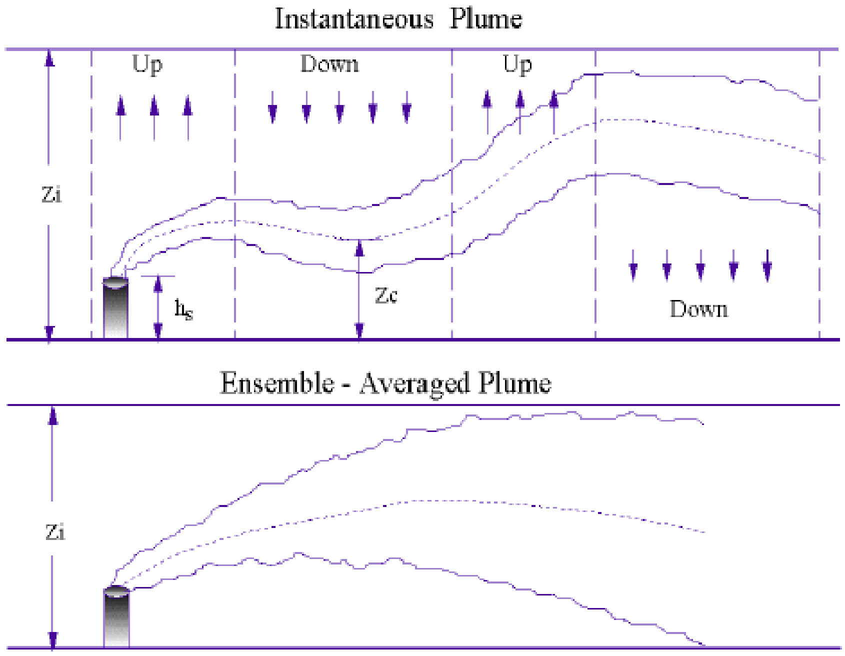


Figure 5 Instantaneous And Corresponding Ensemble-Averaged Plume in the CBL

The direct transport of plume material to the ground is treated by the "direct" source located at the stack. That is, the direct source treats that portion of the plume's mass to first reach the ground, and all subsequent reflections of the mass at $z = z_i$ and 0 (where z_i is the mixed layer height in the CBL (Cimorelli et al., 2004).

For plume segments or particles initially rising in updrafts, an "indirect" or modified-image source is included (above the mixed layer) to address the initial quasi-reflection of plume material at $z = z_i$, i.e., for material that does not penetrate the elevated inversion. This source is labelled "indirect" because it is not a true image source (i.e., as is found in models such as ISC) - the plume is not perfectly reflected about z_i. Thus, the indirect source treats that portion of the plume's mass that first reaches z_i and all subsequent reflections of that particular mass at $z = 0$ and z_i,

For the indirect source, a plume rise (Δh_i) is added to delay the downward dispersion of material from the CBL top (see **Figure 6**); this mimics the plume's lofting behaviour, i.e., the tendency of buoyant plumes to remain temporarily near z_i and resist downward mixing. For non-buoyant sources the indirect source reflection at $z = z_i$. Additionally, a "penetrated" source or plume (above the CBL top) is included to account for material that initially penetrates the elevated inversion but is subsequently re-entrained by and disperses in the growing CBL.

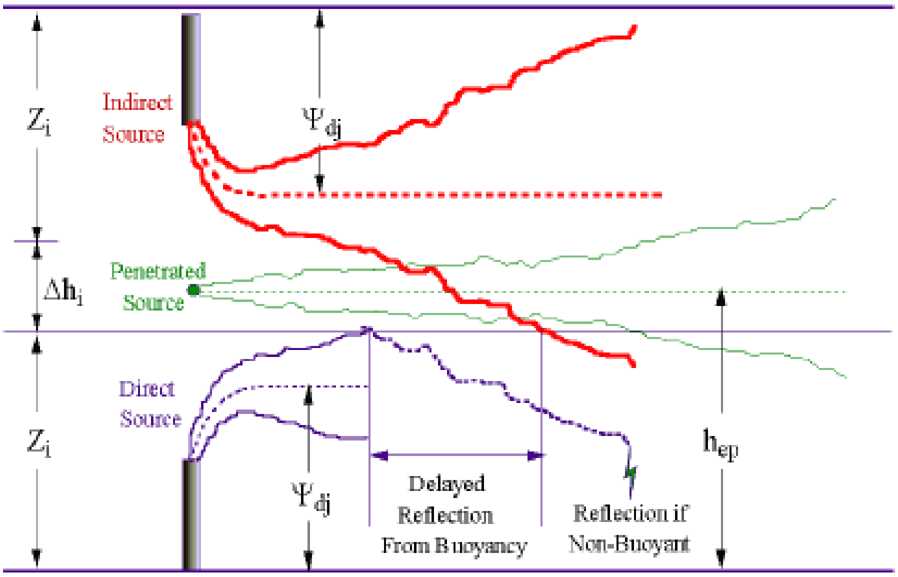


Figure 6 AERMOD's Three Plume Treatment of the CBL

In line with the above concepts there are three main mathematical sources that contribute to the modelled concentration field: 1) the direct source (at the stack), 2) the indirect source, and 3) the penetrated source. The strength of the direct source is f_pQ where Q is the source emission rate and f_p is the calculated fraction of the plume mass trapped in the CBL ($0 \leq f_p \leq 1$). Likewise, the indirect source strength is f_pQ since this (modified image) source is included to satisfy the no flux boundary condition at $z = z_i$ for the trapped material. The strength of the penetrated source is $(1- fp)Q$, which is the fraction of the source emission that initially penetrates into the elevated stable layer. In addition to the three main sources, other image sources are included to satisfy the no-flux conditions at $z = 0$ and z_i.

In AERMOD, the total concentration (C_c) in the CBL is found by summing the contribution from the three sources. For the horizontal plume state, the C_c is given by:

$$C_c\{x_r, y_r, z_r\} = C_d\{x_r, y_r, z_r\} + C_r\{x_r, y_r, z_r\} + C_p\{x_r, y_r, z_r\} \qquad \textbf{Eq. 3}$$

where C_d, C_r, and C_p are the contributions from the direct, indirect and penetrated sources, Following Weil et al. (1997), the concentration due to the direct plume is given by:

$$C_d\{x_r, y_r, z\} = \frac{Qf_p}{\sqrt{2\pi}\tilde{u}} F_y \cdot \sum_{j=1}^{2}\sum_{m=0}^{\infty} \frac{\lambda_j}{\sigma_{zj}} \left[\exp\left(-\frac{(z-\Psi_{dj}-2mz_i)^2}{2\sigma_{zj}^2}\right) + \exp\left(-\frac{(z+\Psi_{dj}+2mz_i)^2}{2\sigma_{zj}^2}\right)\right] \qquad \textbf{Eq. 4}$$

The concentration due to the indirect source is calculated from:

$$C_r\{x_r, y_r, z\} = \frac{Qf_p}{\sqrt{2\pi}\,\tilde{u}} \cdot F_y \cdot \sum_{j=1}^{2}\sum_{m=1}^{\infty} \frac{\lambda_j}{\sigma_{zj}} \left[\exp\left(-\frac{(z+\Psi_{rj}-2mz_i)^2}{2\sigma_{zj}^2}\right) + \exp\left(-\frac{(z-\Psi_{rj}+2mz_i)^2}{2\sigma_{zj}^2}\right)\right] \qquad \textbf{Eq. 5}$$

For the penetrated source the concentration expression has a Gaussian form in both the vertical and lateral directions. The concentration due to this source is given by:

$$C_p\{x_r, y_r, z\} = \frac{Q\left(1 - f_p\right)}{\sqrt{2\pi}\ \tilde{u}\ \sigma_{zp}} F_y \cdot \sum_{m=-\infty}^{\infty}\left[\exp\left(-\frac{\left(z - h_{ep} + 2mz_{ieff}\right)^2}{2\sigma_{zp}^2}\right) + \exp\left(-\frac{\left(z + h_{ep} + 2mz_{ieff}\right)^2}{2\sigma_{zp}^2}\right)\right] \qquad \textbf{Eq. 6}$$

Concentrations Prediction in the SBL

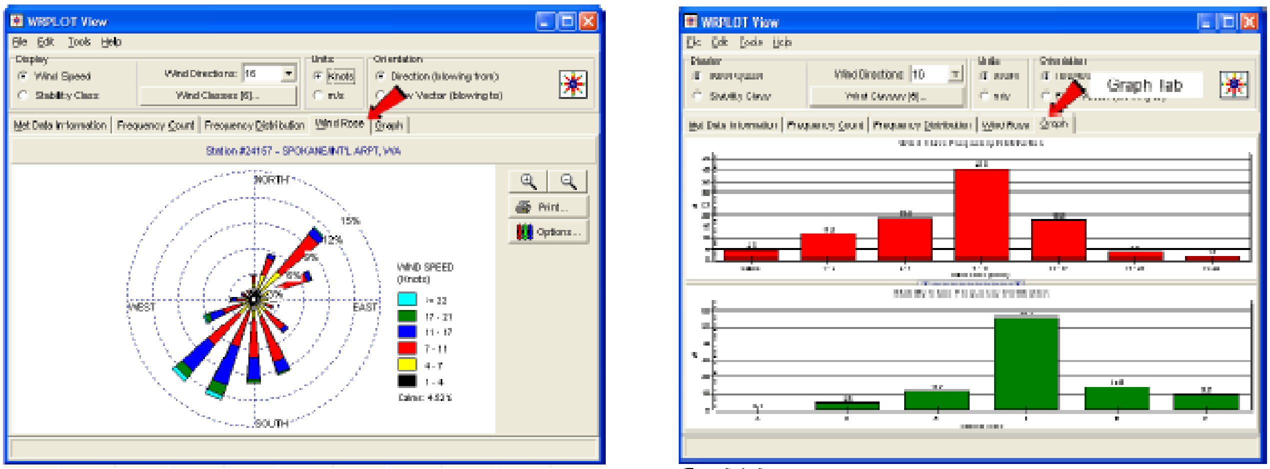
For stable conditions, the AERMOD concentration expression has the Gaussian form, and is similar to that used in many other steady-state plume models (e.g., HPDM (Hanna and Paine 1989)). The *Cs* is given by:

$$C_s\{x_r, y_r, z\} = \frac{Q}{\sqrt{2\pi}\tilde{u}\ \sigma_{zs}} \cdot F_y \cdot \sum_{m=-\infty}^{\infty}\left[\exp\left(-\frac{\left(z - h_{es} - 2mz_{ieff}\right)^2}{2\sigma_{zs}^2}\right) + \exp\left(-\frac{\left(z + h_{es} + 2mz_{ieff}\right)^2}{2\sigma_{zs}^2}\right)\right] \qquad \textbf{Eq. 7}$$

where z_{ieff} is the effective mechanical mixed layer height, F_{zs} is the total vertical dispersion in the SBL and h_{es} is the plume height (i.e., stack height plus the plume rise).

WRPLOT View

WRPLOT View is a Windows program that generates wind rose statistics, frequency tables and graphs for a wide variety of surface data file formats (SCRAM, CD144, HUSWO, SAMSON, etc.), and for the ISC pre-processed met data file (**Figure 7**)



Wind Rose tab *Graph tab*

Figure 7 WRPLOT View Windows

MM5 Modelling at Lakes Environment

Since it is difficult to derive the hourly meteorological data for ISC AERMOD from surface station in Indonesia, the meteorological data were be ordered from lakes environment in weblakes.com This part is designed to provide a brief description of MM5 modelling at Lakes Environmental. The MM5 modelling focuses on generating high resolution meteorological data with the objective of gathering enough information to create AERMOD meteorological input files.

For AERMOD, Lakes Environmental generates the surface met file in SAMSON format and the upper air met file in TD-6201 format from hourly MM5 results. These two files are input into the AERMET pre-processor to produce the .SFC and .PFL files required by AERMOD. Lakes Environmental has chosen MM5 modelling options based on publications of studies for high resolution (small grids) evaluation runs.

MM5 (5th-generation Mesoscale Model) is a prognostic meteorology model developed by Pennsylvania State University and the U.S. National Centre for Atmospheric Research (NCAR). The model is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. MM5 was primarily developed using FORTRAN coding, and is still widely used as a community model even though formal development of the model has ended.

MM5 cannot directly use conventional meteorological data from airport reports. Instead, the model uses objective analysis of global weather reports. Objective analysis is a process of analysing the observed data and outputting them into a regular grid. The meteorological field is “balanced” to take account of the energy and momentum equations of the atmosphere. These objective analyses are products of global models, which are maintained by national weather centres or federal agencies such as UKMO (United Kingdom Meteorological Office) or NCEP (National Centre for Environmental Protection).

Lakes Environmental has obtained NCEP Global Reanalysis data for input to MM5, from 1999 to 2008 (and beyond as further data becomes available). The NCEP reanalysis has a resolution of 2.5 degrees by 2.5 degrees for the entire globe, given every 6 hours. The reanalysis data incorporates global weather data. **Figure 8** presents an example for the Great Lakes region of North America. The station numbers in the figure below show which weather stations were used for the re-analysis data. Note that these stations do not directly provide the data used for MM5 output; they serve as input into the MM5 model.

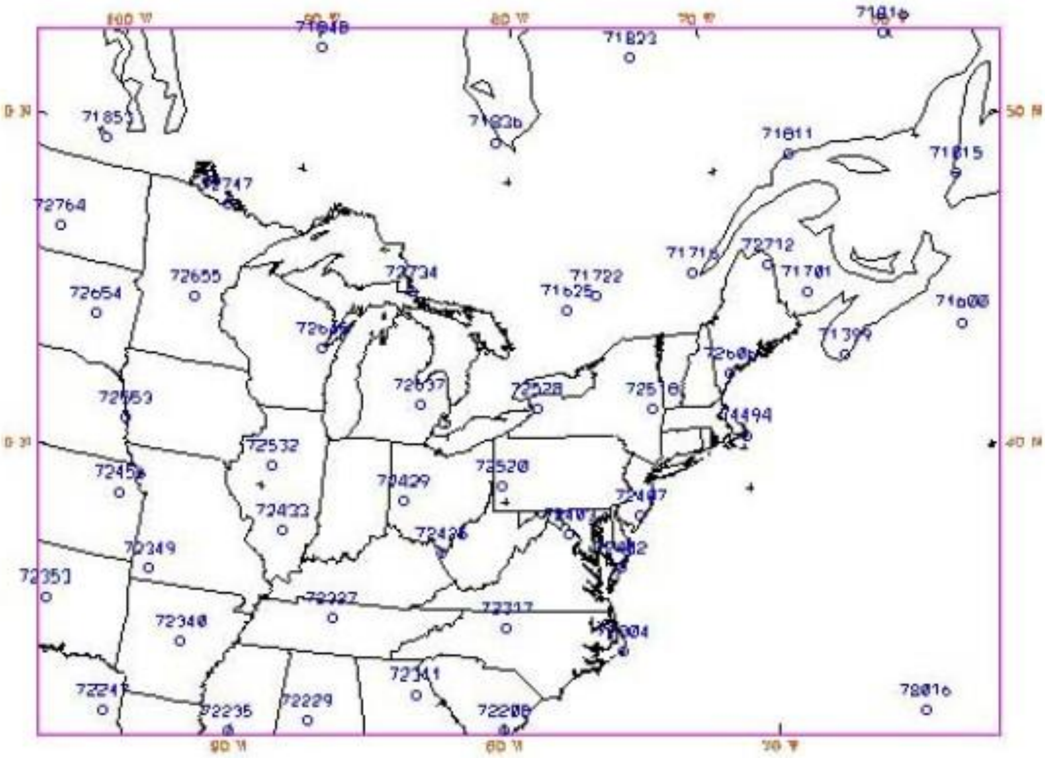


Figure 8 Sample MM5 domain with meteorological stations

Modelling Nested Grids Domain

MM5 uses a nested grid approach. In this way, an area of interest can be modelled without the penalty of excessive run times created by having a fine grid over the entire modelling domain. Depending on the application, Lakes Environmental employs a 12 km grid or a 4 km grid spacing at the highest resolution (internal) grid. MM5 data for the AERMOD model is available only in 12 km resolution.

Four-Dimensional Data Assimilation (FDDA)

Four-Dimensional Data Assimilation, or FDDA for short, is used in MM5 modelling. Specifically, analysis or grid nudging is applied – Newtonian relaxation terms are added to the prognostic equations for wind, temperature, and water vapour. These terms relax the model value towards a given analysis. The model linearly interpolates the analyses in time to determine the value towards which the model relaxes its solution

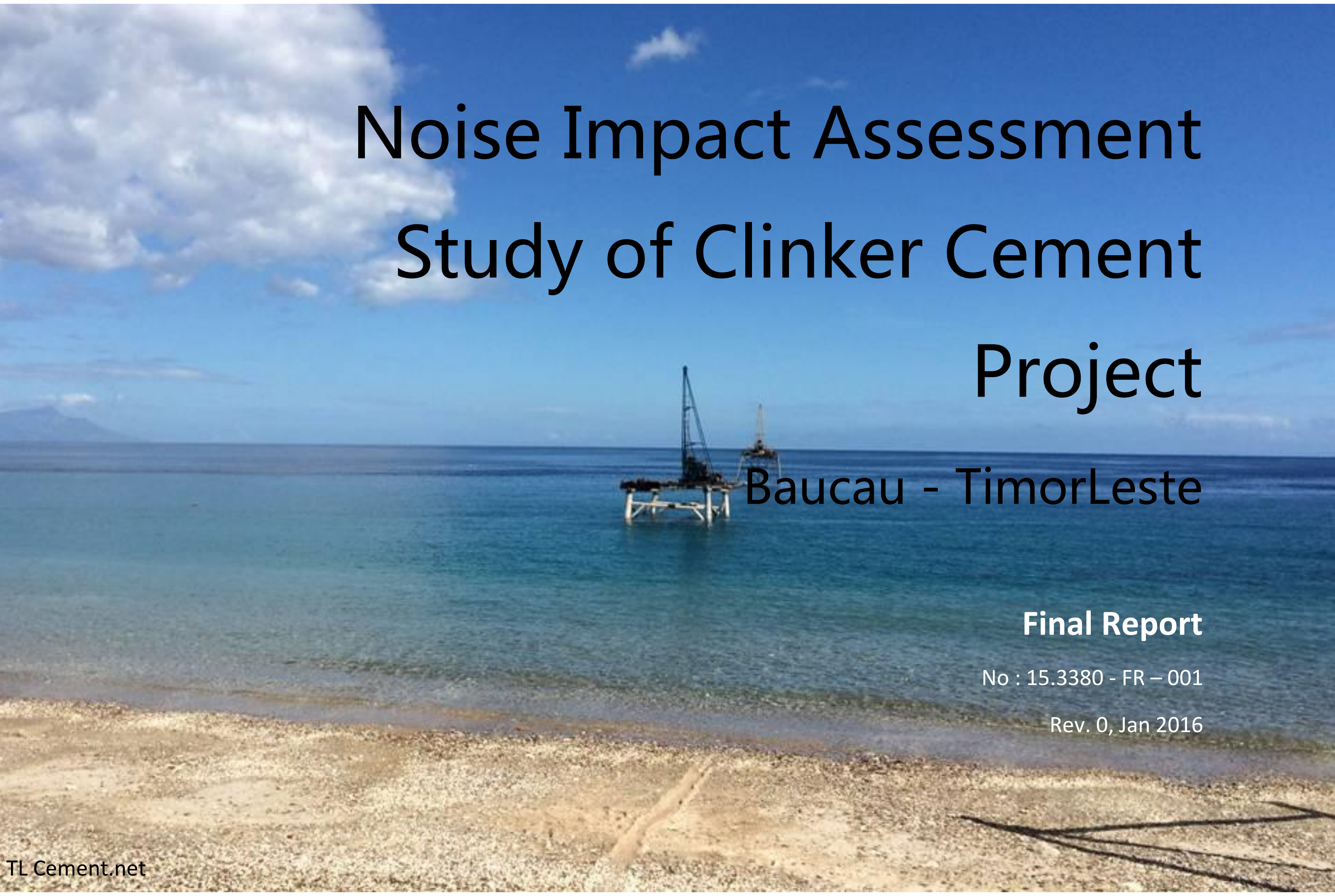
Working Procedure

The working procedure can be briefly described as follows:

1. All necessary data were collected to run the dispersion model as well as for model analysis;
2. Quality control and quality assurance of collected data were be carried out, in order to get a reliable data for model data input;
3. Running software for meteorological data using AERMET View;
4. Running software for statistical presentation of meteorological data using WRPLOT View;
5. Running software for topographical map generation by AERMAP;
6. Running software for particulate and gas dispersion using ISC-AERMOD View;
7. Interpretation and analysis of model dispersion output in the form of isopleth maps.

Appendix 2 Noise Impact Assessment Report

TL CEMENT Lda.



Noise Impact Assessment Study of Clinker Cement Project

Baucau - TimorLeste

Final Report

No : 15.3380 - FR – 001

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TL Cement.net

Prepared by:

PT. **BITA** BINA SEMESTA

CONTENTS

EXECUTIVE SUMMARY

With a view to expand cement manufacturing business, a new company TL Cement LDA (TLC) has been established at Baucau in Timor-Leste. In the construction and operational phases, heavy equipment used will become a new source of noise in the area TL Cement. During the development, noise emission will occur continuously, therefore it is necessary to model the noise dispersion with the aim to predict the distribution of noise caused by activities and actions during construction and operations phase in TL Cement. This report provides an analysis of noise prediction during construction and operation phase. To obtain reliable noise prediction results, a study on the effects of noise distribution is done with reference to ISO 9613-2. ISO 9613-2 describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of vironmental noise at a distance from a variety of sources with considerations of geometrical attenuation, atmospheric absorption, ground effect, reflection from surfaces, screening by obstacles, and the presence of housing, foliage, and industrial site along the propagation path. Seven locations which represent sensitive receptors around TL Cements had been chosen to represent the noise baseline around the project area. The site selection was carried out based on the considerations of locations which will undergo the impact of noise from the cement plant activities and are occupied by local people.

Results from the predictions shows that during the construction phase, predicted noise level in seven sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N01, predicted noise level during construction exceeds the noise limit by 9 dBA. In N02, predicted noise level during construction exceeds the noise limit by 12 dBA. In N03 and N06, predicted noise level exceeds the noise limit by 13 dBA. In N04, predicted noise level during construction exceeds the noise limit by 19 dBA. In N05, predicted noise level during construction exceeds the noise limit by 26 dBA. In N07, predicted noise level during construction exceeds the noise limit by 14 dBA.

During the operation phase, predicted noise level in six sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N02, predicted noise level during operation exceeds the noise limit by 6 dBA. In N03, predicted noise level during operation exceeds the noise limit by 7 dBA. In N04, predicted noise level during operation exceeds the noise limit by 13 dBA. In N05, predicted noise level during operation exceeds the noise limit by 18 dBA. In N06, predicted noise level during operation exceeds the noise limit by 4 dBA. In N07, predicted noise level during operation exceeds the noise limit by 7 dBA. While in N01, predicted noise level during operation is in allowable level.

In general, modelling results indicate that the predicted impacts of TL Cement development have quite significant impact on the increase in noise levels in areas around TL Cement. Therefore, mitigation must be implemented to keep the noise level in residential areas is in allowable level. To reduce the impact of noise both in the construction and the operation phase, there are mitigation options like design options, mitigation at the source, mitigation along the path, and mitigation at the receptors.

1. INTRODUCTION

1.1 Brief Project Description

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker.

Clinker refers to small lumps (3.0-25.0 mm diameter), produced by heating limestone and other materials such as clay and sand in a cement kiln. Clinker, if stored in dry conditions, can be kept for several months without appreciable loss of quality. Because of this, it can easily be handled by ordinary mineral handling equipment, clinker is traded internationally in large quantities. Clinker is then ground to a fine powder, along with gypsum and other substances to produce useable cement.

The proposed project will provide cement for both domestic use and international sale. A feasibility study is currently being undertaken to demonstrate the commercial viability of the project.

The proposed project represents a significant investment of approximately $350 million and the largest industrial project undertaken in Timor-Leste to date. It is anticipated to create 1000 jobs at the peak of the construction. It will then continue to have 700 permanent employees during operation. The project aims to develop local capacity and will develop a training center.

The spin off benefit would be indirect employment to local community members, through the multiplier effect due to downstream socio-economic benefits and consequent improvement in the living conditions of local population in the project area.

A. <u>Cement Clinker Plant</u>

The plant includes clinkerisation and cement grinding facilities with a rated capacity of 5,000 tons per day (tpd) of clinker and 100 tons per hour (tph) of cement. The plant also includes a waste heat recovery (WHR) power plant.

Up to 60% of 0.53 Mtpa of cement will be sold in the local markets and balance 40% will be shipped to Australia in 8,000 Deadweight-Ton (DWT) ships either in bulk or in. Balance clinker of 1.15 Mtpa will be shipped in vessels of 40,000 DWT ships to Australia.

The project involves developing a green field plant including, but not limited, to the engineering, design, manufacturing and supply of new equipment for cement plant, a waste heat recovery based power plant, a captive thermal power plant of approx. 30 MW and Port (Double wharf jetties) about 1.5-2 Km from the plant site.

B. <u>Thermal Power Plant bottom and fly ash utilization</u>

The waste from the thermal power plant will be fly ash and bottom ash. The total ash will be utilised in the cement grinding for producing PPC based on the coal data and ash in the coal the fly/bottom ash generation will be approximately 50 t/day i.e. approx 16500 t/annum. This will produce around 66000 t/a of PPC based on 25% ash in PPC. All ash from the thermal power plant will be transported pneumatically to the cement grinding section.

C. <u>Mines and Raw Materials</u>

The raw and fuel material requirements for the proposed plant are to be met from different sources as given in Table below.

Table 1.1 Raw Materials

No.	Material	Source	Source Locality	Remarks
1.	Limestone	Local	SucoTirilolo, Bahu, Caibanda, Triloca, Bucoli, Wailili and Fatumaca in administrative post Baucau, Vemasse and Venilele , Baucau Municipality	Primary raw material. Transported from mine site to crusher by trucks.
2.	Clay	Local	Suco Wailacama, Baucau administrative post in Baucau municipality	A corrective material. Transported from quarry to plant by road.
3.	Iron Ore	Import	Australia	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.
4.	Gypsum	Import	Australia or other	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and pipe conveyor.
5.	Coal	Import	Australia/ Indonesia	Fuel source and corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.

D. Limestone Deposit

The limestone deposit is accessible from Baucau by a tar road. The mine is located about 1 km from the main road and Bucoli village. The mining area is located around 0.5 km from the coastline where a jetty is proposed to be constructed. The limestone concession area (I-1) which shall meet the initial limestone requirement of the plant covers an area of 576 ha. The deposit area is generally undulating and hilly. As observation result, the limestone bearing area is covered by thick or scattered trees, thorny bushes and tall grass.

E. Clay Deposit

Clay is found to occur close to the plant site in Suco Wailacama in Baucau administrative post, less than 10 km west of the plant site. Clay shall be used as corrective to compensate for silica and alumina deficiency in the raw mix. Clay is proposed to be transported to the plant site by trucks.

F. Jetty

A dedicated jetty is proposed at a distance of 2 km from the plant site. Inbound material, (e.g., coal, gypsum, iron ore) and outbound clinker shall be transported between the plant and the jetty by a 0.5 km long conveyor belt + 1.5 km Pipe Conveyor (fully enclosed). The maximum load during unloading is estimated as 1000 tons per hour and during loading is estimated as 1000 tons per hour.

G. Utilities

a. Power

Power will be supplied by captive thermal power plant of approximately 30 mega-watts (MW) capacity and Waste Heat Recovery power plant.

Power for initial phase of plant operation when cement grinding is commissioned will be from grid power. Tapping from the nearby grid line of 20 KV will be tapped and step down to 11 KV at the plant substation. Generator sets will be utilized for construction power.

Emergency power requirement for initial commissioning of cement grinding is not required. For full plant 1.5 MW generator will be required. Thermal power plant shall include black start power requirement separately.

b. Water Supply

The water requirement for the cement project shall be met from groundwater by drilling bore wells. A makeup water supply of approximately 3,150 m^3/day is required for operations including requirement of mines, colony and green belt which may be possible to obtain this from one or two boreholes.

An underground aquifer is reported to occur below the mining blocks. As there is no industry in the area, the exploitation of water resources during the operation is not expected to adversely affect the water availability in the area for other competing users.

A detailed hydro geological study is proposed to be carried out to assess the availability of groundwater in the area. Water shall be required for:

- Process Water Circuit
- Cooling water (required for machine cooling)
- Make-up water shall be provided while re-circulating water shall be in a close loop
- Water required for township
- Water for on-site facilities
- Construction and operations (dust suppression)

c. Waste Water

The cement plant is being designed as a Zero Discharge facility and there shall be no discharge of waste water outside the plant premises. All the process waste water shall be treated in Water Treatment Plant and reused for plantation purposes. The waste water generated from domestic activities shall also be treated and reused for dust suppression, green belt development to the extent possible.

d. Solid Waste

Domestic solid waste generated from plant and jetty area shall be segregated and will be sent to waste disposal site as allocated by the local administrative authorities.

1.2 Location Study

The proposed cement plant and marine jetty are located in Suco Tirilolo, Aldeia Osso-ua, in the Baucau administrative post of Baucau municipality, Timor-Leste. The location is about 120 km east of Dili and approximately 16 km west of Baucau.

The Proponent has been granted a Prospecting License for limestone over three blocks, including, Block I-1 (Bucoli North Area-1), covering areas of 576 ha. The prospecting blocks are spread over Sucos Tirilolo, Bahu, Caibada, Triloka, Bucoli, and Wailili in administrative posts of Baucau, Vemasse and Venilele in Baucau municipality.

Sources of clay are located at Suco Wailacama within 10 km from proposed plant site. Corrective iron ore and additive gypsum are proposed to be procured from Australia. Coal will be used as a fuel for the kiln and power supply at the cement plant and is proposed to be procured from either Indonesia or Australia. The location of plant, mines (Block I-1) and jetty are shown in figure below.

Source : https://commons.wikimedia.org/wiki/File:Sucos_Baucau.png
https://www.mof.gov.tl/about-the-ministry/statistics-indicators/sensus-fo-fila-fali/download-suco-reports/baucau-suco-reports/

Figure 1.1 Location of TL Cement Development Project

1.3 Scope Of Work

According to scope of works from WorleyParsons, the noise impact assessment study will assess the following task :

- Preparation of baseline status of the noise intensity of the study area;
- Preparation of extensive noise impact modeling is undertaken to predict the likelihood of impacts on sensitive receptors;
- Identifying avoidance measures or design mitigation measures.

2. ASSESSMENT CRITERIA

Noise level either as the result of primary measurement (baseline data) or prediction shall be compared to the international noise standard from EPA (Environmental Protection Agent) 550/9-74-004 as shown in **Table 2.1**. The standards are based on 'equivalent sound levels identified as requisite to protect the public health and welfare with an adequate margin of safety'. The most important feature of these guidelines is the recommended limit of 55 dBA L_{DN} for noise in residential areas. The limit has been widely used as the basis for community noise internationally.

Table 2.1 International Noise Standard from EPA 550/9-74-004

Measure		Indoor			Outdoor		
		Activity Interference	Hearing loss consideration	To protect against both effect	Activity Interference	Hearing loss consideration	To protect against both effect
Residential with outside space and farm residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with no outside space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)}$ **(d)**	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	L_{dn}	45		45	55		55
	$L_{eq(24)}$ **(d)**		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farmland and unpopulated land	$L_{eq(24)}$				(a)	70	70(c)

Code:

(a)Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity.

(b) Based on lowest level

(c)Based only on hearing loss

(d)An Leq(8h) of 75 dB may be identified in these situations so long as the exposure over the remaining 16 h per day is low enough to result in a negligible contribution to the 24-h average, i.e., no greater than an Leq of 60 dB.

3. ENVIRONMENTAL BASELINE

Seven locations which represent sensitive receptors around TL Cement as shown in **Table 3.1**, **Figure 3.1** had been chosen to represent the noise baseline around the project area. The site selection was carried out based on the followings considerations:

- Locations which will undergo the impact of noise from the cement plant activities.
- Locations which are occupied by local people.

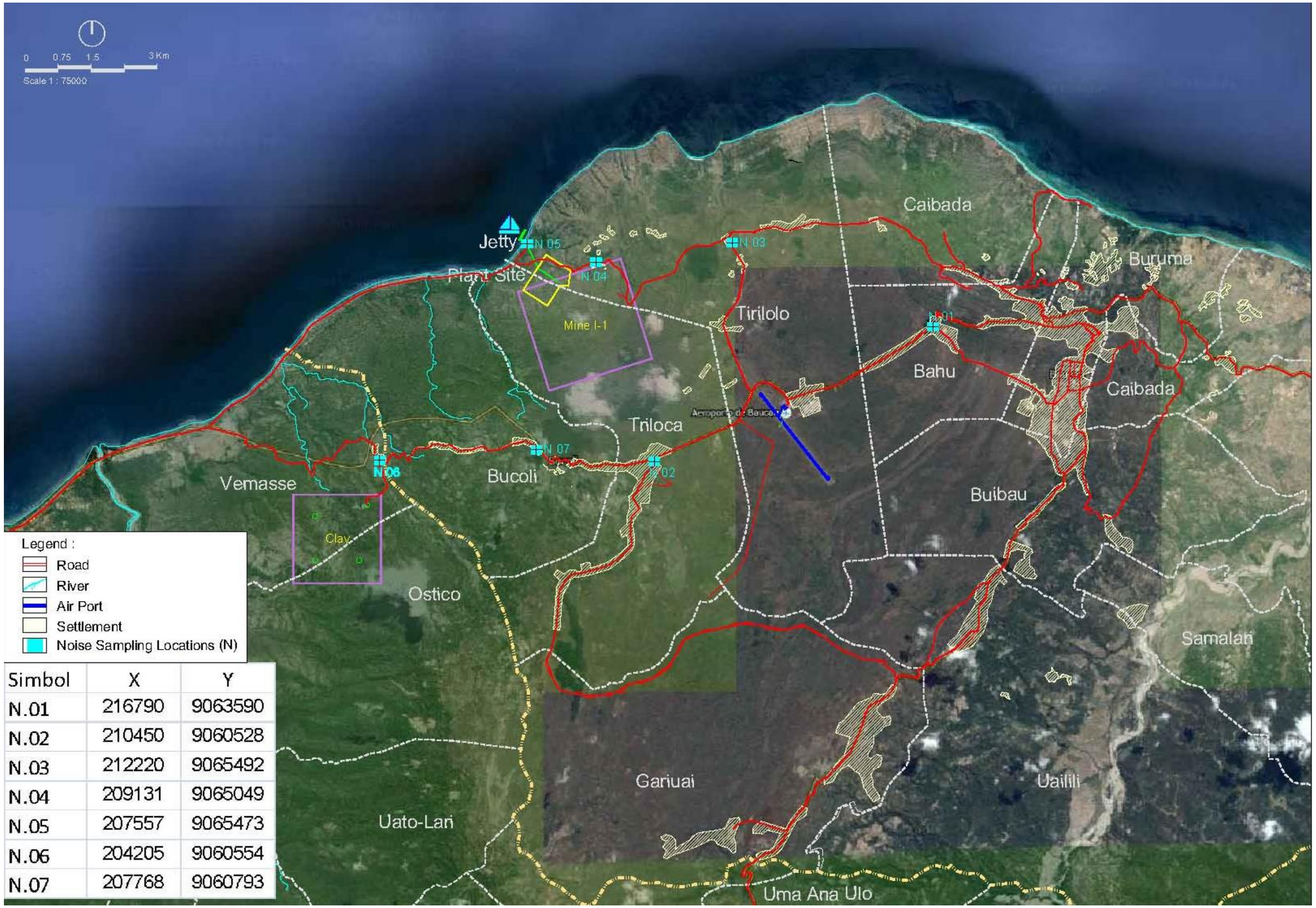
Noise baseline was measured every 5 seconds for 10 minutes for each measurement. The measurement is carried out to determine the equivalent noise level (Leq).

Basically, noise measurement was conducted to describe activities and noise background for 24 hours at TL Cement by measuring a minimum of 4 times at noon and 3 times at night. The measurement must be able to represent an interval of 16 hours during the day (6:00 to 22:00) and 8 hours during night (22:00 to 06:00).

Recapitulation of Leq and calculation of Ld, Ln, and Ldn can be seen in **Table 3.2**.

Table 3.1.Coordinates of noise baseline measurement point (representative locations of sensitive receptors)

Measurement Point	Location	Description	Zone	Easting	Northing
N01	Bahu	Settlement Area	52L	216790	9063590
N02	Check Point Triloca	Settlement Area	52L	210450	9060528
N03	Aldeia Parlementu	School Area	52L	212220	9065492
N04	Aldeia Osso-ua	Settlement Area	52L	209131	9065049
N05	Jetty Plan	Jetty Area	52L	207557	9065473
N06	Wailacama	Settlement Area	52L	204205	9060554
N07	Bucoli	Settlement Area	52L	207768	9060793



Simbol	X	Y
N.01	216790	9063590
N.02	210450	9060528
N.03	212220	9065492
N.04	209131	9065049
N.05	207557	9065473
N.06	204205	9060554
N.07	207768	9060793

Figure 3.1 Location of Noise Baseline Measurement

Figure 3.2 N-01, Location of Noise Measurement in Bahu

Figure 3.3 N-02, Location of Noise Measurement in Check Point Triloca

Figure 3.4 N-03, Location of Noise Measurement in Aldeia Parlemento

Figure 3.5 N-04, Location of Noise Measurement in Aldeia Osso-ua

Figure 3.6 N-05, Location of Noise Measurement in Jetty Plan

Figure 3.7 N-06, Location of Noise Measurement in Bucoli

Figure 3.8 N-07, Location of Noise Measurement in Wailacama

Table 3.2. Noise baseline measurement data L_{eq} and the calculated L_d,L_n,and L_{dn}

		Measurement Point						
		N01	**N02**	**N03**	**N04**	**N05**	**N06**	**N07**
Measurement of LAeq (dBA)	**1**	54.0	60.2	55.5	56.3	50.5	63.8	58.3
	2	54.4	58.8	43.6	52.8	49.9	57.4	55.9
	3	55.6	54.3	45.1	53.3	51.1	62.4	54.9
	4	64.2	60.1	48.9	48.6	51.6	62.8	58.1
	5	60.7	58.2	50.3	51.7	42.6	55.9	58.3
	6	53.6	59.4	50.2	49.7	47.3	41.2	58.1
	7	54.1	59.0	51.1	50.2	47.9	55.9	46.9
	8	52.8	57.9	46.2	50.0	47.9	38.3	43.7
	9	52.6	48.4	46.5	50.3	49.8	46.9	40.7
	10	57.5	53.3	47.5	49.5	50.2	54.1	43.6
	11	58.1	52.9	45.9	55.2	49.5	39.1	43.1
	12	52.5	56.4	50.2	52.8	49.2	56.5	50.6
Ldn (dBA)		58.45	58.97	50.99	54.83	51.92	59.48	55.34
Ld (dBA)		58.43	58.87	50.67	52.80	49.83	60.67	57.46
Ln (dBA)		53.53	54.07	46.57	51.66	48.78	52.85	46.06

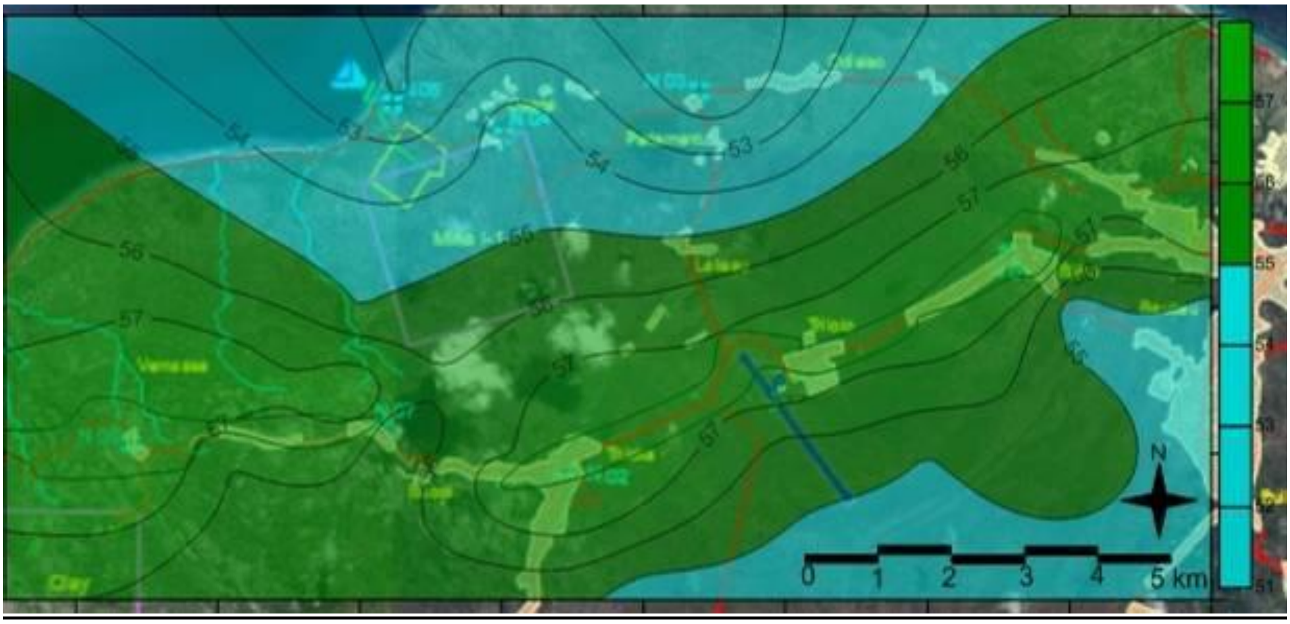


Figure 3.9 Estimated noise baseline in TL Cement (in dBA)

Based on **Table 3.2**, the value of Ldn in seven measurement points are 50.99 - 59.48 dBA. At the measurement point N03, N04, N05, and N07, Ldn values meet the noise quality standards with 3 dBA tolerance. While at the measurement point N01, N02, and N06, Ldn values slightly exceeded the noise quality standards.

Some measurement points with higher noise level were due to the cars or motorcycles that passed by during measurement. Therefore it is necessary to eliminate incidential noise from cars or motorcycle. Noise baseline level that has been adjusted by eliminating the incidential noise from cars or motorcycle can be seen in **Table 3.3** and **Fig 3.10**. From **Table 3.3**, it can be seen that noise baseline levels meet the community noise standard (see **Table 2.1**) with a tolerance of 3 dB.

Table 3.3.Noise baseline measurement data L_{eq} and the calculated L_d,L_n,and $L_{dn}$with incidential noise elimination

Measurement of LAeq (dBA)	Measurement Point						
	N01	N02	N03	N04	N05	N06	N07
1	54.0			56.3	50.5		
2	54.4		43.6	52.8	49.9		
3	55.6	54.3	45.1	53.3	51.1		
4			48.9	48.6	51.6		
5			50.3	51.7	42.6		
6	53.6		50.2	49.7	47.3	41.2	
7	54.1		51.1	50.2	47.9		46.9
8	52.8		46.2	50.0	47.9	38.3	43.7
9	52.6	48.4	46.5	50.3	49.8	46.9	40.7
10		53.3	47.5	49.5	50.2		43.6
11		52.9	45.9	55.2	49.5	39.1	43.1
12	52.5		50.2	52.8	49.2		50.6
Ldn (dBA)	56.27	55.52	50.20	54.83	51.92	46.34	50.71
Ld (dBA)	53.98	54.30	49.17	52.80	49.83	41.20	50.32
Ln (dBA)	53.53	50.77	46.57	51.66	48.78	42.03	46.06

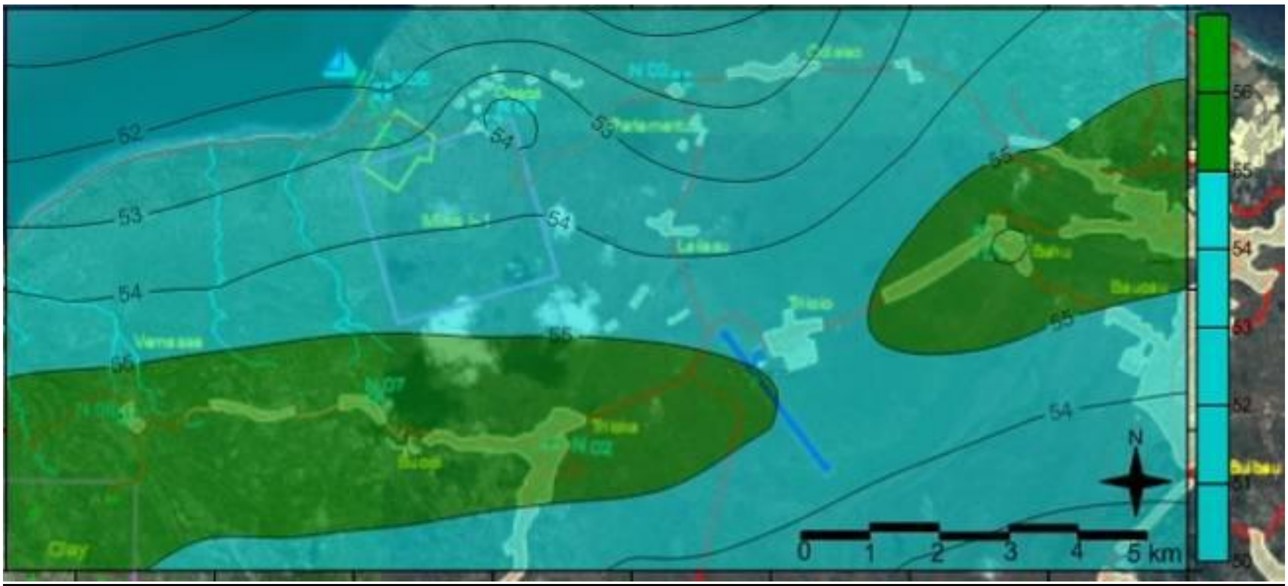


Figure 3.10 Estimated noise baseline in TL Cement with incidential noise elimination (in dBA)

4. ASSESSMENT METHOD

To obtain reliable results, a study on the effects of noise distribution is carried out using MATLAB® with reference to ISO 9613, the Attenuation of Sound during Propagation Outdoors. For the noise prediction of industrial sources the standard ISO 9613-2 is applied in most countries. However the noise mapping is conducted using Golden Surfer software.

In this chapter, modeling scenarios, formulas and standards used in calculating noise levels will be presented. Most formulas used refer to the International Standards Organization (ISO).

4.1 Propagation Noise Calculation using MATLAB®

MATLAB® is a software that can be used for data analysis, algorithm development, modeling, and a variety of other applications. MATLAB® is equipped with syntax, tools, and various mathematical functions that facilitate the analysis and modeling of the various approaches, so the results are expected to be produced more quickly.

This calculation is based on ISO 9613, the Attenuation of Sound during Propagation Outdoors describing a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources. The agreement between calculated and measured values of the average sound pressure level for downwind propagation supports the estimated accuracy of calculation shown in **Table 4.1**. However, the ± 3 dB accuracy is still in tolerable level.

Table 4.1. Estimated accuracy of noise predictions based on ISO 9613-2

Height, h *)	**Distance, d *)**	
	0 < d < 100 m	**100 m < d < 1000 m**
0 < *h* < 5 m	± 3 dB	± 3 dB
5 m < *h* < 30 m	± 1 dB	± 3 dB

*) *h* is the mean height of the source and receiver.

d is the distance between the source and receiver.

NOTE – These estimates have been made from situations where there are no effects die to reflection or attenuations due to screening.

Attenuation that occurs during sound wave propagation in the outdoor experience is divided into attenuation due to the distance (divergence) from the sound source to the observation point, attenuation due to atmospheric absorption (atmospheric attenuation), ground effect attenuation, attenuation due to the objects that hinder the propagation of sound, etc.

The equivalent continuous sound pressure level at a receiver location shall be calculated for each point source from equation:

$$L_{fT} = L_w + D_c - A \quad \textbf{Equation 1}$$

$$L_p = L_w - 20\log(r) + DI - 11 - A$$ **Equation 2**

$$A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$ **Equation 3**

where L_p : sound pressure level, in decibels, received at distance r from noise source relative to a reference sound pressure

r : distance between noise source and receiver, in meter

L_w : sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (1 pW)

D_c : the directivity correction, in decibels

A : Attenuation that occurs during propagation from the point sound source to the receiver.

A_{div} : the attenuation due to geometrical divergence

A_{atm} : the attenuation due to atmospheric absorption

A_{gr} : the attenuation due to ground effect

A_{bar} : the attenuation due to a barrier

A_{misc} : the attenuation due to miscellaneous other effects

The distance r is calculated based on elevation of source and the coordinate of the receiver points. The directional characteristics of a sound source DI are highly influenced by nearby reflecting surfaces. Take the example of an omni directional source - one that radiates sound equally in all directions. Imagine that this source is placed on a flat, reflecting surface. Its sound output is now constrained within half of the space that it would be if the surface were not present. So, all of the energy is constrained within half the space, therefore the sound intensity in that space is twice as great. This is equivalent to a 3 dB increase in level.

All sources are considered to be incoherent (independent) and can be calculated separately. Thus, the total sound pressure level due to all noise sources at each area becomes:

$$L_{p_{tot}} = 10Log\left(\sum_{n=1}^{\infty} 10^{Lp_n/10}\right)$$ **Equation 4**

Due to data limitations (no octave bands data and barrier available), this modelling only takes into account the attenuation due to the geometrical divergence, the attenuation due to ground effect, and the attenuation due to the shrubs in the savanna area.

4.1.1 Attenuation due to Geometrical divergence (A_{div})

Attenuation due to geometrical divergence is calculated using the following equation:

$$A_{div} = [20Log(\frac{d}{d_o}) + 11] \;\; dB$$ **Equation 5**

where: *d* : the distance from the source to receiver, in metres

d_o : the reference distance (= 1 m).

4.1.2 Attenuation due to Atmospheric Absorption (A_{atm})

Attenuation due to atmospheric absorption is calculated using the following equation:

$$A_{atm} = \frac{\alpha d}{1000}$$ **Equation 6**

α is the atmospheric attenuation coefficient, in decibels per kilometre for each octave band at the midband frequency (see the example of atmospheric attenuation coefficient in **Table 4.2**).

Table 4.2. The example of atmospheric attenuation coefficient α

Temperature	Relative humidity	Atmospheric attenuation coefficient α, dB/km							
		Frequency, Hz							
°C	%	63	125	250	500	1000	2000	4000	8000
10	70	0.1	0.4	1.0	1.9	3.7	9.7	32.8	117
20	70	0.1	0.3	101	2.8	5.0	9.0	22.9	76.6
30	70	0.1	0.3	1.0	3.1	7.4	12.7	23.1	59.3
15	20	0.3	0.6	1.2	2.7	8.2	28.2	88.8	202
15	50	0.1	0.5	1.2	2.2	4.2	10.8	36.2	129
15	80	0.1	0.3	1.1	2.4	4.1	8.3	23.7	82.8

4.1.3 Attenuation due to Ground Effect (A_{gr})

Ground attenuation, Agr, is mainly the result of sound reflected by the ground surface interfering with the sound propagating directly from source to receiver.

The downward-curving propagation path (downwind) ensures that this attenuation is determined primarily by the ground surfaces near the source and near the receiver. This method of calculating the ground effect is applicable only to ground which is approximately flat, either horizontally or with a constant slope. Three distinct regions for ground attenuation are specified as follows:

1. The source region, stretching over a distance from the source towards the receiver of 30hs, with a maximum distance of dp (hs is the source height, and dp the distance from source to receiver, as projected on the ground plane);
2. The receiver region, stretching over a distance from the receiver back towards the source of 30hr, with a maximum distance of dp (hr is the receiver height);
3. A middle region, stretching over the distance between the source and receiver regions. If dp< (30hs + 30hr), the source and receiver regions will overlap, and there is no middle region.

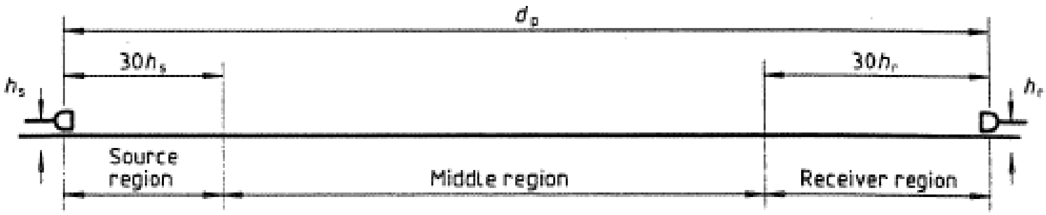


Figure 4.1 Three distinct regions for determination of ground attenuation

The acoustical properties of each ground region are taken into account through a ground factor G. Three categories of reflecting surface are specified as follows.

1. Hard ground, which includes paving, water, ice, concrete and all other ground surfaces having a low porosity. Tamped ground, for example, as often occurs around industrial sites, can be considered hard. For hard ground G = 0.
2. Porous ground, which includes ground covered by grass, trees or other vegetation, and all other ground surfaces suitable for the growth of vegetation, such as farming land. For porous ground G= 1.
3. Mixed ground: if the surface consists of both hard and porous ground, then G takes on values ranging from 0 to 1, the value being the fraction of the region that is porous.

To calculate the ground attenuation for a specific octave band, first calculate the component attenuations A_s for the source region specified by the ground factor G_s (for that region), $A_r$for the receiver region specified by the ground factor G_r and A_m for the middle region specified by the ground factor G_m, using the expressions in **Table 4.3**. The total ground attenuation for that octave band shall be obtained from equation:

$$A_{gr} = A_s + A_r + A_m \qquad \textbf{Equation 7}$$

Table 4.3. Expressions to be used for calculating ground attenuation contributions A_s, A_r and A_m in octave bands

Frequency Hz	A_s or A_r [1)] dB	A_m dB
63	-1.5	$-3q^{2)}$
125	-1.5 + G x *a'(h)*	$-3q(1-G_m)$
250	-1.5 + G x *a'(h)*	
500	-1.5 + G x *a'(h)*	
1000	-1.5 + G x *a'(h)*	
2000	-1.5 + (1-G)	
4000	-1.5 + (1-G)	
8000	-1.5 + (1-G)	

Notes

$a'(h)=1.5 + 3.0 \times e^{-0.12(h-5)^2}(1-e^{-dp/50}) + 5.7 \times e^{-0.09h^2}(1-e^{-2.8\times10^{6} \times dp^2})$

$b'(h)=1.5 + 8.6 \times e^{-0.09h^2}(1-e^{-dp/50})$

$c'(h)=1.5 + 14.0 \times e^{-0.46h^2}(1-e^{-dp/50})$

$d'(h)=1.5 + 5.0 \times e^{-0.9h^2}(1-e^{-dp/50})$

1) For calculate A_s, take $G=G_s$ and $h=h_s$. For calculate A_r, take $G=G_r$ and $h=h_r$.
2) $q=0$, when $d_p <= (30h_s + 30h_r)$
$q=1-(30*(h_s+h_r)/d_p)$, when $d_p > (30h_s + 30h_r)$

Under the following specific conditions:

1. only the A-weighted sound pressure level at the receiver position is of interest,
2. the sound propagation occurs over porous ground or mixed ground most of which is porous
3. the sound is not a pure tone

and for ground surfaces of any shape, the ground attenuation may be calculated from equation:

$$A_{gr} = 4.8 - (2h_m / d)\left[17 + (300/d)\right] \geq 0 \quad dB$$ **Equation 8**

where h_m is the mean height of the propagation path above the ground, in metres; and d is the distance from the source to receiver, in metres (see **Figure 4.2**).

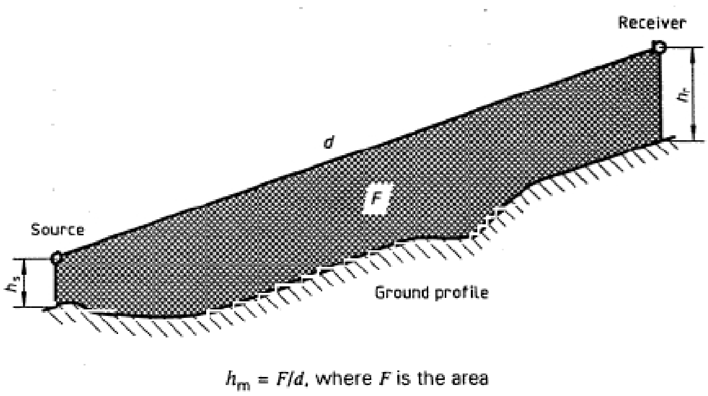


Figure 4.2 Method to evaluate h_m

In the calculation of attenuation due to ground effect, the ground surface around the area TL Cement is considered a combination between the porous and hard surfaces. Impedance effect due to the ground surface, calculated using the equation:

$$P \sim R^{-b}$$ **Equation 9**

where R is the distance of propagation and b is an attenuation coefficient that varies with the properties of the ground. (Albert, 2004).

4.1.4 Attenuation due to a barrier (A_{bar})

An object shall be taken into account as a screening obstacle (often called a barrier) if it meets the following requirements:

1. The surface density is at least 10 kg/m^2;
2. The object has a closed surface without large cracks or gaps;

3. The horizontal dimension of the object normal to the source-receiver line is larger than the acoustic wavelength λ at the nominal midband frequency for the octave band of interest; in other words $l_l+l_r>\lambda$ (see **Figure 4.3**).

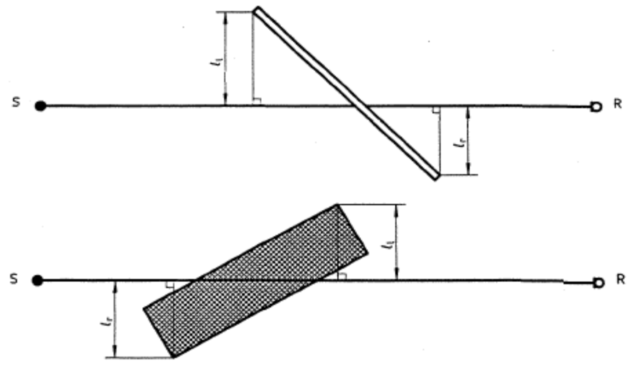


Figure 4.3 Plan view of two obstacles between the source (S) and the receiver (R)

Diffraction over the top edge and around a vertical edge of a barrier may both be important. For downwind sound propagation, the effect of diffraction (in decibels) over the top edge shall be calculated by:

$$A_{bar} = D_z - A_{gr} > 0$$ **Equation 10**

and for diffraction around a vertical edge calculated by:

$$A_{bar} = D_z > 0$$ **Equation 11**

where D_z is the barrier attenuation for each octave band calculated by:

$$D_z = 10Log\left[3+\left(C_2/\lambda\right)C_3 zK_{met}\right]\ dB$$ **Equation 12**

where C_2 = 20, 20, and includes the effect of ground reflections; if in special cases ground reflections are taken into account separately by image sources, C_2 = 40;

C_3 = 1, for single diffraction:

Or $C_3 = [1+(5\lambda/e)^2]/[(1/3)+(5\lambda/e)^2]$ for double diffraction

λ : the wavelength of sound at the nominal midband frequency of the octave band

z : the difference between the pathlengths of diffracted and direct sound

K_{met} : the correction factor for meteorological effects

E : the distance between the two diffraction edges in the case of double diffraction

4.1.5 Meteorological correction (C_{met})

Meteorological correction is calculated by:

$$C_{met} = 0,\ when\, d_p \le 10\left(h_s + h_r\right)$$
$$C_{met} = C_0\left[1-10\left(h_s+h_r\right)/d_p\right],\ when\, d_p > 10\left(h_s+h_r\right)$$ **Equation 13**

4.1.6 Miscellaneous Attenuation (A_{misc})

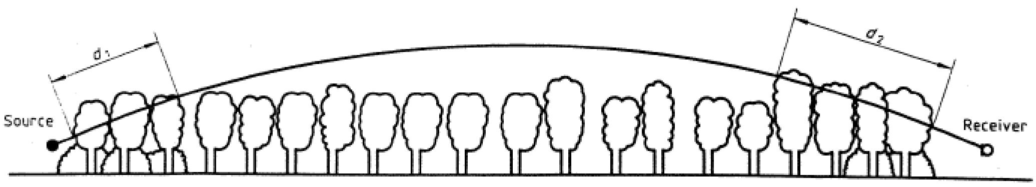
Other attenuation that counts is the attenuation due to vegetation and foliage, the attenuation due to the industrial area, as well as the attenuation due to the housing.

Attenuation due to the vegetation and foliage A_{fol}

Vegetation and foliage provides a small amount of attenuation, but only if it is sufficiently dense to fully block the view along the propagation path. The attenuation may be due to vegetation close to the source, close to the receiver, or both. Approximate values for the excess attenuation from dense foliage are listed in **Table 4.4**.

Table 4.4. Attenuation of noise due to propagating a distance d_f through dense foliage

Propagation distance d_f, meter	Frequency, Hz							
	63	125	250	500	1000	2000	4000	8000
10 > df > 20	Attenuation, dB:							
	0	0	1	1	1	1	2	3
20 > df > 200	Attenuation, dB/m:							
	0.02	0.03	0.04	0.05	0.06	0.08	0.09	0.12



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure 4.4 Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Attenuation due to industrial site A_{site}

At industrial sites, attenuation can occur due to scattering from installation of equipment and other objects in an industrial area. The value of A_{site} is depend strongly on the type of site and equipment, therefore it is recommended that it is determined by measurement. **Table 4.5** shows great estimation of attenuation due to the industrial area. The attenuation increases linearly with the length of the curved path d_s through the installation (see **Figure 4.5**), with a maximum of 10 dB.

Table 4.5. Attenuation coefficient of an octave band of noise during propagation through installations at industrial plants

Frequency, Hz	63	125	250	500	1000	2000	4000	8000
A_{site}, dB/m	0	0.015	0.025	0.025	0.02	0.02	0.015	0.015

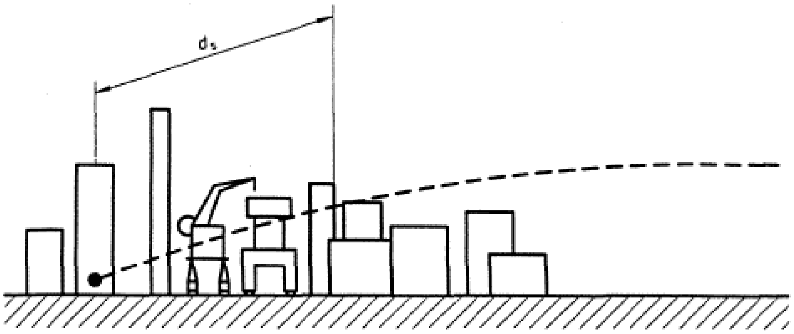


Figure 4.5 The attenuation A_{site}increaseslinearly with the propagation distance d_s through the installations at industrial plants

Attenuation due to housing A_{hous}

When either the source or receiver, or both are situated in a built-up region of houses, an attenuation will occur due to scrrening by the houses. However, this effect may largely be compensated by propagation between houses and by reflections from other houses in vicinity. Because the value of A_{hous} is very situation-dependent, such as calculation may be justified in practice. An approximate calue for A_{hous} may be estimated as follows:

$$A_{hous} = A_{hous,1} + A_{hous,2} \qquad \textbf{Equation 14}$$

$$A_{hous,1} = 0.1Bd_b \quad dB \qquad \textbf{Equation 15}$$

$$A_{hous,2} = -10Log\left[1-\left(p/100\right)\right] \quad dB \qquad \textbf{Equation 16}$$

where Ahous,2 : included if there are well-defined rows of building near a road, a railway, or a similar coridor

B : the density of the buildings along that path given by the total plan area of the houses divided by the total ground area

d_b : the length of the sound path through the houses, as seen in **Figure 2.4**.

p : the percentage of the length of the façades relative to the total length of the road or railway in vicinity

4.2 SURFER

Surfer is a full-function 3D visualization, contouring and surface modeling software package. Surfer is used extensively for terrain modeling, bathymetric modeling, landscape visualization, surface analysis, contour mapping, watershed and 3D surface mapping, gridding, volumetrics, and much more.

Basically, Surfer transforms XYZ data into 3D shape, contour, or surface mapping. Surfer provides some options in gridding methods and parameters that can be changed as needed.

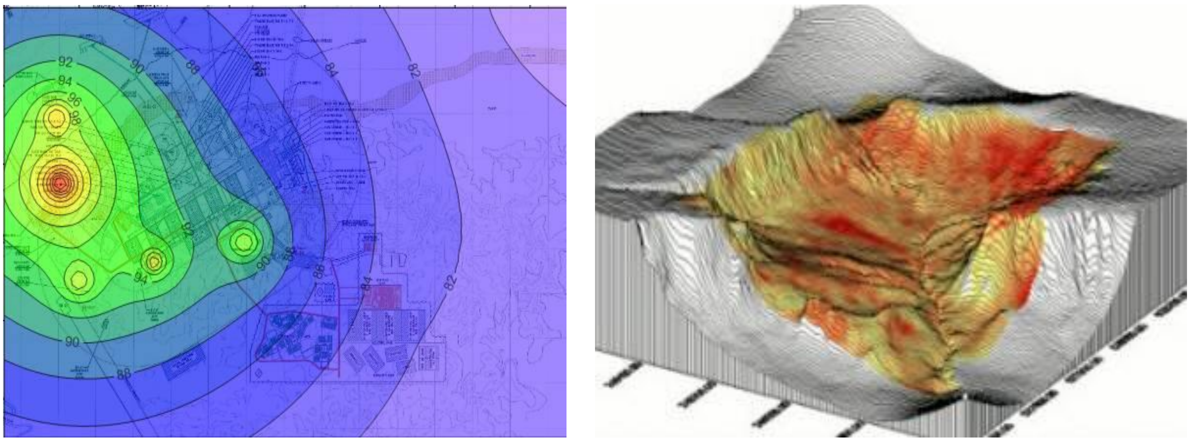


Figure 4.6 Examples of SURFER visualization output data

4.2.1 Surfer Gridding Methodology

Surfer offers many different grid based maps, such as 2D contour maps and 3D surface maps. To create a grid based map, a grid file must be provided. To create a grid file, Surfer takes XYZ data and uses it to create a regularly spaced grid file, composed of grid nodes. Each grid node is located at a particular XY location and has a Z value associated with it. Although the algorithms are computed internally in Surfer, choosing the best gridding method for the data can be difficult. Surfer has several different options for gridding methods, but for this project the methods used is *Kriging* method.

Kriging is one of the more flexible and accurate gridding methods; typically the one that is recommended when gridding data. Kriging is effective because it produces a good map for most data sets. It also can compensate for clustered data by giving less weight to the cluster in the overall prediction. One of the disadvantages to Kriging is that it can be slower than other methods. It also can extrapolate grid values beyond the range of the data's Z values.

Each grid node value is based on the known data further from the node will have less weight in the estimation of the node. For example, to compute points neighboring the node. Each data point is weighted by its distance away from the node. This way, points that are the Z value at grid node A, this equation is used:

$$Z_A = \sum_{i=1}^{n} W_i Z_i \qquad \textbf{Equation 17}$$

Where Z_A is the estimated value of grid node A, n is the number of neighboring data values used in the estimation, Z_i is the value at location i with weight, W_i. The valueof weights will sum to 1 to make sure there is no bias towards clustered data points. The formula can get more complex if things such as drifts and a search radius are applied.

Below is a classed post map displaying a set of data values that were gridded using the Krigingmethod.

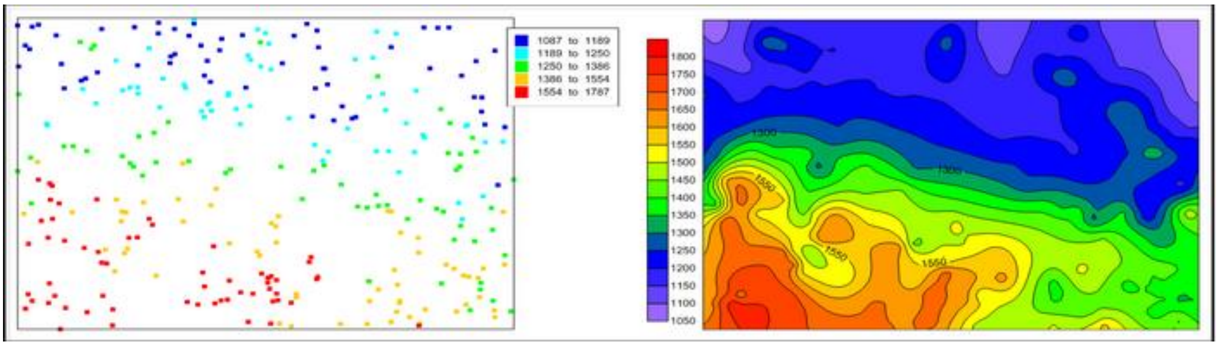


Figure 4.7 The classed post map, left, represents scattered elevation data that producedthe contour map, right, using theKriging gridding method.

4.3 Modelling Procedures

Modelling procedures can be described as follows:

1. Collecting all the necessary input data for the model, including parameters and noise source data (the location of the sound source and the generated power source), as well as other supporting data that are useful for the analysis of modeling results.
2. Checking of the data collected quality (quality control /and quality assurance)
3. Calculation using MATLAB®
4. Presentation of results using SURFER.
5. Interpretation and analysis of the modeling result.

4.4 Modelling Scenarios

Cement TL development and operational activities could potentially improve noise level at TL Cement area. In predicting noise, type and duration of activities and equipment used is taken into account.

Noise impact during Cement TL development and operational is mostly due to the activities during the construction phase. The actions and activitied during Cement TL Development Project includes the following activities:

- Activities and actions during construction are movement of manpower, machinery, and materials, site clearing, leveling, and excavation, civil construction, mechanical construction, camp, and jetty.
- Activities and actions during operation phase are excavation of limestone and clay from the captive mines, crushing of limestone and clay, transportation of limestone from mines to plant site, transportation of other correctives to the plant site, preparation of raw meal by adding correctives to limestone, clinkerisation of raw meal, cooling and heat recovery, blending & grinding of clinker by adding additives, packing and dispatch, ship traffic, transportation of raw material like coal, additives, etc. to plant by belt conveyor, and transportation of outbound clinker by belt conveyor.

The equipment used in construction and operations activities includes equipment for civil works and equipment for the mechanical work. Based on the type of activity undertaken, duration of activities and equipment used, noise levels increase is predicted. As noted in Chapter 3, scenario modeling was based on the plan of construction and operation activities in each area of TL Cement. Then modeling of each construction and operation activities is also performed in all areas simultaneously. The actual noise value will depend on variations of activities and the number of equipment used. This modeling assumed sound source reference distance is calculated from the midpoint of the sound source. In this modeling, attenuation due to the ground effect and due to foliage (shrubs) was also taken into account.

4.4.1 Input Parameters and Supporting Data

Modeling of noise dispersion involves interrelated data, for example characteristic and the location of noise source and scenarios used in the modeling. Therefore, the reliable data will determine the accuracy of the modeling results. The following is the relevant data input for the model.

Location of Noise Source and Receiver

Noise source from activities in TL Cement is divided into five areas, each of which has different activities. The location of activities is shown in **Figure 1.1**. The division of the area is the jetty area, plant area, and limestone mining area (Mine 1-1, Mine 1-2, and Mine 2). In the first phase, construction and operation activities are carried out only in **Jetty area, Plant area, and Mine 1-1**.

Source Noise Levels

Noise exposure level is determined by the number of noise sources and noise radiated power. Due to data limitation, assumptions and professional judgement from similar projects are used. **Table 4.6** shows the type, radiated sound power levels, and the amount of equipment used during construction and operations activities in TL Cement. Sound power data was taken from FHWA Highway Construction Noise Handbook. The noise source layout in TL Cement plant area is shown in **Figure 4.8**.

Modeling Scenario

The modeling was done in each area for each construction and operation activities. Then, it was also done for each construction or operations activities in jetty, plant, mine 1-1, and clay area simultaneously. The actual noise level will depend on variations of activities and the number of equipment used. This modeling assumed sound source reference distance is calculated from the midpoint of the sound source. In this modeling, attenuation due to the ground effect was also taken into account.

Table 4.6. Equipment Noise Emission Levels

Machinery/ Equipment	Power level (dB re 1 PicoWatt)	Construction					Operation			
		Jetty	Plant	Limestone Mine	Clay Mine	Stock Pile	Jetty	Plant	Mine 1-1	Clay
Water truck/fuel truck	112	2	5							
Pile driving rig	127	2	2							
Crane	117	2	5				2			

Machinery/ Equipment	Power level (dB re 1 PicoWatt)	Construction					Operation			
		Jetty	Plant	Limestone Mine	Clay Mine	Stock Pile	Jetty	Plant	Mine 1-1	Clay
Low &Flat bed trailer	116	2	5							
Prime mover	116		2							
Fork lift	117		3							

Table 4.7. Equipment Noise Emission Levels (cont)

Machinery/ Equipment	Power level (dB re 1 PicoWatt)	Construction					Operation			
		Jetty	Plant	Limestone Mile	Clay Mine	Stock Pile	Jetty	Plant	Mine 1-1	Clay
ship unloader	100						2			
Welding generators	105		5							
Conveyor	113						1	3		
Ship loader	100						1			
Crusher	103.5							3		
Raw mill	100.1							1		
Preheater	80							1		
Kiln	94							1		
Clinker silo	80.8							2		
Clinker cooler	78							1		
cement mill	99.4							1		
Cement silo	80.8							1		
packing plant	100							1		
Truck	112			7	4				4	4
storage	90							3		
office	65							1		
Pump, fan, compressor	100							3	4	4
Drilling	102								4	4
Excavator	85			3	1				2	2
Bulldozer/Ripper	95			1	1	3				
Wobbler feeder	80								1	1
Crushers	95								4	4
Box feeder	80								1	1

Machinery/ Equipment	Power level (dB re 1 PicoWatt)	Construction					Operation			
		Jetty	Plant	Limestone Mile	Clay Mine	Stock Pile	Jetty	Plant	Mine 1-1	Clay
Belt conveyor	113								4	4
Magnetic separator	80								1	1
Stackers	117								2	2
Motor Grader	95			1						
Wheel Loader	90					5				
Power generators	113	1	1				1	1	1	1

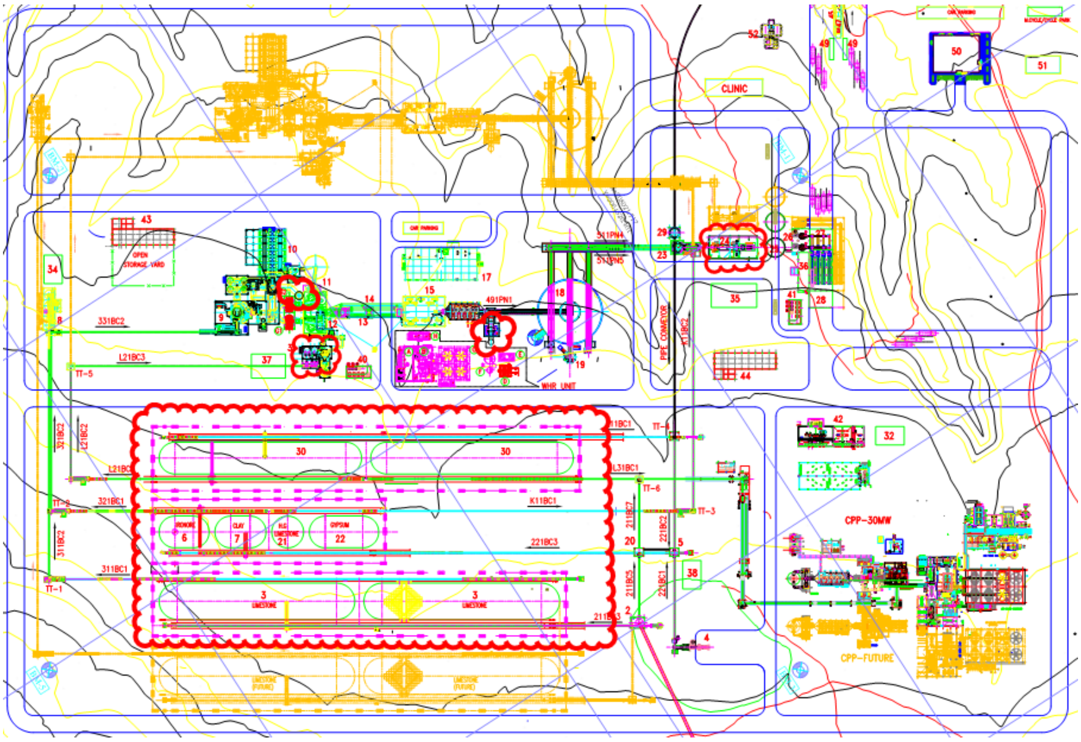


Figure 4.8 TL Cement Plant Layout

7

5. IMPACT ASSESSMENT

5.1 Construction Phase

Modeling noise contours during construction phase are shown in **Figure 5.1**, **Figure 5.2**, **Figure 5.3, Figure 5.4** and **Figure 5.5**.

<u>**Noise Contour of Construction Activities in Jetty area**</u>

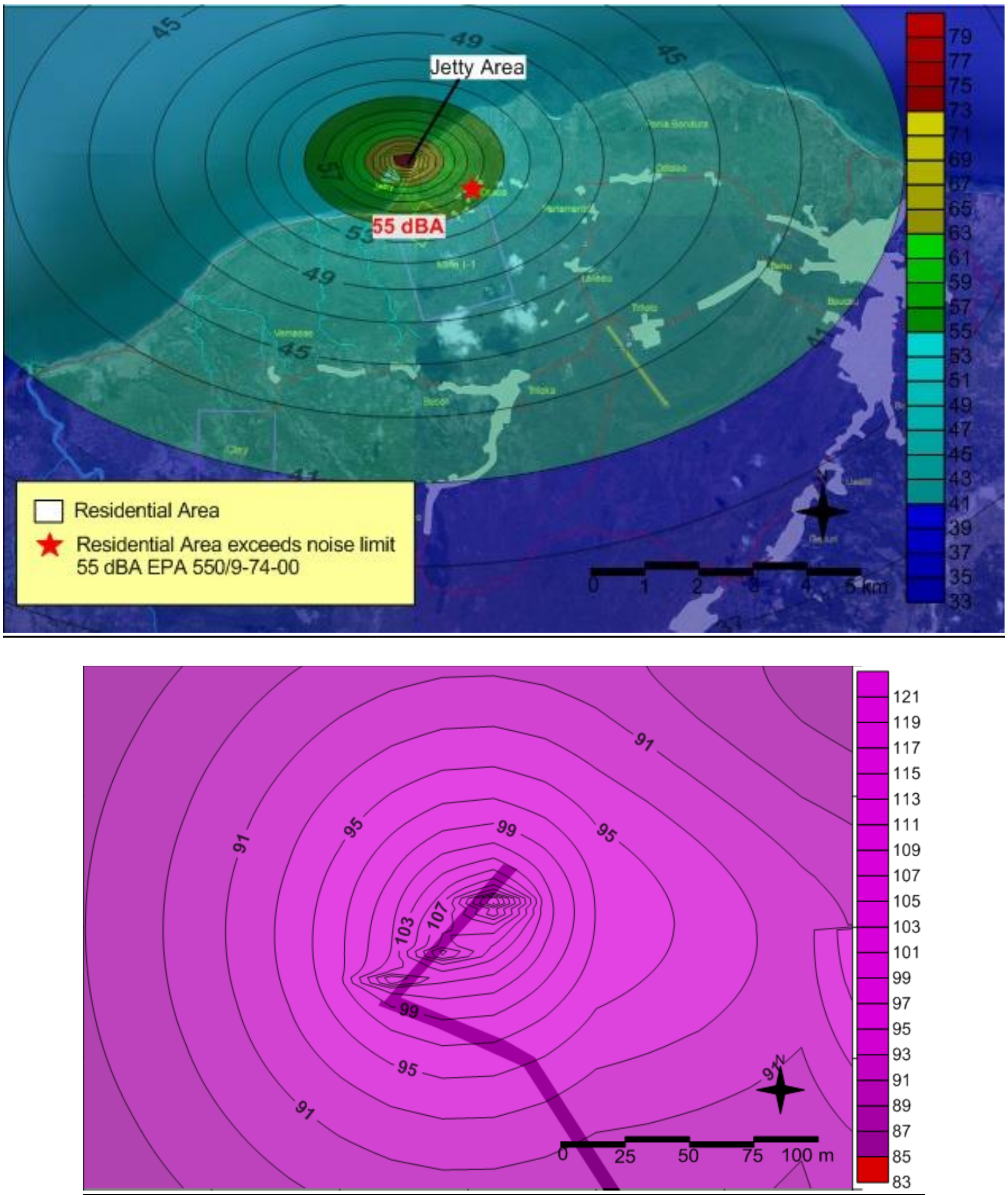
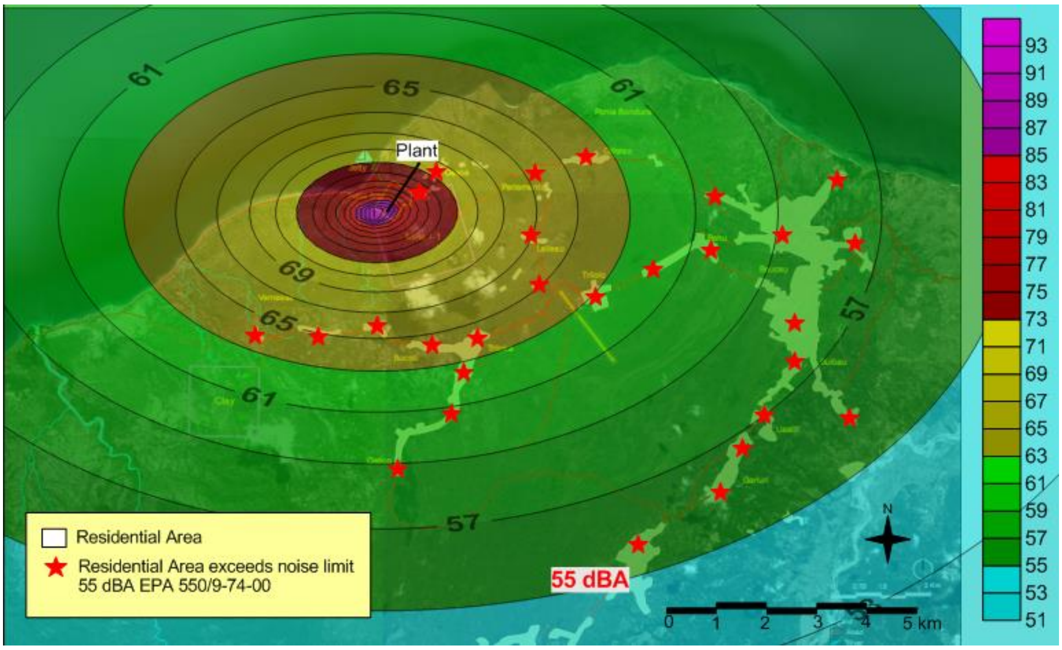


Figure 5.1 Noise contour of construction activities in Jetty area (in DBA)

Figure 5.1 is predicted noise level due to construction activity in the jetty area. This contour is on the certain height, which is 1.5 meters from the ground. It is based on the standard measurement used during baseline measurement. From **Figure 5.1** it can be seen that there is a residential area affected by noise from construction in the Jetty area, namely in Osso-ua, exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA).

Noise Contour of Construction Activities in Plant area



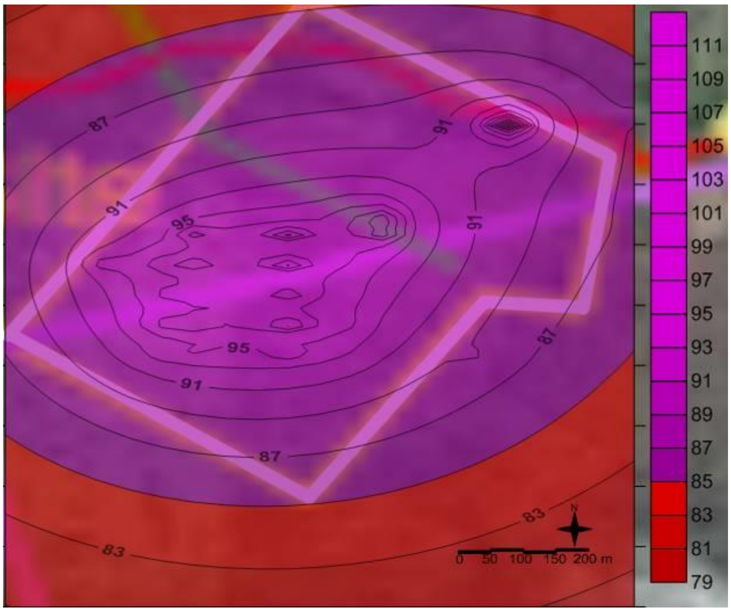
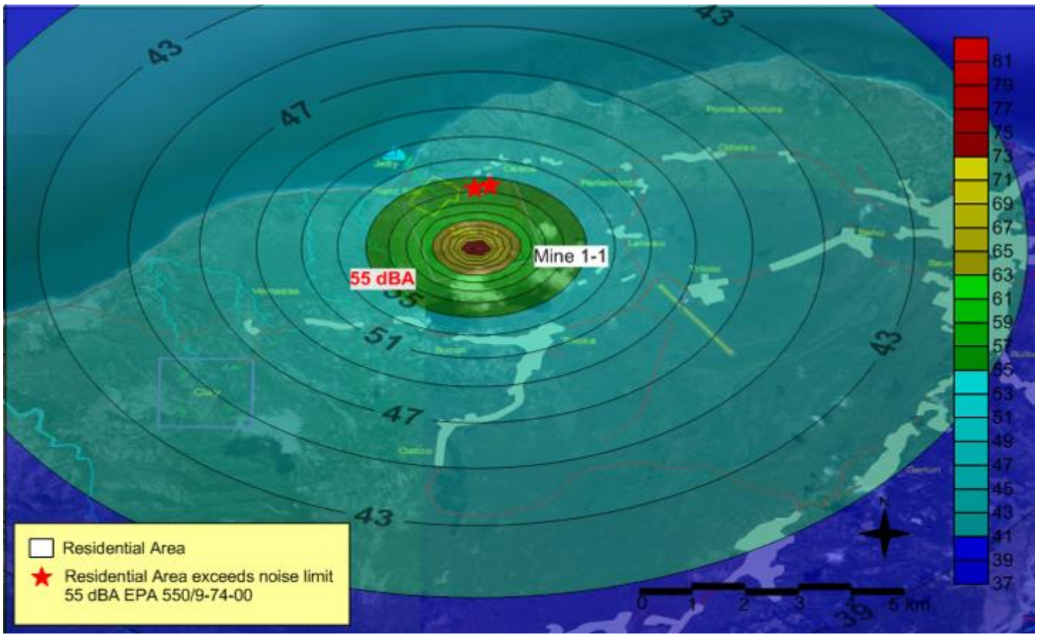


Figure 5.2 Noise contour of construction activities in Plant area (in DBA)

Figure 5.2 is predicted noise level due to construction activity in the Plant area. This contour is on the certain height, which is 1.5 meters from the ground. **Figure 5.2** showed that there are residential areas affected by noise from construction in the Plant area, namely Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, Ostico, Tirilolo ,Bahu, Baucau, Buibau, Ualili, and partly Garluri. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua.

Noise Contour of Construction Activities in Limestone Mine area



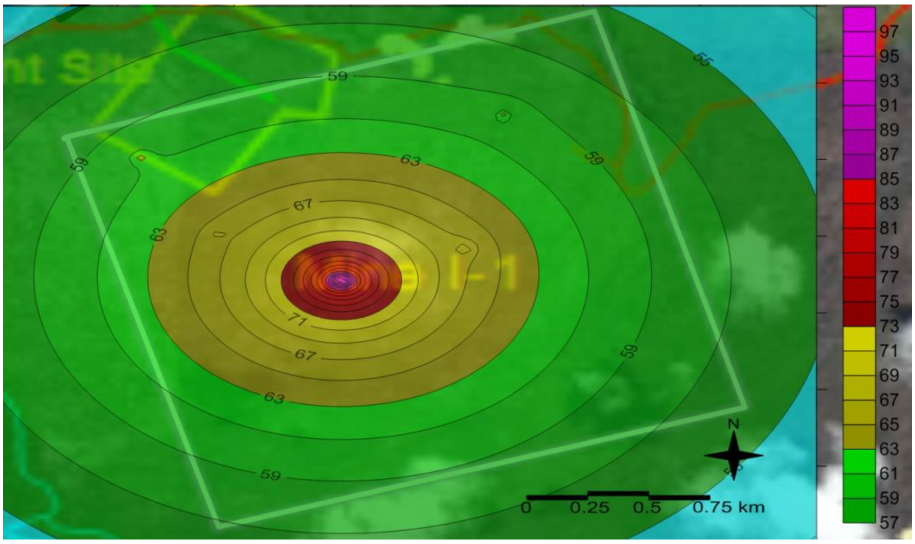


Fig 5.3 Noise contour of construction activities in Limestone Mine area (in DBA)

Figure 5.3 is predicted noise level due to construction activity in the Limestone mine area. This contour is on the certain height, which is 1.5 meters from the ground. There is a residential area affected by noise from construction activity in the mine areas, namely Osso-ua. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA).

Noise Contour of Construction Activities in Clay area

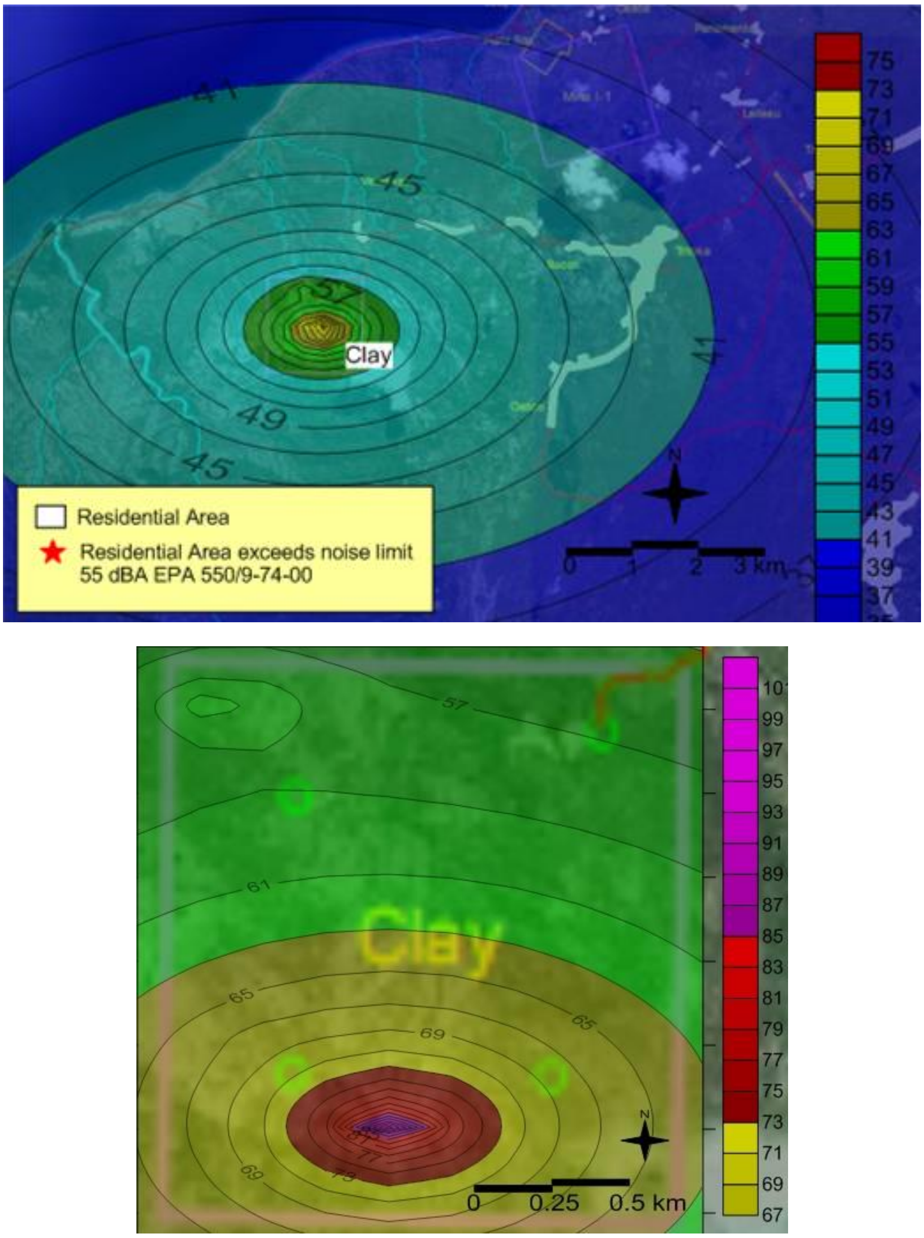


Figure 5.4 Noise contour of construction activities in Clay area (in DBA)

Figure 5.4 is predicted noise level due to construction activity in Clay area. This contour is on the certain height, which is 1.5 meters from the ground. There is no residential area affected by noise from construction activity in the clay areas.

<u>Noise Contour of Construction Activities in Jetty, Plant, Limestone, and Clay area</u>

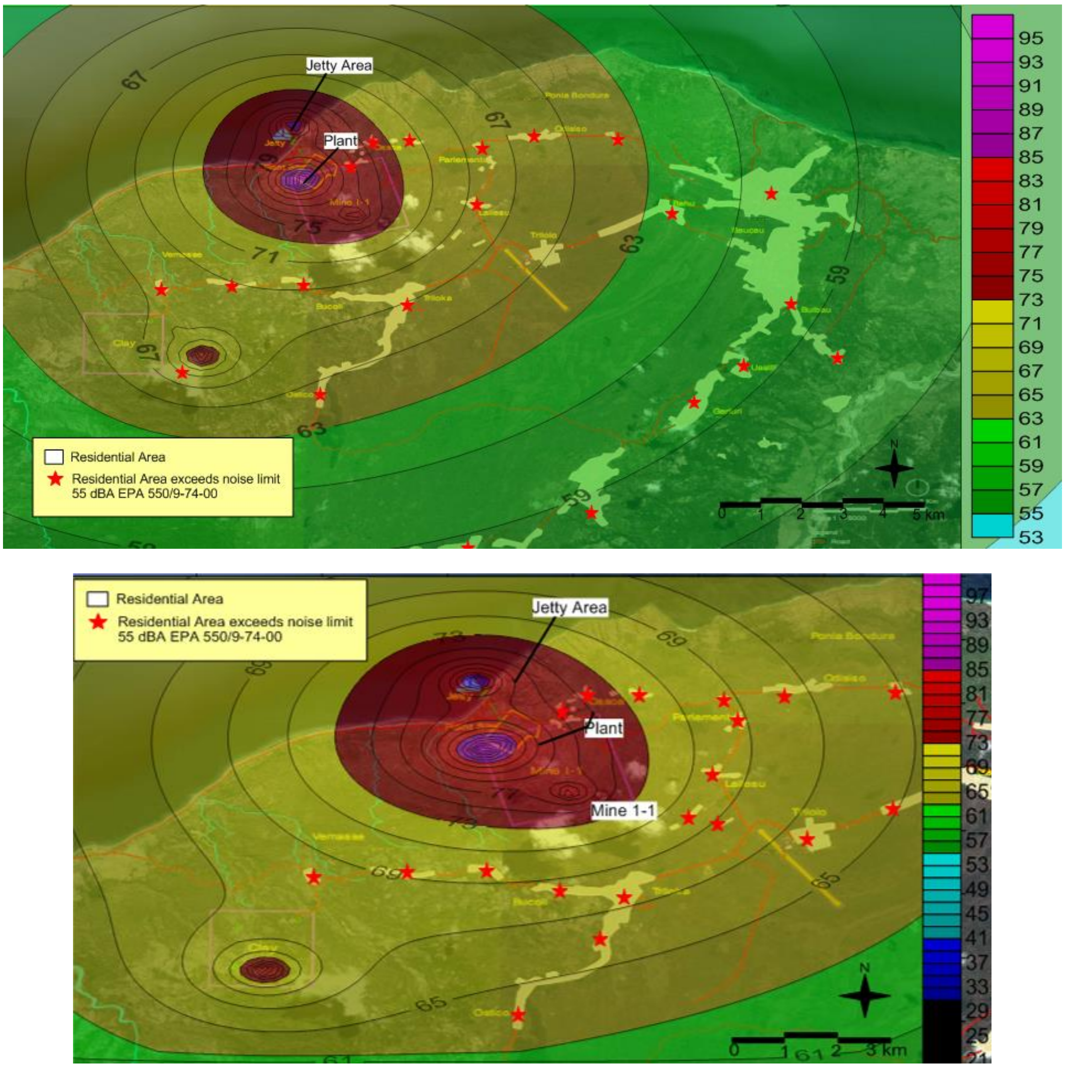


Figure 5.5 Noise contour of construction activities in Plant, Jetty, Limestone, and Clay areas (in DBA)

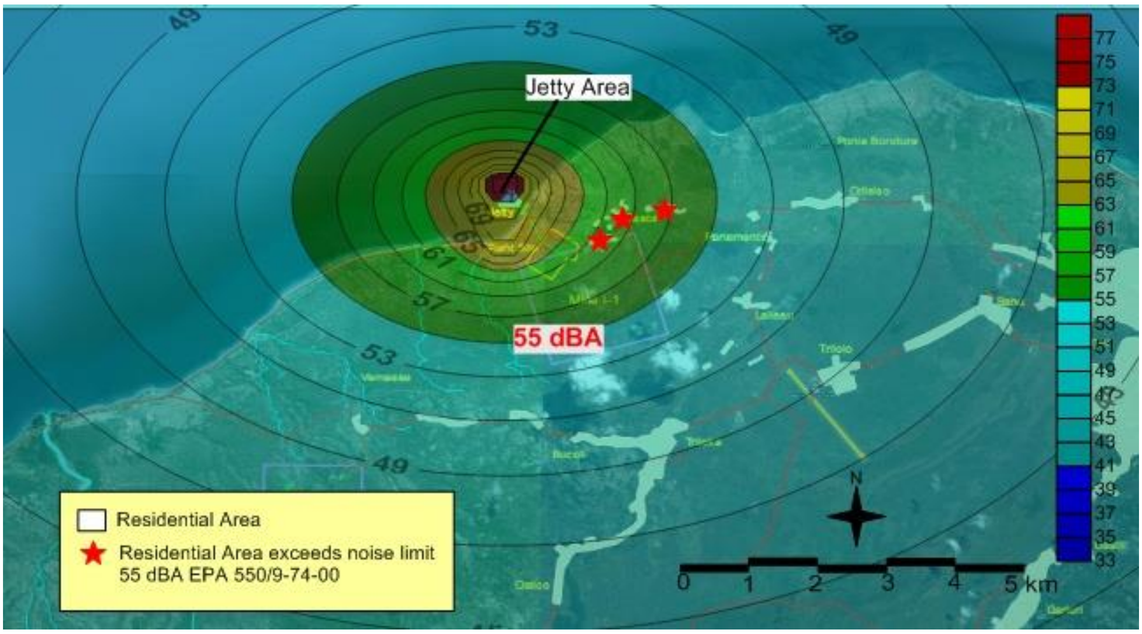
Figure 5.5 is predicted noise level due to simultaneous construction activity in the Plant, Jetty, Limestone, and Clay areas. This contour is on the certain height, which is 1.5 meters from the ground. There are residential areas affected by noise from construction activity in the Plant and Jetty areas, namely Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, Ostico, Tirilolo, Bahu, Buibau, Ualili, and Garluri. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA).Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua.

5.2 Operation Phase

Modeling noise contours during operation phase are shown in **Figure 5.6**, **Figure 5.7**, **Figure 5.8**, **Figure 5.9**, **Figure 5.10** and **Figure 5.11**.

Noise Contour of Operation Activities in Jetty area (in DBA)

Figure 5.6 is predicted noise level due to operation activities in the jetty area. This contour is on the certain height, which is 1.5 meters from the ground. **Figure 5.6** showed that there is a residential area affected by noise from the operation in the Jetty area, namely in Osso-ua. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua. The highest noise level is around 81 dBA.



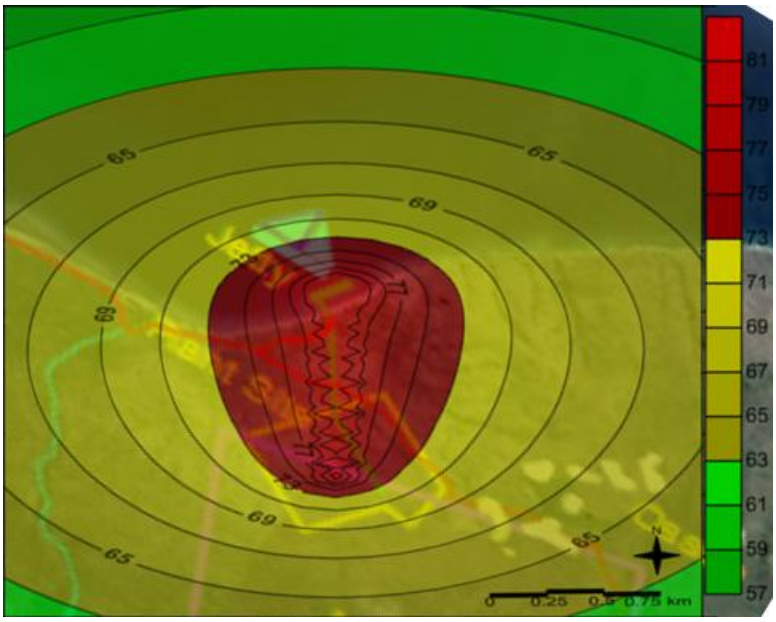


Figure 5.6 Noise contour of operation activities in Jetty area (in DBA)

Noise Contour of Operation Activities in Plant area

Figure 5.7 is predicted noise level caused by the operation activity in the Plant area. This contour is on the certain height, which is 1.5 meters from the ground. **Figure 5.7** showed that some residential area is affected by noise from the operation in the Plant area, namely Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, Ostico, Trilolo, Bahu, Buibau, Ualili, and partly Garluri. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). In addition, in the Plant area noise level due to the activities reaches more than 85 dBA. This exceeds the noise limit EPA 550/9-74-004 in industrial area (70 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua. The highest noise level is around 107 dBA.

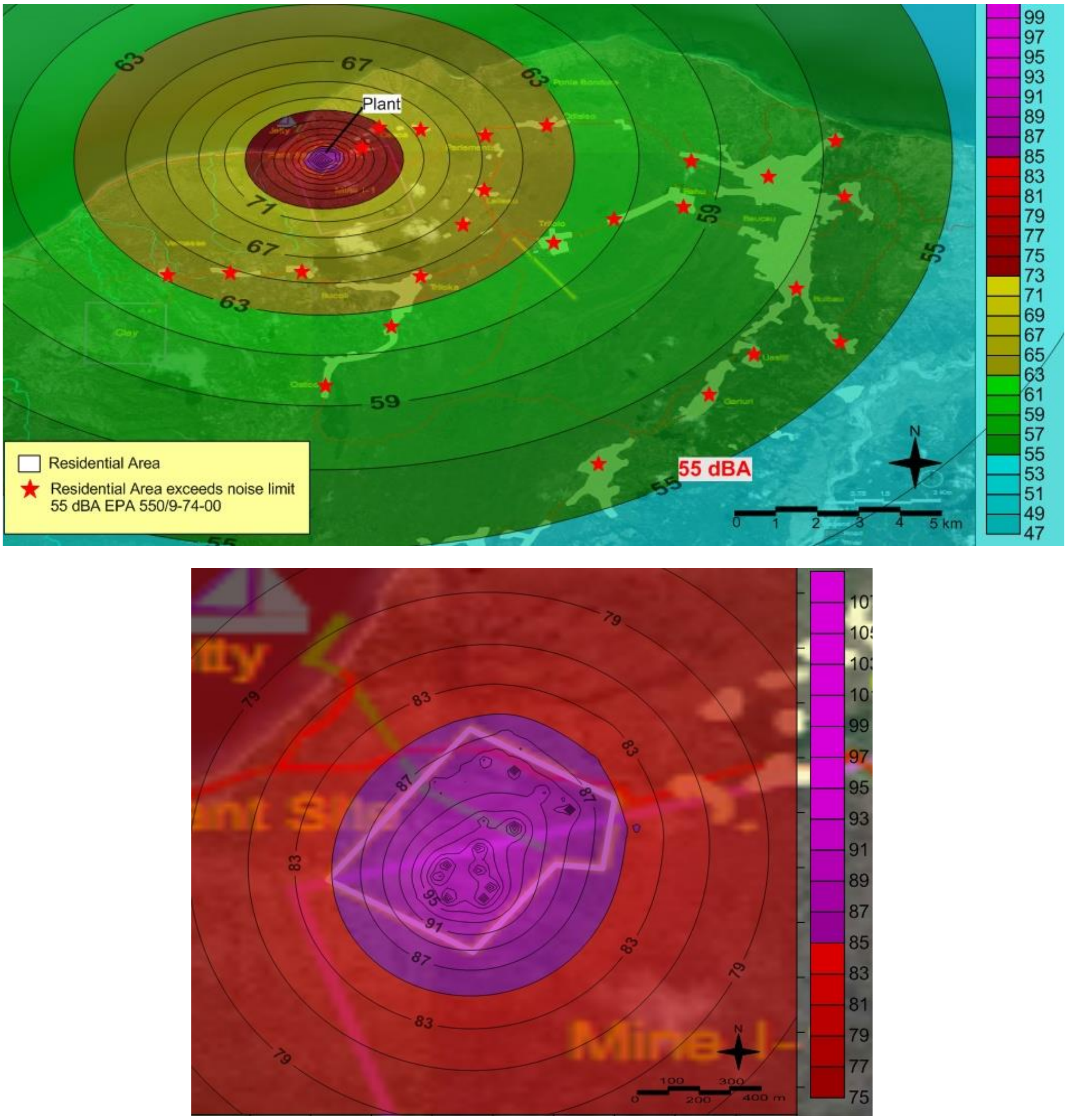


Figure 5.7 Noise contour of operation activities in Plant area (in DBA)

Noise Contour of Operation Activities in Jetty and Plant area

Figure 5.8 is predicted noise level caused by the operation activity in the Plant and Jetty area. This contour is on the certain height, which is 1.5 meters from the ground. **Figure 5.8** showed that some residential area is affected by noise from the operation in the Plant area, namely Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, Ostico, Tirilolo, Bahu, Buibau, Ualili, and Garluri. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua.

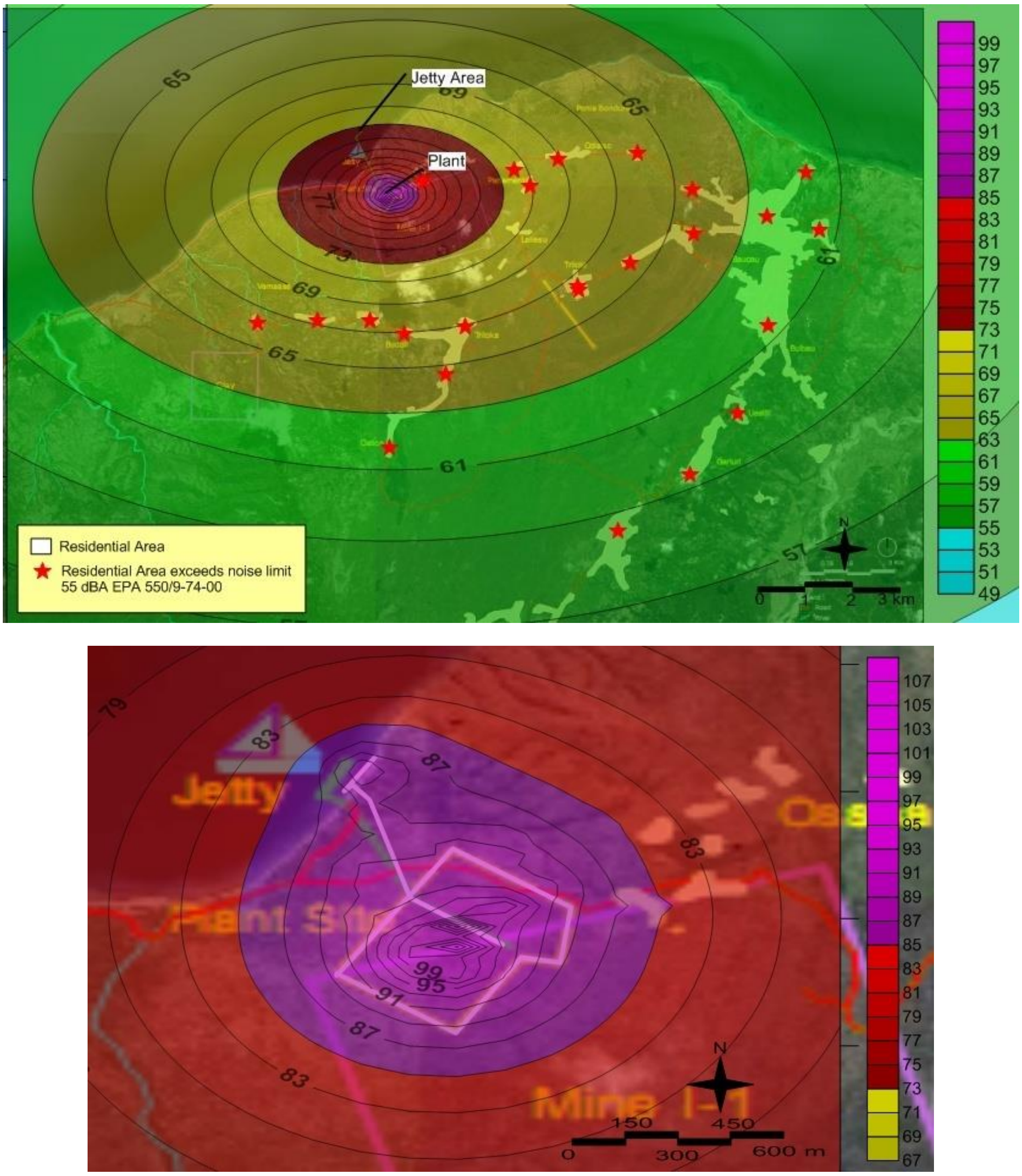
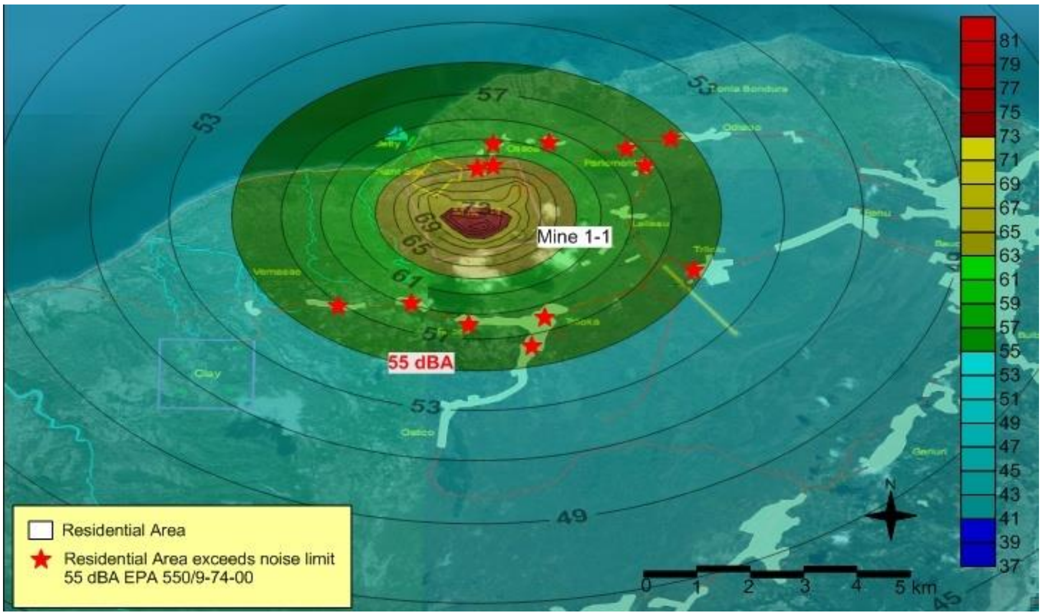


Figure 5.8 Noise contour of operation activities in Jetty and Plant area (in DBA)

Noise Contour of Operation Activities in Mine 1-1 area

Figure 5.9 is predicted noise level due to operation activities in the Mine 1-1 area. This contour is on the certain height, which is 1.5 meters from the ground. There are residential areas affected by noise from the operation in area Mine 1-1, which Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, and Tirilolo. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). In the Mine 1-1 area, the noise caused by the activities is below 65 dBA. This value meets the noise limit EPA 550/9-74-004 in industrial area (70 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua. The highest noise level is around 97 dBA.



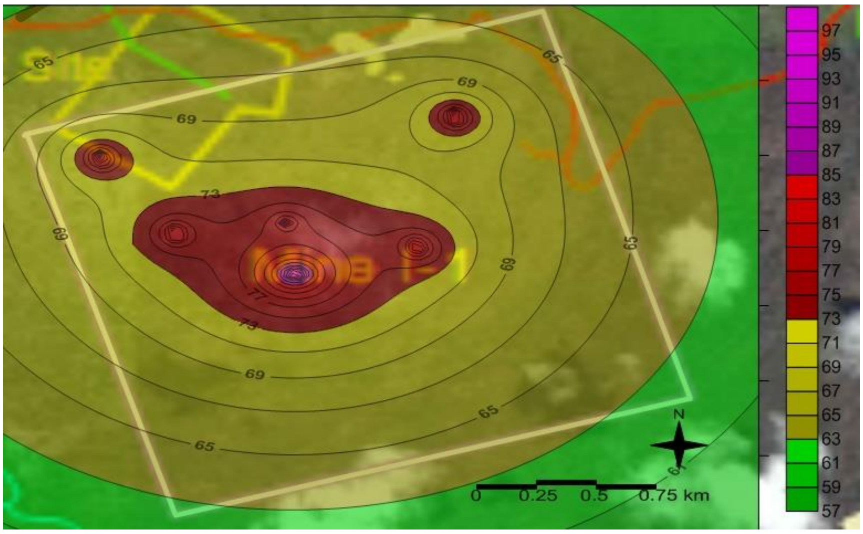


Figure 5.9 Noise contour of operation activities in Mine 1-1 area (in DBA)

<u>Noise Contour of Operation Activities in Clay area</u>

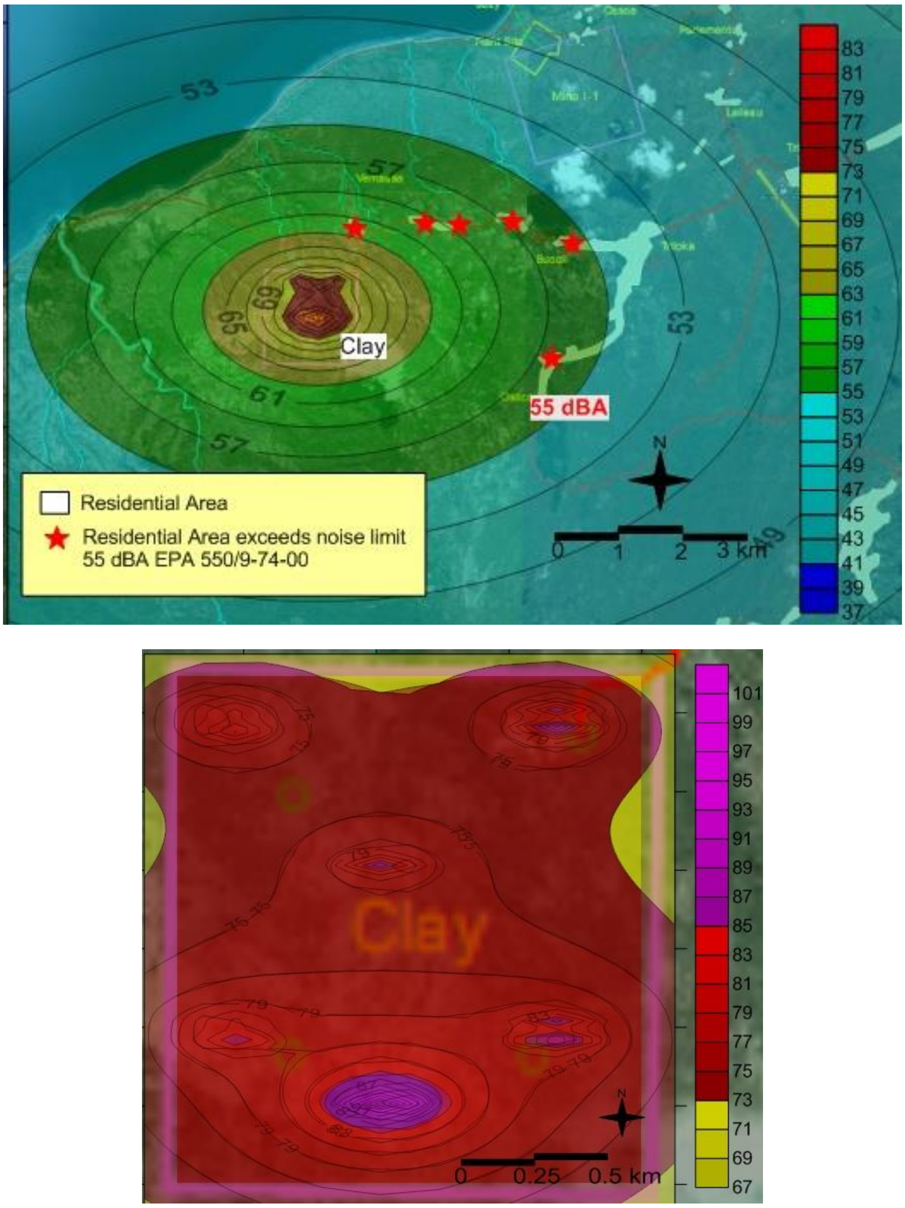


Figure 5.10 Noise contour of operation activities in Clay area (in DBA)

Figure 5.10 is predicted noise level due to operation activities in the Clay area. This contour is on the certain height, which is 1.5 meters from the ground. Some residential areas are affected by noise from the operation in the area of Clay, namely Wailacama, Vemasse, Bucoli, and Ostico. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). In addition, in the clay area, noise level due to the activities reaches 75 dBA. This exceeds the noise limit EPA 550/9-74-004 in industrial area (70 dBA) by 5 dBA. Sensitive receptors which may experience higher noise impact than other receptors are located in Wailacama. The highest noise level is around 101 dBA.

Noise Contour of Operation Activities in Jetty, Plant, Clay, and Mine 1-1 area

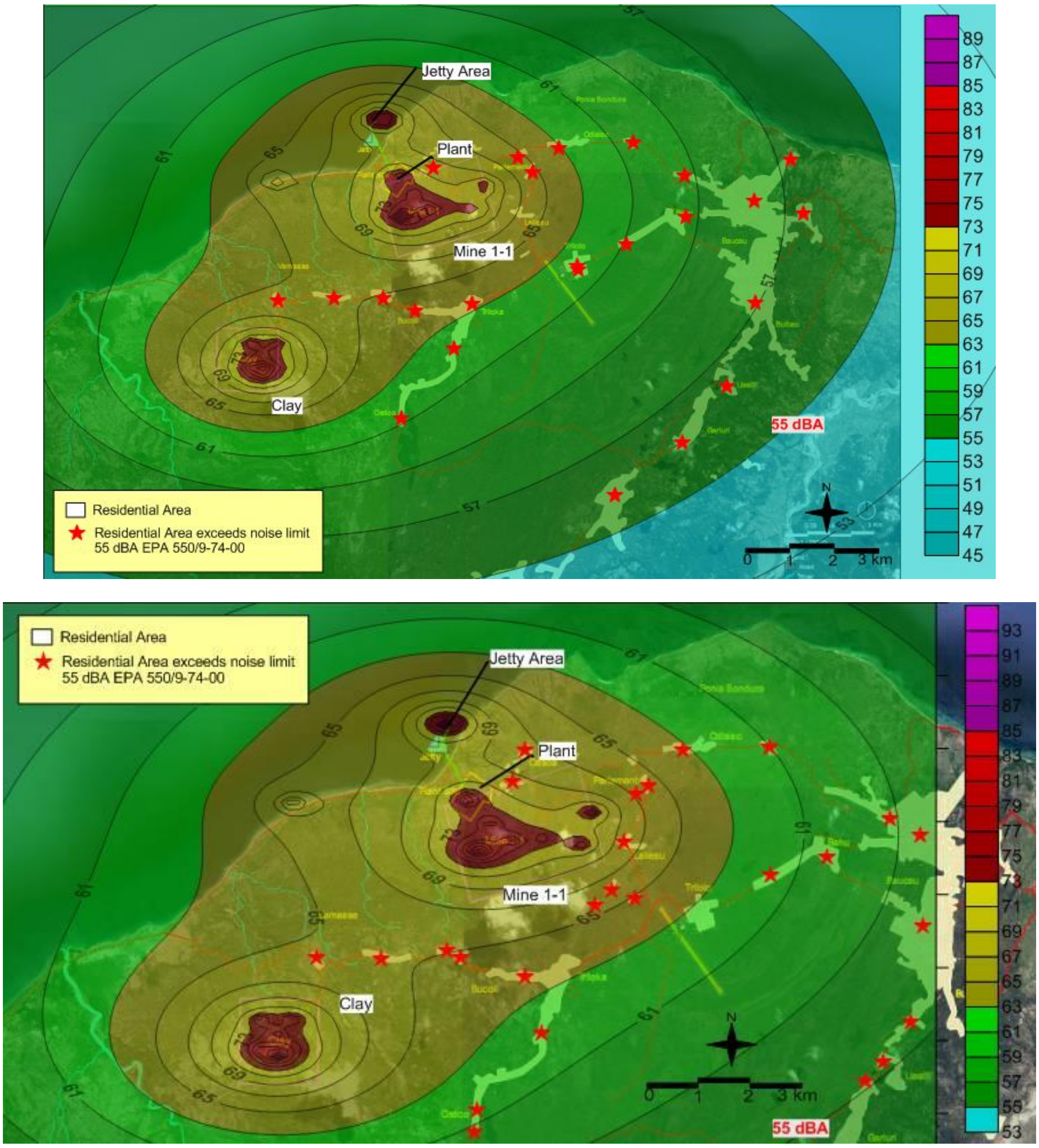


Figure 5.11 Noise contour of operation activities in Jetty, Plant, Clay, and Mine 1-1 area (in DBA)

Figure 5.11 is predicted noise level due to operation activities simultaneously at the jetty, plant, mine 1-1, and clay areas. This contour is on the certain height, which is 1.5 meters from the ground. There are residential areas affected by noise from simultaneous operation activities, namely Osso-ua, Parlemento, Caisido, Lialailesu, Vemasse, Bucoli, Wailacama, Ostico, Trilolo, Bahu, Buibau, Ualili, and Garluri. The impact of noise in the area exceeds noise limit EPA 550/9-74-004 in residential area (55 dBA). Sensitive receptors which may experience higher noise impact than other receptors are located in Osso-ua.

5.3 Sensitivity Analysis

5.3.1 Construction Phase

Table 5.1 Predicted Noise Level during Construction Phase in Sensitive Receptors Points

Receptor Points	Noise Baseline (dBA)	Predicted Noise Level during Construction Phase (dBA)	Δ ($L_{baseline}$ - $L_{predicted}$)(dBA)	Note
N01	56.27	64	8	Exceed noise limit EPA 550/9-74-004 by 9 dBA
N02	55.52	67	12	Exceed noise limit EPA 550/9-74-004 by 12 dBA
N03	50.20	68	18	Exceed noise limit EPA 550/9-74-004 by 13 dBA
N04	54.83	74	19	Exceed noise limit EPA 550/9-74-004 by 19 dBA
N05	51.92	81	29	Exceed noise limit EPA 550/9-74-004 by 26 dBA
N06	46.34	68	22	Exceed noise limit EPA 550/9-74-004 by 13 dBA
N07	50.71	69	19	Exceed noise limit EPA 550/9-74-004 by 14 dBA

During the construction phase, predicted noise level in seven sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N01, predicted noise level during construction is 64 dBA, it exceeds the noise limit EPA 550/9-74-004 by 9 dBA. In N02, predicted noise level during construction is 67 dBA, it exceeds the noise limit EPA 550/9-74-004 by 12 dBA. In N03 and N06, predicted noise level during construction is 68 dBA, it exceeds the noise limit EPA 550/9-74-004 by 13 dBA. In N04, predicted noise level during construction is 74 dBA, it exceeds the noise limit EPA 550/9-74-004 by 19 dBA. In N05, predicted noise level during construction is 81 dBA, it exceeds the noise limit EPA 550/9-74-004 by 26 dBA. In N07, predicted noise level during construction is 69 dBA, it exceeds the noise limit EPA 550/9-74-004 by 14 dBA.

From **Figure 5.12**, it can be seen that during construction phase in the jetty area, noise criteria for residential area is achieved at a distance of approximately 2,000 meters (2 km) from noise source. During construction phase in the plant area with activities that involve more equipment, noise criteria for residential areas is not yet achieved at a distance of 5,000 meters (5 km) from noise source. While during construction phase in clay area, noise criteria for residential area is achieved at a distance of approximately 1,000 meters (1 km) from noise source. During construction phase in the limestone mine area, noise criteria for residential area is achieved at a distance of approximately 2,500 meters (2.5 km) from noise source. While during construction phase in the plant, jetty, clay, and limestone mine area, noise criteria for residential is not yet achieved at a distance of 5,000 meters (5 km). Beyond 5 km, there may be other existing dominant noise in the local area.

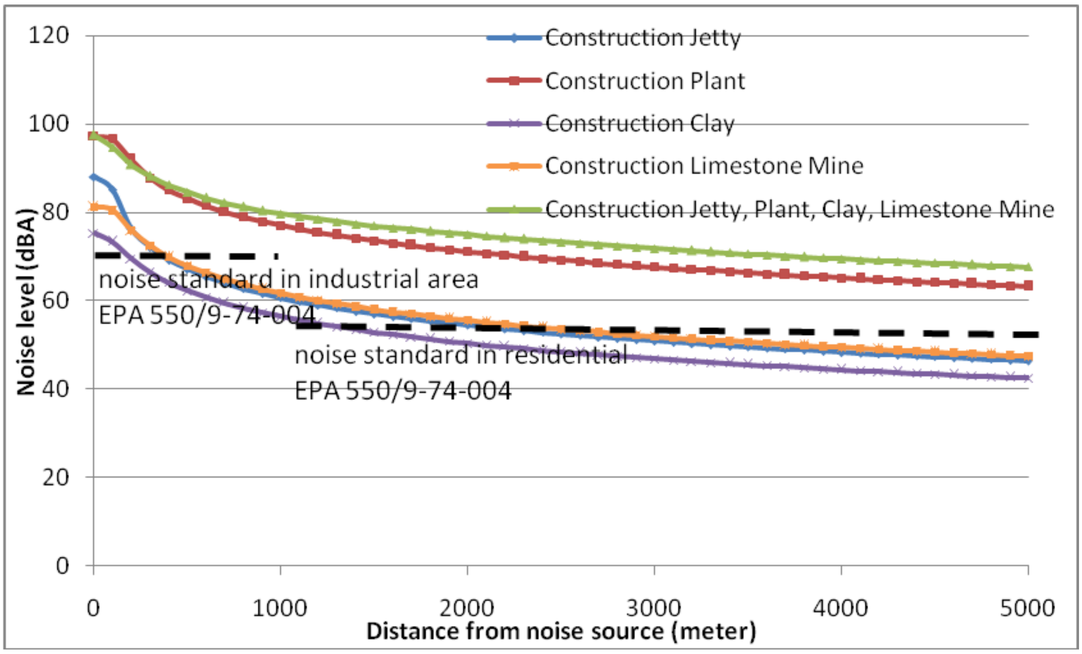


Figure 5.12 The decrease of sound pressure level to the distance from the noise source in construction

5.3.2 Operation Phase

Table 5.2 Predicted Noise Level during Operation Phase in Sensitive Receptors Points

Receptor Points	Noise Baseline (dBA)	Predicted Noise Level during Operation Phase (dBA)	Δ ($L_{baseline}$ - $L_{predicted}$)(dBA)	Note
N01	56.27	56	0	
N02	55.52	61	6	Exceed noise limit EPA 550/9-74-004 by 6dBA
N03	50.20	62	12	Exceed noise limit EPA 550/9-74-004 by 7dBA
N04	54.83	68	15	Exceed noise limit EPA 550/9-74-004 by 13dBA
N05	51.92	73	21	Exceed noise limit EPA 550/9-74-004 by 18dBA
N06	46.34	60	14	Exceed noise limit EPA 550/9-74-004 by 4dBA
N07	50.71	63	14	Exceed noise limit EPA 550/9-74-004 by 7dBA

During the operation phase, predicted noise level in six sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N01, predicted noise level during operation is 56 dBA. The value is in allowable level of the noise limit EPA 550/9-74-004 with 3 dB tolerance. In N02, predicted noise level during operation is 61 dBA, it exceeds the noise limit EPA 550/9-74-004 by 6 dBA. In N03, predicted noise level during operation is 62 dBA, it exceeds the noise limit EPA 550/9-74-004 by 7 dBA. In N04, predicted noise level during operation is 68 dBA, it exceeds the noise limit EPA 550/9-74-004 by 13 dBA. In N05, predicted noise level during operation is 73 dBA, it exceeds the noise limit EPA 550/9-74-004 by 18 dBA. In N06, predicted noise level during operation is 60 dBA, it exceeds the noise limit EPA 550/9-74-004 by 4 dBA. In N07, predicted noise level during operation is 63 dBA, it exceeds the noise limit EPA 550/9-74-004 by 7 dBA.

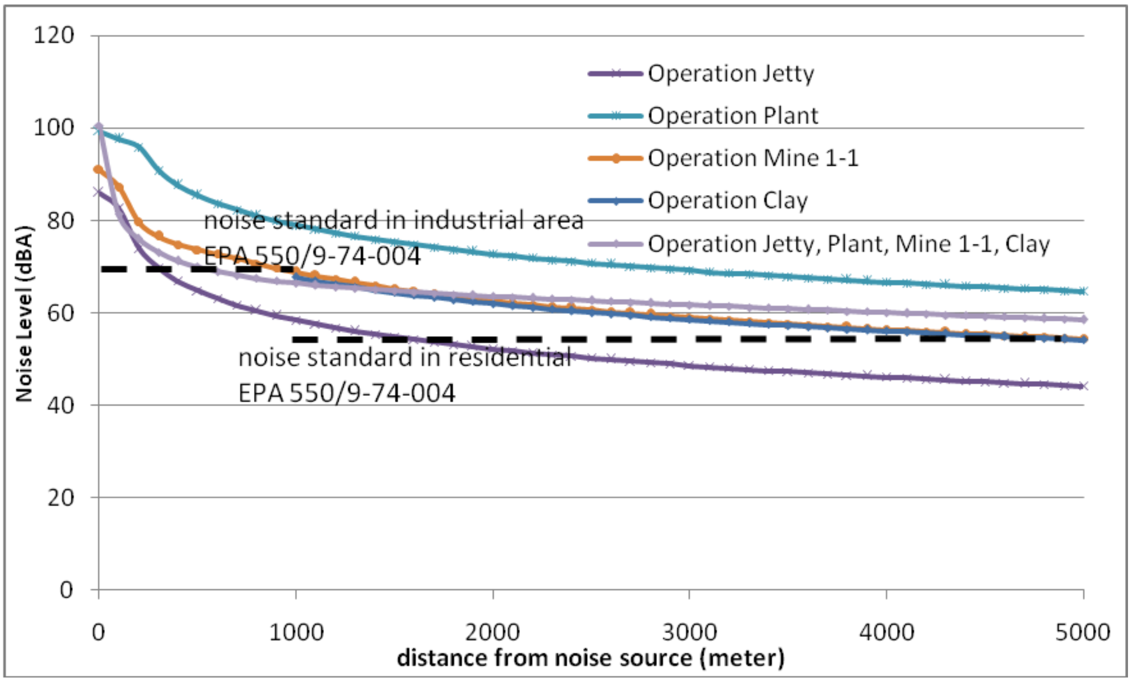


Figure 5.13 The decrease of sound pressure level to the distance from the noise source in operation activities

From **Figure 5.13**, it can be seen that during operation phase at the jetty area, noise criteria for residential area is achieved at a distance of approximately 1,500 meters (1.5 km) from the source. During operation phase in the plant area, noise criteria for residential area is not yet achieved at a distance of approximately 5,000 meters (5 km) from the source. During operation phase in Mine 1-1 area with more noise source, noise criteria for residential area is achieved at a distance of approximately 4,500 meters (4.5 km) from the source. During operation phase in Clay area, noise criteria for residential area is achieved at a distance of approximately 4,500 meters (4.5 km) from the source. While during operation phase in the jetty area, plant, clay, and Mine 1-1, noise criteria for residential area is not yet achieved at a distance of 5,000 meters (5 km) from the source. Beyond 5 km, there may be other existing dominant noise in the local area.

6. IMPACT MITIGATION

Table 6.1 Sound attenuation to meet noise limit EPA 550/9-74-004 during construction and operation

Receptor Points	Sound Attenuation to meet noise limit EPA 550/9-74-004 during Construction (dBA)	Sound Attenuation to meet noise limit EPA 550/9-74-004 during Operation (dBA)
N01	9	6
N02	12	7
N03	13	13
N04	19	18
N05	26	4
N06	13	7
N07	14	6

The cement plant project will have negative impacts to the noise ambience level, not only during construction but also during operation phase. The impact is indicated by the increase of noise level. Impact assessment has shown that the noise level generally will have increase in TL Cement area. Furthermore, in residential areas it even exceeds the noise limit exceeds the noise limit EPA 550/9-74-004 (55 dBA) by 4 to 26 dBA (**Table 6.1**). Therefore, mitigation must be implemented to keep the noise level in residential areas is in allowable level. Mitigation is intentionally to increase the attenuation of sound level from noise sources to receptors.

To reduce the impact of noise both in the construction and the operation phase, there are mitigation options as follows:

1. **Design Options**

   Noise impacts can occur during the construction and operation phase. While the magnitude of the impact construction noise may have on a community may not be known early in the project development stages, measures can be implemented during the design phase that can help to reduce the anticipated noise impacts at sensitive receptors. However, design changes and modification to project layout are not always practical or feasible.

   a. Design and Project Layout

      In addressing construction noise mitigation during the design phases of a project, abatement opportunities can be considered for a variety of areas and features including those listed below:

      - **Storage Areas**: During the planning and design stages of a project, storage areas may be able to be designated in locations removed from sensitive receptors. Where this is not possible, the storage of waste materials, earth, and other supplies may be able to be positioned in a manner that will function as a noise barrier.

- **Haul Roads:** Haul roads can be designated in locations where the noise impacts caused by truck traffic will be reduced.
- **Existing Barriers:** As early as possible in the design development process, natural and artificial barriers such as ground elevation changes, existing buildings, noise walls, and other structures can be considered for use as a noise shield during certain operations.

b. Sequence of Operations

The sequencing and scheduling of construction or operation is equally important in addressing and mitigating noise:

- **Concurrent Operations:** It may be possible to schedule several noisy operations concurrently to take advantage of the fact that the combined noise levels produced may not be significantly greater than the level produced if the operations were performed separately.
- **Early Construction of Noise Barriers:** Ultimately, noise barriers that are to be constructed as part of the project for traffic noise abatement can possibly be installed during the initial stages of construction to reduce the noise impacts of the construction.

c. Alternative Construction Methods

Alternatives to standard construction techniques may also be available and determined to be more practical and/or cost-effective in dealing with construction noise impacts and perceptions. Examples associated with several operations are;

- **Pile Driving:** Pile driving may produce noise levels in excess of acceptable limits, even when feasible noise reduction methods are used. Various dampening and shielding methods discussed later can attain some reduction. However, such methods rarely reduce the noise level to an acceptable level for the sensitive receptors close to the site. As an alternative to driving piles, it is possible to use vibration or hydraulic insertion techniques. Drilled or augured holes for cast-in-place piles are another alternative that may produce noise levels significantly lower than the traditional driving method.
- **Compressors:** While most compressors are powered by diesel or gasoline engines, many are contained or have baffles to help abate noise levels. Electric compressors are significantly quieter than diesel or gasoline engine powered compressors.

2. **Mitigation at the Source**

Source control is, in general, the most effective form of noise mitigation and involves controlling a noise source before it is able to emit potentially offensive noise levels. Construction noise (exclusive of blasting) is typically generated by two source types, which are stationary equipment; and mobile equipment. Noise levels from both types of noise sources are dependent on equipment characteristics and their operation.

a. All types equipment

- **less noisy equipment**: One of the most effective methods of diminishing the noise impacts caused by individual equipment is to use less noisy machinery. By specifying and/or using less noisy equipment, the impacts produced can be reduced or, in some cases, eliminated. Source control requirements may have the added benefits of promoting technological advances in the development of quieter equipment.

- **Mufflers:** Most construction noise originates from internal combustion engines. A large part of the noise emitted is due to the air intake and exhaust cycle. Specifying the use of adequate muffler systems can control much of this engine noise.
- **Shields**: Employing shields that are physically attached to the particular piece of equipment is effective, particularly for stationary equipment and where considerable noise reduction is required.
- **Dampeners**: Equipment modifications, such as dampening of metal surfaces, is effective in reducing noise due to vibration. Another possibility is the redesign of a particular piece of equipment to achieve quieter noise levels
- **Aprons:** Sound aprons generally take the form of sound absorptive mats hung from the equipment or on frames attached to the equipment. The aprons can be constructed of rubber, lead-filled fabric, or PVC layers with possibly sound absorptive material covering the side facing the machine. Sound aprons are useful when the shielding must be frequently removed or if only partial covering is possible.
- **Enclosures:** Enclosures for stationary work may be constructed of wood or any other suitable material and typically surround the specific operation area and equipment. The walls could be lined with sound absorptive material to prevent an increase of sound levels within the structure. They should be designed for ease of erection and dismantling.
- **Blasting Mats:** These mats are typically made with layers of used tires cabled together. They are commonly used as blankets for blasting operations to control and confine debris. These mats also provide a degree of noise attenuation from the blast. However, they do not mitigate vibration, which is usually more of a concern than noise.
- **Selection of Equipment:** Newer equipment is generally quieter than old equipment for many reasons, including technological advancements and the lack of worn, loose, or damaged components. Some equipment manufacturers have made their equipment quieter in recent years and have achieved significant reductions over older equipment. In some cases, the use of over- or under-powered equipment may be an unexpected source of excessive noise. The types of engines and power transfer methods also plays a significant roll in achieving lowered equipment noise. The use of electric powered equipment is typically quieter than diesel, and hydraulic powered equipment is quieter than pneumatic power.
- **Maitenance Programs**: Poor maintenance of equipment typically causes excessive noise levels. Faulty or damaged mufflers and loose engine parts such as screws, bolts, or metal plates contribute to increased noise levels. Removal of noise-reducing attachments and devices such as mufflers, silencers, covers, guards, vibration isolators, etc., will to varying degrees, increase noise emission levels. Old equipment may be made quieter by simple modifications, such as adding new mufflers or sound absorbing materials. Loose and worn parts should be fixed as soon as possible.

b. Stationary Equipment

Whenever possible, positioning stationary noise sources as far away as possible from noise sensitive areas should be considered. Temporary barriers can be employed and/or enclosures can be built around noisy equipment. These techniques can significantly reduce noise levels and, in many cases, are relatively inexpensive. These barriers can typically be constructed on the work site from common construction building material (plywood, block, stacks, or spoils). Enclosures are often constructed from commercial panels lined with sound absorbing material to achieve the maximum possible shielding effect.In addition, providing increased distance between a noise source and a noise receiver can also be considered a form of abatement.

c. Mobile Equipment

Many construction operations are mobile and tend to progress along the length of a project at varying rates. Noise levels at the receiver tend to vary considerably, not only as the speed and power of the equipment varies, but also as the equipment is constantly changing in terms of its distance from the receivers and its relative location. Enclosing mobile equipment is usually not possible, unless the operation is slow moving and the enclosures can be easily moved.

3. **Mitigation Along the Path**

In some situations, such as in urban areas or on isolated sections of a project, it may be beneficial and necessary to construct barriers adjacent to the work area or at the right-of-way. These can take the form of natural shielding, temporary shielding, and/or permanent shielding. The types of barriers are:

a. Natural Shielding

b. Temporary Shielding

c. Permanent Shielding

4. **Mitigation at the Receiver**

Mitigation at a receiver can vary in its complexity, ranging anywhere from relocating residents for a day to insulation of a building. Even after mitigation measures have been applied, the outcome may still be unpredictable with no guarantees that the implemented methods achieve expected results. Therefore, mitigation at the receiver should only be considered as a last alternative.

a. Building Envelope Improvements

Building envelope mitigation to reduce noise can include techniques such as sealing existing building elements, providing new sealed windows and doors, adding building insulation, etc. Such techniques, while effective, may also require modification of the building's heating, ventilation, and air conditioning system. Prior to proposing such treatments, thorough consideration of the costs and implications of such modifications is suggested.

b. Masking

Noise masking is a technique that is still in the developmental stage but may have potential in isolated cases. Masking considerations could include techniques such as constructing water falls or other cascading water designs, employment of noise cancellation technologies, changing "background" noise levels, etc. Such techniques require a consideration of the type of noise generator (stationary, mobile, etc.), the source's noise frequency content, variability of the noise source in terms of its magnitude and duration, and the noise environment of the receptor being protected.

7. CONCLUSION

With a view to expand cement manufacturing business, a new company TL Cement LDA (TLC) has been established at Baucau in Timor-Leste. In the construction and operational phases, heavy equipment used will become a new source of noise in the area TL Cement. During the development, noise emission will occur continuously, therefore it is necessary to model the noise dispersion with the aim to predict the distribution of noise caused by activities and actions during construction and operations phase in TL Cement. To obtain reliable noise prediction results, a study on the effects of noise distribution is done using software that has been widely used, MATLAB® with reference to ISO 9613, the Attenuation of Sound during Propagation Outdoors. Theresults from Matlab is then plotted using Surfer software.

During the construction phase, predicted noise level in seven sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N01, predicted noise level during construction is 64 dBA, it exceeds the noise limit EPA 550/9-74-004 by 9 dBA. In N02, predicted noise level during construction is 67 dBA, it exceeds the noise limit EPA 550/9-74-004 by 12 dBA. In N03 and N06, predicted noise level during construction is 68 dBA, it exceeds the noise limit EPA 550/9-74-004 by 13 dBA. In N04, predicted noise level during construction is 74 dBA, it exceeds the noise limit EPA 550/9-74-004 by 19 dBA. In N05, predicted noise level during construction is 81 dBA, it exceeds the noise limit EPA 550/9-74-004 by 26 dBA. In N07, predicted noise level during construction is 69 dBA, it exceeds the noise limit EPA 550/9-74-004 by 14 dBA.

Modeling result shows that during construction phase in the jetty area, noise criteria for residential area is achieved at a distance of approximately 2,000 meters (2 km) from noise source. During construction phase in the plant area with activities that involve more equipment, noise criteria for residential areas is not yet achieved at a distance of 5,000 meters (5 km) from noise source. Beyond 5 km, there may be other existing dominant noise in the local area.

During the operation phase, predicted noise level in six sensitive receptors points exceeds the noise limit EPA 550/9-74-004. In N01, predicted noise level during operation is 56 dBA. The value is in allowable level of the noise limit EPA 550/9-74-004 with 3 dB tolerance. In N02, predicted noise level during operation is 61 dBA, it exceeds the noise limit EPA 550/9-74-004 by 6 dBA. In N03, predicted noise level during operation is 62 dBA, it exceeds the noise limit EPA 550/9-74-004 by 7 dBA. In N04, predicted noise level during operation is 68 dBA, it exceeds the noise limit EPA 550/9-74-004 by 13 dBA. In N05, predicted noise level during operation is 73 dBA, it exceeds the noise limit EPA 550/9-74-004 by 18 dBA. In N06, predicted noise level during operation is 60 dBA, it exceeds the noise limit EPA 550/9-74-004 by 4 dBA. In N07, predicted noise level during operation is 63 dBA, it exceeds the noise limit EPA 550/9-74-004 by 7 dBA.

During operation phase at the jetty area, noise criteria for residential area is achieved at a distance of approximately 1,500 meters (1.5 km) from the source. During operation phase in the plant area, noise criteria for residential area is not yet achieved at a distance of approximately 5,000 meters (5 km) from the source. During operation phase in Mine 1-1 area with more noise source, noise criteria for residential area is achieved at a distance of approximately 4,500 meters (4.5 km) from the source. During operation phase in Clay area, noise criteria for residential area is achieved at a distance of approximately 4,500 meters (4.5 km) from the source.While during operation phase in the jetty area, plant, clay, and Mine 1-1, noise criteria for residential area is not yet achieved at a distance of 5,000 meters (5 km) from the source.Beyond 5 km, there may be other existing dominant noise in the local area.

In general, modeling results indicate that the predicted impacts of TL Cement development have quite significant impact on the increase in noise levels in areas around TL Cement. Therefore, mitigation must be implemented to keep the noise level in residential areas is in allowable level. To reduce the impact of noise both in the construction and the operation phase, there are mitigation options like design options, mitigation at the source, mitigation along the path, and mitigation at the receptors.

8. REFFERENCE

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Appendix 3 Surface Water Impact Assessment Report

TL Cement

Baucau Cement Project

Surface Water Impact Assessment Report

14-Dec-15

Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

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WorleyParsons Group

TL Cement
Baucau Cement Project
Surface Water Impact Assessment Report

Synopsis

Advisian were engaged by TL Cement to assess the potential surface water impacts associated with the Baucau Cement Project and to present surface water management measures needed to protect areas of social and ecological value that are dependent on surface water runoff. Specifically, the springs used for public water supply and Closed Tropical Forest vegetation and associated fauna species identified along the natural watercourses and drainage lines must be protected.

The results of this surface water assessment suggest the proposed developments associated with the Baucau Cement Project, with the recommended surface water management measures in place, are not expected to have a significant impact on the quantity and quality of streamflow or on the associated environmental receptors in the study area.

Although the presence of highly permeable karst limestone limits the volume of rainfall-runoff generated in the catchments areas, there is still some risk of flash flooding during extreme rainfall events. Therefore diversion drains and bunds are proposed in this report to divert floodwater around mine and plant areas. Further hydrological investigations are needed to design diversions and culvert-floodway crossings in the mine and plant areas.

Surface water quality management measures are proposed in this report to mitigate risk of contamination of spring water from surface water flowing off the plant and mine sites. Monitoring of surface water flows and water quality in watercourses and drainage lines is recommended to establish baseline conditions and for compliance monitoring.

PROJECT NO 301012-02135– BAUCAU CEMENT PROJECT: SURFACE WATER IMPACT ASSESSMENT REPORT

Rev	Description	Author	Review	Advisian Approval	Date
Rev 0	Issued for Use	S Atkinson	T Weaver	S Atkinson	17/02/15

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1 Introduction

1.1 Background

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (mtpa) of Portland cement clinker. For the purposes of this EIS, the overall project will be referred to as the Baucau Cement Project. The project location is shown in Figure 1-1.

The limestone required for the proposed clinker plant is to be provided by mining the Bucoli limestone deposit. The limestone is to be transported via haul road to the cement plant site for processing. The cement product is then transported via conveyor to the marine jetty where it is loaded onto vessels for export. The location of the mine, cement plant, conveyor and jetty are shown in Figure 1-1.

The project will have four phases: Pre-construction (18 months), Construction (2 years), Operations (over 35 - 50 years) and Decommissioning (5 years). A summary of the activities to be undertaken during each phase are presented in Table 1-1.

The key project characteristics are listed in Table 1-2.

Figure 1-1: Project Location, Limestone Mine, Cement Plant, Conveyor and Jetty

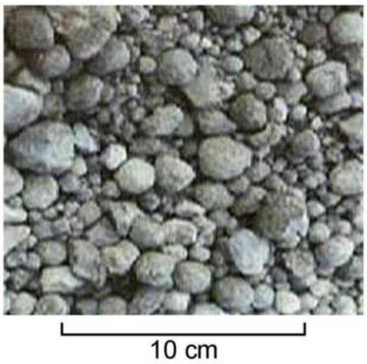
Table 1-1: Summary of Baucau Cement Project phase characteristics

Phase	Activities
Pre-construction (Duration of approximately 18 months)	• Clearing of fence lines & Installing fences • Clearing for construction of access roads internal to the project area • Establishment of Laydown areas and preliminary office infrastructure such as portable toilets and shipping containers for storage • Relocation of people and animals from within the project area • Exploratory water source drilling and installation of water supply wells. • Installation of power supply infrastructure corridors via clearing, excavation and pegging • Geological studies including bore drilling and pit surveys • Monitoring weir installations in ephemeral watercourses to record flows and water quality. • Establishment of exclusion zones around fishing areas, boreholes and springs (known impact, appropriation of natural asset) • Construction of material offloading facility (construction jetty)
Construction (Duration of approximately 2 years)	• Clearing of the cement plant site/area - excavation, piling, pouring of concrete foundations and establishment of permanent accommodation, offices and workshops • Building structures in concrete and steel for cement manufacturing equipment • Developing internal cement plant roads and drainage • Establishment of bunds, hauling roads, drainage management areas and mine stope markers ahead of mining commencing • Installation of cement plant equipment • Construction of power plant • Installation of conveyor system • Piling and construction of jetty • Construction of internal access roads and haul roads • Discharge into landfill – solid and liquid waste

Operation Duration of approximately 35-50 years)	• Mining 24hours a day, 7 days a week • Blasting • Truck hauling • Operating conveyor transporting material to/from Jetty • Operational cement plant • Operational power plant operational • Operational jetty and MOF • Maintenance clearing within the plant site boundary (e.g. tree lopping for power lines) • Discharge to landfill – solid waste
De-Commissioning (Duration of approximately 5 year)	• Mine Closure and Rehabilitation

Table 1-2: Summary of Baucau Cement Project Characteristics

Element	**Description**
Project life	Limestone reserves for over 17years at full production capacity Life of the cement plant is 50+ years
Investment	$400 million USD Largest industrial project undertaken in Timor-Leste to date
Annual production	1.65 million tons per annum (mtpa) of Portland cement clinker (main component of cement; • 0.5 mtpa will be combined with the other required components to make Ordinary Portland Cement (a complete cement mixture) to be sold locally in Timor Leste and Australia (~70 % in Timor-Leste and ~30% to Australia) • 1.15 mtpa will be packaged as Portland cement clinker and exported by ships to Australia

<table>
<tr><td>Cement types produced</td><td>
Portland cement clinker</td><td>
Ordinary Portland cement</td></tr>
<tr><td>List of major project components</td><td colspan="2">Limestone mine (up to 5.76 km^2)
Cement processing plant (650 m x 400 m)
• Including a construction camp and worker residential area (35 containers of 40 feet in length. 1 office unit, one cafeteria unit, 5 accommodation units each with 24 rooms (120 rooms in total).
Fully Enclosed Pipe Conveyor Belt (1.5 km long)
Marine Jetty (500 m long)</td></tr>
<tr><td>Area of disturbance</td><td colspan="2">Limestone mine – 185 ha (1.85km^2)
Cement Processing Plant + Captive Power Plant + Camp – 80 ha- Note all in one compound (0.8km^2)
Marine Jetty + pipe conveyor - 1.5 ha (0.015km^2)</td></tr>
<tr><td>Power Supply</td><td colspan="2">30 Mega Watt coal power plant
3-5 Mega Watt Solar Power Plant</td></tr>
<tr><td>Water Supply</td><td colspan="2">Groundwater from water supply bores at the Uaidei River
• 0.35 ML/day for construction
• 3.15 ML/day for operation</td></tr>
<tr><td>Number of jobs</td><td colspan="2">3000 jobs during peak of construction
1000 permanent jobs during operations</td></tr>
</table>

1.2 Objectives

The objective of this surface water impact assessment is to identify surface water risks associated with the proposed Project development and to develop surface water management measures to mitigate risk and to minimise potential impacts on the environment.

The impact assessment is to assess the following two areas separately:

- **Plant & Jetty Area** - including the cement plant, marine jetty, conveyor and associated plant infrastructure; and
- **Mine Area –** including the limestone mine, haul/access roads to cement plant and associated mine infrastructure (buildings, facilities, internal roads, waste dumps, etc).

1.3 Scope of Work

The scope of work for this impact assessment includes undertaking the following assessments for both the Mine Area and Plant & Jetty Area separately:

- Identify surface water related risks associated with the proposed developments and sensitive environmental receptors;
- Identify surface water management measures to mitigate risk and potential impacts on the environment. Present design concepts that:
  - Capture and treat runoff from disturbed or potentially contaminated areas on site;
  - Mitigate the risk of flooding from rainfall runoff;
  - Maintain quantity and quality of flow conditions to downstream environments that are similar under pre and post development conditions; and
  - Protect environmentally sensitive areas such as natural springs which are used for public water supply.
- Complete SWMM modelling to assess the potential impacts of the proposed developments on the frequency and magnitude of streamflow events with the recommended surface water management measures in place.

2 Methodology

The following methodology was adopted for this surface water impact assessment:

- Characterise the existing site conditions;
- Identify sensitive receptors in the project area and the surface water risks associated with the Project;
- Develop surface water management measures to mitigate risk;
- Utilise client supplied topographic contour data and infrastructure layouts to delineate catchment areas under pre and post development conditions;
- Estimate daily runoff from project areas under pre and post development conditions using SWMM modelling software; and
- Complete an impact assessment with proposed surface water management measures in place.

The surface water assessment presented in this report has adopted methods consistent with industry best practice in Australia and East Timor.

3 Existing Site Conditions

3.1 Climate

Climatic statistics presented in Figure 3-1 and Figure 3-3 for Baucau were developed using climatic data recorded between April 2010 and March 2014 at the Baucau Meteorological Observatory in East Timor. This data was provided by the Meteorological Department at the Nicolau Lobato International Airport at Dili.

Timor-Leste lies in a tropical region where temperature varies by only 2-3 degrees Celsius (°C) between the warmest months and the coolest months. The average daytime temperature in coastal areas of the Baucau region is around 27°C and around 25°C in the highlands.

Timor-Leste has two distinct seasons, a dry season from June to November and a wet season from December to May. The wet season is characterized by extreme rainfall over short periods created by the West Pacific Monsoon. Torrential rain storms and cyclones commonly occur in the country during the wet season.

3.1.1 Temperature

Average monthly temperatures presented in Figure 3-1 show that maximum temperatures of approximately 31°C occur between November and December, while the lowest average minimum temperature of 17°C occurred in August.

3.1.2 Rainfall

The average annual rainfall recorded between 1st April 2010 and 28th February 2015 at the Baucau Meteorological Observatory was 1384 mm. Approximately ninety percent of the annual rainfall occurred each year between October and May. The average number of rainy days varied from 100 to 140 during this period with an average of 125 days each year. The maximum daily rainfall recorded over this monitoring period was 203.1 mm on the 2nd February 2012. This was a significant rainfall event and was likely to have caused widespread flooding. A plot of the daily rainfall record is provided in Figure 3-2.

The average monthly rainfall data presented in Figure 3-3 shows the majority of rainfall falling during the wet season with over 100mm falling in each month on average, peaking in February at around 300mm. During the dry season (June to November), average monthly rainfall in Baucau is less than 100 mm, with almost no rain recorded during the month of August.

3.2 Topography

3.2.1 Mine Area

The area of the proposed limestone mine site consists of undulating terrain with small hills and a valley. The elevation rises gently from north to south (Figure 3-4). The north-west corner has an elevation of approximately 25 m above mean sea level and the south-east corner has an elevation of about 395 m. The digital terrain model of the topography of the limestone mine area is shown in Figure 3-5.

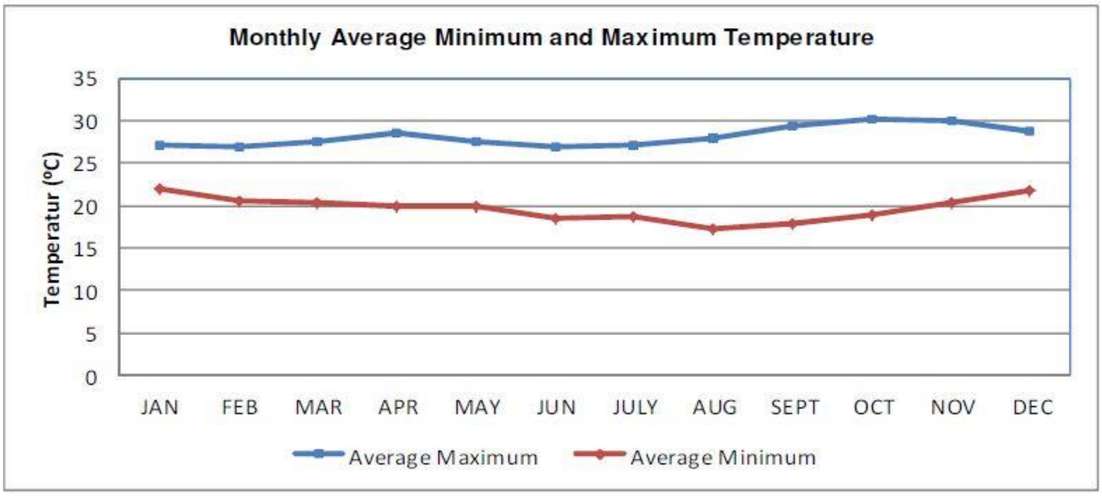


Figure 3-1: Average Monthly Temperatures recorded at Baucau Meteorological Observatory

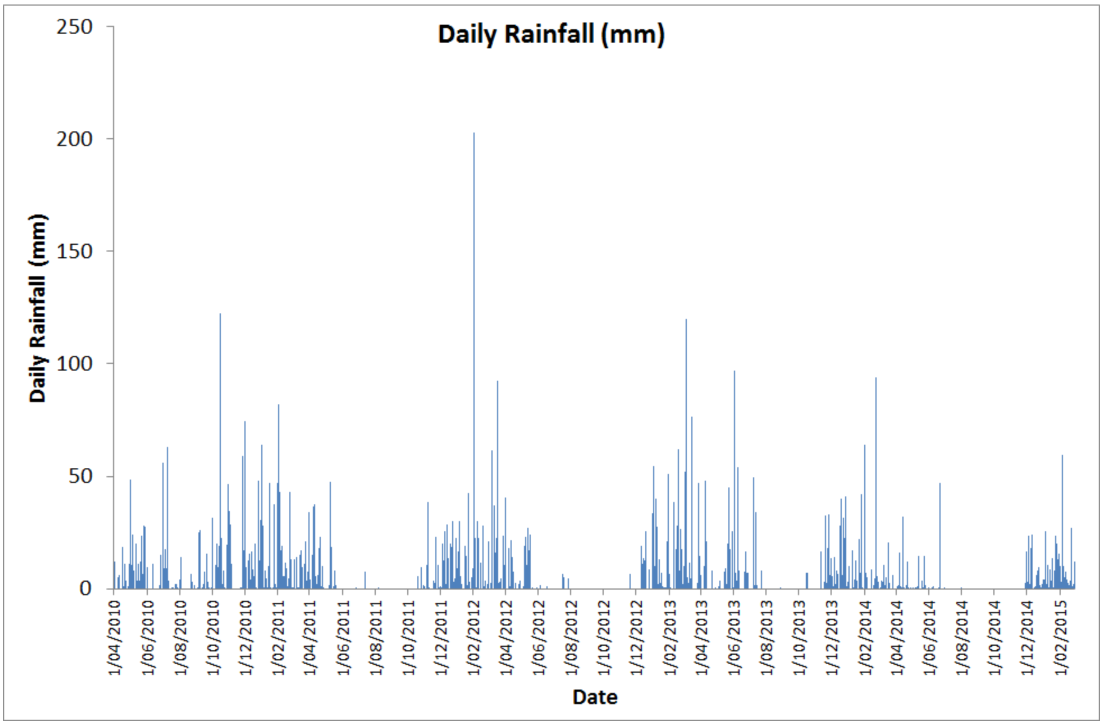


Figure 3-2: Daily rainfall recorded at Baucau Meteorological Observatory between 1st April 2010 and 28th February 2015

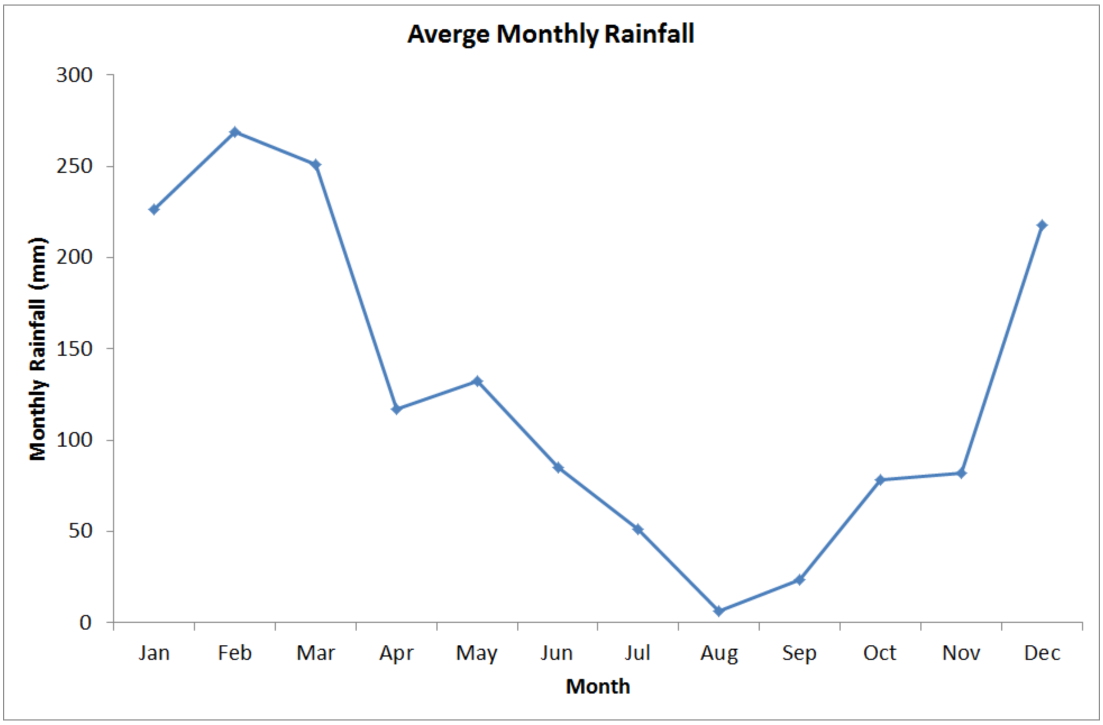


Figure 3-3: Average Monthly Rainfall recorded at Baucau Meteorological Observatory between 1st April 2010 and 28th February 2015

Figure 3-4: Topography of mineral license area looking from north to south

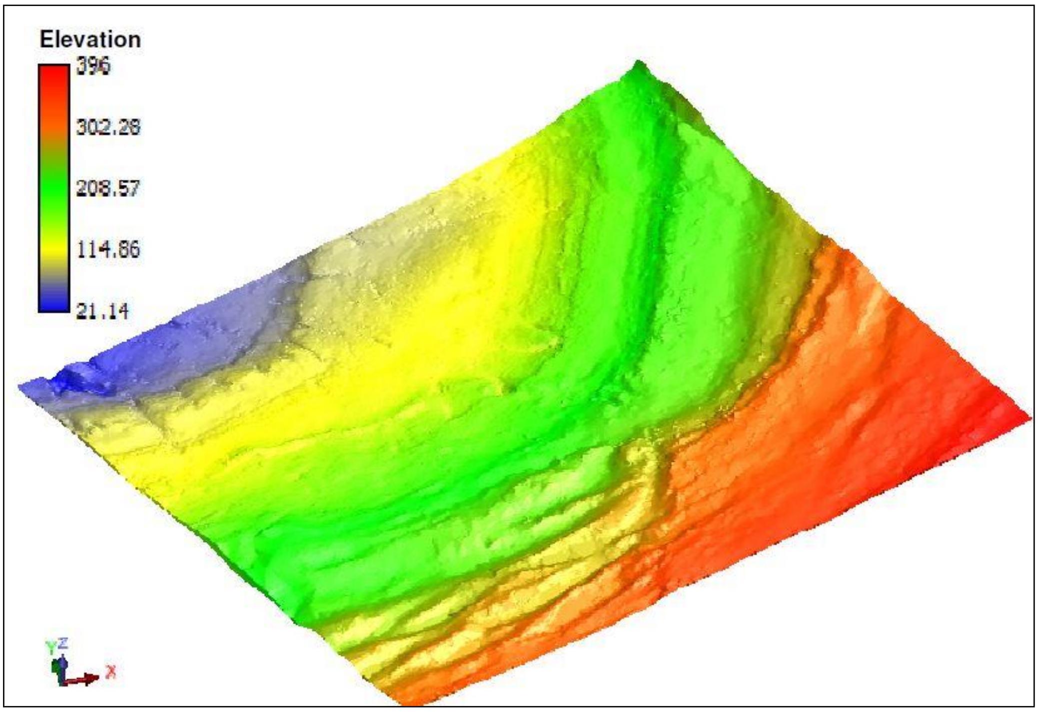


Figure 3-5: Digital terrain model of topography for limestone mine area (m above sea level)

3.2.2 Plant and Jetty Area

The area proposed for the cement plant site is characterized as hilly and slopes up away from the coast (Figure 3-6). The site is 40 m to 50 m above sea level and 0.9 k m to the south east of the proposed jetty.

Figure 3-6: Panoramic view of limestone mine site and plant site

3.3 Surficial Soils

3.3.1 Mine Area

The mine site is located across stepped slopes and plains on limestone outcrops with higher slopes on the southern edge of the site and flatter plains towards the northern boundary. There are minor ravines and gullies, and grassland present. The site is characterized by shallow limestone soils and extensive scattered, small to medium sized limestone rock outcrops (Trainor & Easton 2015).

3.3.2 Plant and Jetty Area

The plant site is located on north-north-east facing slopes and plains relatively close to the beach, road and proposed jetty area. The site is characterized by shallow limestone soils with scattered limestone rock outcrops, minor ridges and gullies sloping towards the beach (Trainor & Easton 2015).

The topsoil in the jetty area generally consists of sandy soils, corals and gravels, with limited indication of very weakly cemented soils. Most soil layers have indication to be calcareous (contain calcium carbonate).

3.4 Regional Hydrology

No permanent rivers exist within the Jetty Area, Plant Site or Limestone Mine areas. Some small ephemeral watercourses flow through the area, mainly during the wet season. These tend to stop flowing in the dry season and are not considered suitable as full time water sources. There are a number of coastal swamps containing fresh water from rain and groundwater discharge, but these also dry up in the dry season.

The closest significant watercourse is the Manulede River located approximately 9 km from the proposed Cement Plant site. The river only flows when there is rainfall but is quite extensive as it drains the western side of the Baucau Plateau (Lindsay 2015). The river also feeds the underground karst aquifer (groundwater) discharge.

Significant catchment areas and drainage lines within the study area were mapped using a Digital Elevation Model (DEM) developed using ASTER data (NASA) and shown in Figure 3-7. The catchment area associated with the mine and plant site has an area of approximately 29.2km^2. Runoff from the higher ground, to the south of the project area, flows northwards, via ephemeral watercourses, toward the ocean.

Karst Baucau limestone is present throughout the majority of the catchment areas reporting to the mine site, which limits rainfall-runoff. Karst features such as including springs, caves, collapsed caves, sink holes, and sharp outcrops are present in the study area (Furness, 2015). The Baucau Limestone aquifer is recharged by rainfall infiltrating on the Baucau Plateau during the wet season. The infiltration rate for the exposed karst features on the plateau was estimated by Furness (2015) to be approximately 40% of the annual rainfall.

Anecdotal evidence (personal communication L. Furness, 2015) suggests there is very little runoff during rainfall events and therefore surface water flows are only expected in the upper catchment areas during extreme rainfall events. This is evident in the air photographs where watercourses are poorly defined. Watercourses become better defined between the mine site and coastline, in proximity to the plant site where limestone sediment/soils and alluvials are present.

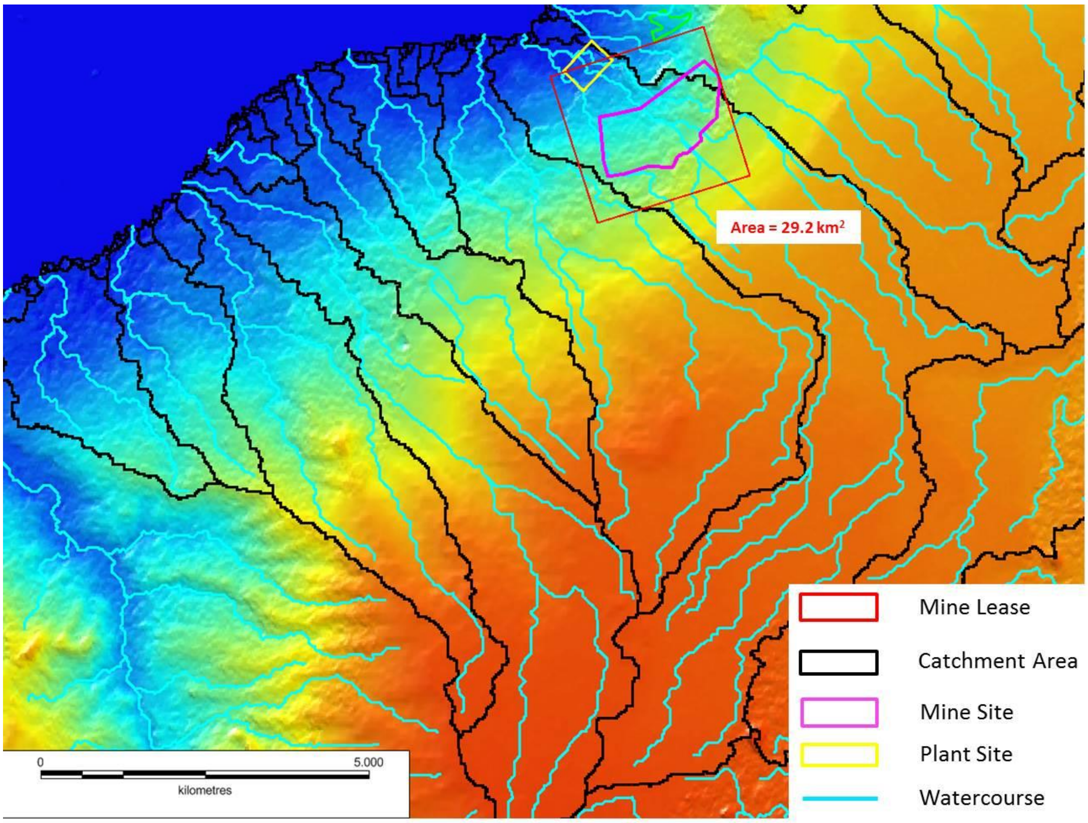


Figure 3-7: Catchment areas delineated using ASTER data (ASTER GDEM is a product of METI and NASA.).

Figure 3-8 shows the known surface springs (triangles) and caves (circles) located on the Baucau Plateau. Springs in the vicinity of the plant and mine areas are shown in Figure 3-9 and include the following:

- Uaimatabai Spring (Plate 3-1);
- Uaisa Spring (Plate 3-2); and
- Uaiono Spring (Plate 3-3).

Uaimatabai Spring emerges from a limestone cave (170 m elevation) along an overhang. The discharge is about 5 L/s and the water is fresh although probably hard (Furness, 2015). Uaisa Spring is the major spring discharge (142 m elevation) located about 400 m downslope of Uaimatabai Spring. It is close to the Caisidu Village School and surrounded by very tall breadfruit and rainforest trees. The discharge is approximately 10 L/s and the water is fresh at 633 µScm. Water is piped and run in open channels to the sub-villages at lower elevation. Furness (2015) recommended that a water reserve is established around these important springs (Figure 3-9).

Uaiono Spring discharges into the sea at the proposed port and jetty area through a fracture in beach rock. Anecdotal evidence from a recent site visit suggests that it is only observed at low tide (L. Furness, 2015).

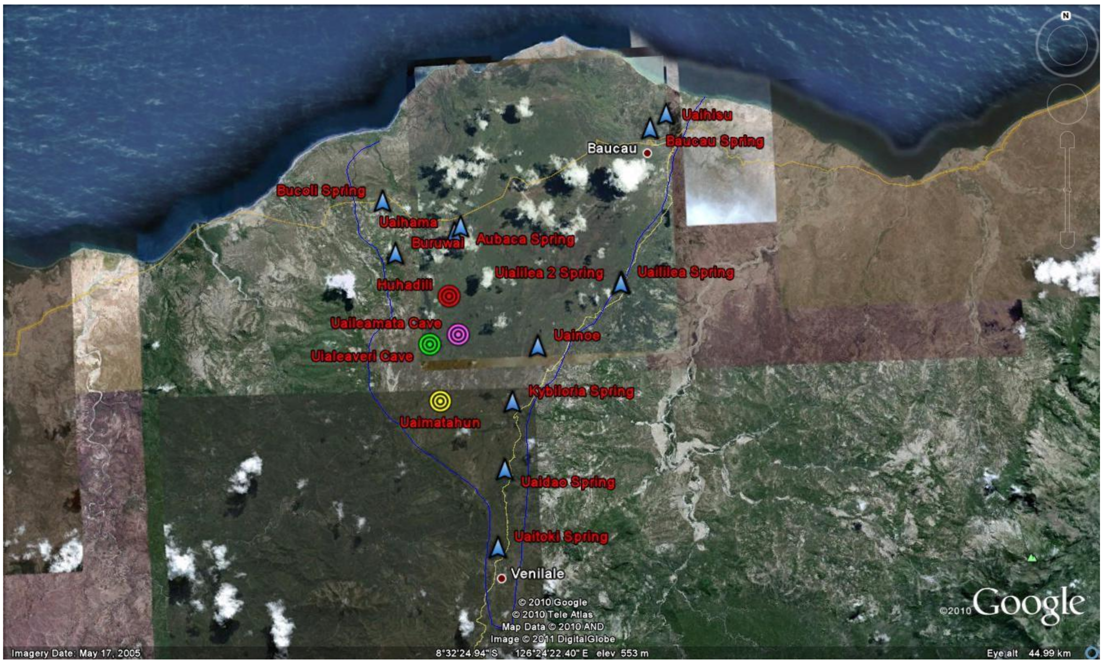


Figure 3-8: Karst features of the Baucau Plateau. Spring locations are shown as “triangles” and caves shown as “circles”

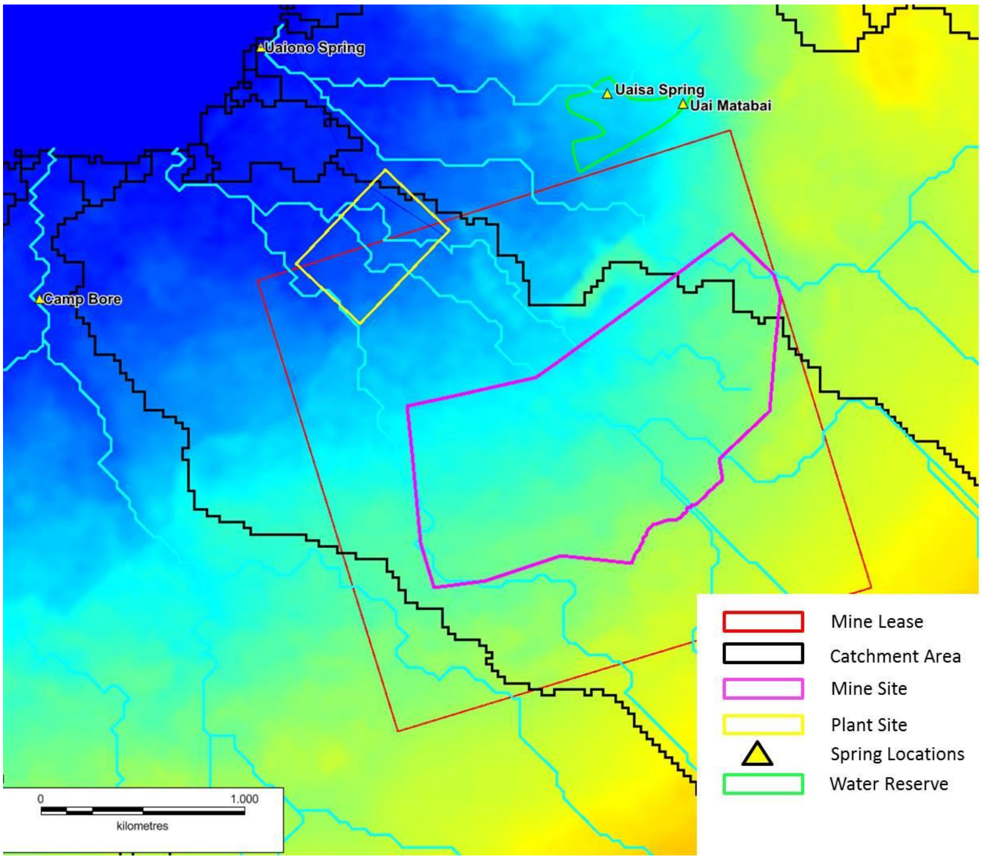


Figure 3-9: Springs in the vicinity of the proposed plant and mine areas.

Plate 3-1: Uaimatabai Spring

Plate 3-2: Uaisa Spring

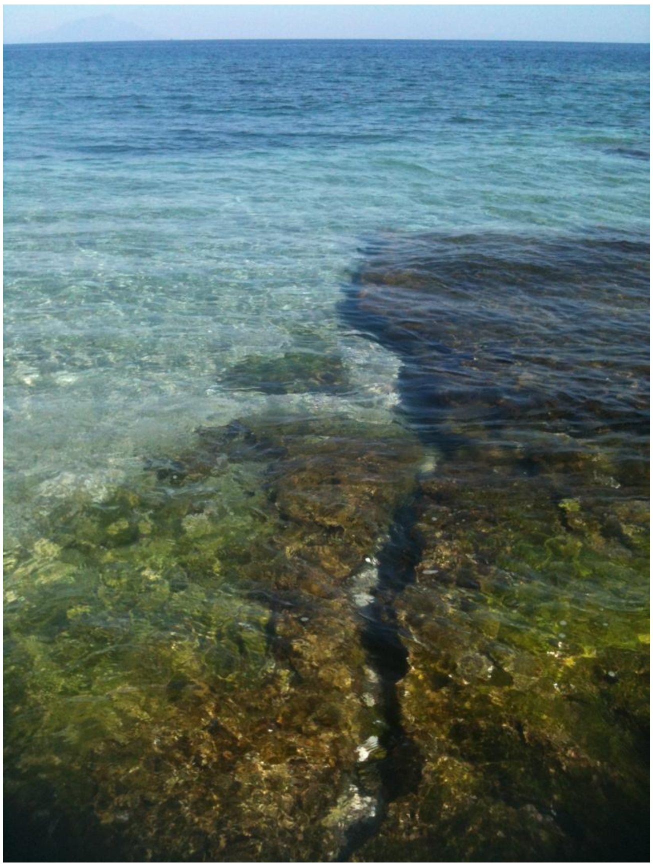


Plate 3-3: Uaiono Spring

4 Environmental Receptors

4.1 Springs

The following surface water springs identified immediately north of the mine and plant areas (Figure 3-9) are surface water receptors potentially at risk from the proposed mine, plant and port developments:

- Uaimatabai Spring (Plate 3-1);
- Uaisa Spring (Plate 3-2); and
- Uaiono Spring (Plate 3-3).

The surface water flows from Uaimatabai and Uaisa Springs occur all year and are used for potable water supply by the Caisidu Village as well as sub-villages at lower elevation. The Uaisa Spring is also surrounded by very tall breadfruit and rainforest trees. The quantity and quality of flows at the springs need to be protected to minimise impact to the associated environmental and social values.

4.2 Terrestrial Vegetation and Flora

Terrestrial flora communities that are dependent on ephemeral surface water flows in streams and drainage lines also are potentially at risk from the proposed developments. The mine, plant and port developments should be designed with surface water management measures in place to minimise adverse impacts on the quantity and quality of surface water flows which pass to existing streams and drainage lines.

Analysis of aerial photography within the study area suggests the ephemeral streams and drainage lines are generally poorly defined in the upper reaches of the catchments, with little or no riparian vegetation apparent. This lack of drainage definition in the landscape is likely to be due to the presence of karstic limestone, with high infiltration capacities, which limits runoff. Further downstream near the coastline and in the vicinity of the proposed mine, plant and port facilities, the drainage lines are well defined with riparian vegetation apparent in the available aerial photography.

Flora communities are concentrated near the springs where surface water flows occur all year. The vegetation includes breadfruit and rainforest trees.

The following summary of terrestrial flora species was taken from the Vegetation and Fauna Survey (Trainor & Easton, 2015).

4.2.1 Plant and Jetty Sites

The Jetty Site is a heavily modified plantation environment with very low biological diversity. The site is not considered representative of a pristine coastal/beach forest and no plant species listed by the International Union for Conservation of Nature (IUCN) were found.

Closed Canopy Tropical Forest is located along streams and drainage lines in the proposed plant site area, with the remaining areas dominated by very open savannah woodland which has been extensively modified for agriculture and grazing in places. *Intsia bijuga* (Borneo Teak), which was present at survey site P002 (Plate 4-1) in a local topographic depression at the Plant Site, is listed as Vulnerable by the International Union for Conservation of Nature (IUCN) Red List.

The Tropical Forest vegetation located along streams and drainage lines in the proposed Jetty and Plant areas is an important environmental receptor which needs to be protected.

Plate 4-1: *Intsia bijuga* (Borneo Teak) at survey site P002 (207981 E, 9064378 S, Z52L).

4.2.2 Mine Site

The mine site is dominated by uniform woodland to open woodland with isolated small patches of Closed Tropical Forest occurring along streams and drainage lines in ravines and gullies.

There is approximately 10% canopy cover in the woodland areas and significant weeds and degradation from grazing. The Closed Tropical Forest has canopy cover in excess of 70% and exhibited the greatest species richness of all sites surveyed.

Santalum album was present at survey site MI03-001 (208405 E, 9063108 S, Z52L) in the Closed Tropical Forest along a drainage line. It also is listed as Vulnerable on the International Union for Conservation of Nature (IUCN) Red List. The Tropical Forest vegetation located along streams and drainage lines at the Mine Site is an important environmental receptor which needs to be protected.

Plate 4-2: *Santalum album* (MI03-001) associated with the Closed Tropical Forest Area at the Mine Site (208405 E, 9063108 S, Z52L).

4.3 Terrestrial Fauna

Terrestrial fauna communities that are dependent on ephemeral surface water flows in streams and drainage lines are surface water receptors potentially at risk from the proposed developments. The mine, plant and port developments should be designed with surface water management measures in place to minimise adverse impacts on the quantity and quality of surface water which flows to existing streams and drainage lines.

The following summary of terrestrial fauna species was taken from the Vegetation and Fauna Survey (Trainor & Easton, 2015).

4.3.1 Plant and Jetty Sites

The fauna survey identified several species of bats at the Jetty Site as well as a few bird species. The site was characterized as having low to moderate fauna habitat quality because of extensive disturbance to natural vegetation.

The Plant Site consists of predominantly of open woodland with a grassy or weedy ground cover. It is generally under high grazing pressure with large flocks of sheep and free range horses. Overall it provides relatively low to moderate fauna habitat quality because it lacks Closed Tropical Forest, has limited vegetation structure, has limited canopy cover and an absence of sharp topographic relief, cliffs, caves, logs and leaf litter.

The only globally near threatened species recorded at the Plant site was the Cinnamon-banded Kingfisher (*Halcyon australasia*) which is generally considered a Closed Tropical Forest specialist found predominately along drainage lines.

The fauna survey that was conducted suggests that the fauna communities associated with the Closed Tropical Forest vegetation are important environmental receptors which need to be protected in the proposed Jetty and Plant areas.

4.3.2 Mine Site

The Mine site has a typical woodland-open country fauna comprising mostly introduced or tramp amphibian and reptile species. Five insectivorous bat species and the introduced Black-spined Toad were recorded, as well as several open woodland and tropical forest bird species.

Five of the six near threatened birds recorded during the surveys were recorded on the Mine and in total 14 globally restricted-range species were recorded. The Cinnamon-banded Kingfisher, Timor Oriole *(Oriolus melanotis*) and Timor Figbird (*Sphecotheres viridis)* are typically considered as forest specialist bird species and are therefore associated with the Tropical Forest vegetation on drainage lines. These species are therefore important environmental receptors which need to be protected in the Mine area.

4.4 Marine Flora and Fauna

Marine flora and fauna species potentially could be adversely impacted by contaminated runoff from the proposed port, plant and mine development areas. The mine, plant and port developments therefore should be designed with surface water management measures in place to minimise adverse impacts on the quality of surface water flows discharging from streams and drainage lines to the ocean.

5 Potential Surface Water Impacts and Mitigation Measures

The potential surface water impacts associated with the proposed plant, jetty and mine developments have been identified with reference to project infrastructure layouts, process flow diagrams as well as the Environmental Guidelines for the Concrete Batching Industry (EPA, 1998) and Western Australian Water in Mining Guideline published by the Department of Water (DoW, 2013).

5.1 Common Impacts and Mitigation Measures

Table 5-1 presents the potential impacts are common to the proposed plant, jetty and mine sites. Mitigation measures are also presented to manage surface water risks and minimise impacts on the environmental receptors identified in Section 4.

Table 5-1: Potential impacts and mitigation measures common to all areas

Potential Impact	Mitigation Measure
Modification and interruption of the existing hydrological regime. This may be caused by: ▪ Blocking of natural drainage lines and creation of ponded areas upstream of development areas with water "shadows" downstream; ▪ Increase or reduction in rainfall-runoff from development areas due to changes in impervious fraction or from changes to surface interception and infiltration characteristics; ▪ Changes to the natural flow frequency and volumes in streams and drainage lines; and ▪ Alteration of recharge rates which sustain the natural springs providing potable water to local communities.	Installation of culvert and/or floodway waterway crossings along access/haul roads to maintain flow paths. Diversions are to be redirected back into the same watercourse downstream where possible to minimize impacts on the hydrological regime. Runoff from disturbed areas is to be managed using drainage systems to minimize impacts on the hydrological regime and recharge to aquifers. Incorporate detention/sedimentation basins into the drainage design if/as required and allow for discharge of treated runoff back to natural watercourses.
Erosion of exposed surfaces by wind, water and construction activities generating increase sediment loads in surface runoff flows discharging to downstream. The potential impacts of increased sediment load in the runoff include sedimentation within vegetated areas, springs, pools, marine environments and other sensitive ecological areas. It also increases turbidity which can reduce the amount of light entering an aquatic	Divert floodwater from undisturbed catchment areas around mine and plant sites to prevent mixing with runoff from disturbed areas, and to protect the infrastructure from flooding during extreme rainfall events. Capture direct rainfall runoff from disturbed areas (cleared areas, stockpiles, waste dumps etc) in drainage systems and direct it to sedimentation ponds to remove suspended sediment prior to discharge to the

Potential Impact	Mitigation Measure
environment which affects the rate of photosynthesis by plants and reduces the visibility of aquatic organisms. In addition, turbidity can clog fish gills, smother aquatic flora and fauna and adversely impact on the general amenity of an area. The potable water supplies used by local communities (springs and streams) also could be adversely affected by sedimentation and increased turbidity.	environment. This will prevent direct discharge of suspended sediment loads into the environment. Sedimentation ponds should be designed to capture sediment particles greater than or equal to 75µm (fine sand/silt) prior to discharging the treated water into the downstream environment.
Mobilisation of hydrocarbons in surface water runoff from site, particularly during rainfall events, which has the potential to contaminate watercourses, springs (water supplies) and marine environments. Potential spillage or discharge of hydrocarbons stored, handled or transported on site is a significant risk to surface water quality during all phases of the project. Transport, storage and handling of hydrocarbons must be carefully managed.	Management plans will be developed to contain contamination at source, to remediate spills, to control dust and erosion and to protect flora and fauna. During both construction and operations, care must be taken to minimise generation of contaminants and to restrict transport to groundwater and surface waterway systems. Hydrocarbons will be managed to avoid leaks and spills. Fuel handling areas will be bunded to capture any spills for remediation and will be located outside of floodplains and karst limestone areas and appropriately elevated to avoid the risk of flood inundation. Bunded areas must be capable of containing the combined volume of runoff from a 20 year ARI 72 hour duration design flood event and 110% of the tank contents in accordance with the DoW Water Quality Protection Guidelines (2000). Stormwater runoff from workshop pavements, fuel unloading and storage areas and from vehicle washdown areas shall be directed to grit and oil interceptors to remove pollutants prior to discharge of the water. Accidental spills outside controlled areas must be appropriately remediated to avoid contamination of groundwater or surface waters.
Generation of Acid Sulfate Soils (ASS) which can lower surface water pH levels and impact on environmental receptors.	It is understood that the risk of Acid Mine Drainage is low as no acid forming material has been encountered (Holtec Consulting, 2015). Therefore there are no apparent potential impacts associated with the formation of AMD.

Potential Impact	Mitigation Measure
	More detailed geochemical characterisation of the materials is needed to confirm AMD potential.

5.2 Plant and Jetty Sites

The site specific surface water risks at the Plant and Jetty areas are presented in Table 5-2 along with the mitigation measures to minimise impacts to the environmental receptors identified in Section 4.

Table 5-2: Potential impacts and mitigation measures specific to the Plant and Jetty area

Potential Impact	Mitigation Measure
The proposed plant site intersects 3 significant ephemeral drainage lines/streams (Figure 3-8 and Figure 3-9). These watercourses pose a potential flood risk to the plant area. There is also a risk that uncontrolled streamflow through the plant site could scour the site, mobilise suspended sediment which could discharge into watercourses downstream and impact on environmental receptors.	The 2 diversion routes presented in Figure 5-1 are recommended for the plant site to: ▪ Direct clean runoff from undisturbed catchment areas around the plant site and to prevent mixing with runoff from disturbed areas and stockpiles; ▪ Protect the plant infrastructure from flooding during extreme rainfall events. It is recommended that the diversions are designed to protect the plant site from flooding during the 100 year ARI event. A concept design for diversion drains and bunds is provided in Figure 5-2. Rock protection is to be included in the diversion design where velocities are high to prevent scour, erosion and sedimentation downstream. Diversions designs should not increase flood risk to local communities. No surface water mitigation measures are required for the conveyor as it is raised and covered so will not impede surface water flows or impact on water quality.
An increased volume of runoff is expected from the plant site area due to: ▪ Clearing and compaction; ▪ Paving of some areas; ▪ Roof areas on site buildings. This increased runoff has the potential to impact on the volume and frequency of flows to	As the plant site area (0.82 km^2) is only 2.8% of the total catchment area (29.2 km^2) contributing flow to the outlet at the coast, the impact of the additional runoff from the plant site on the hydrological flow regime is considered negligible. This is supported by rainfall runoff calculations in Section 6.

Potential Impact	Mitigation Measure
watercourses.	
Access and haul roads within the mine site have the potential to block surface water flows which could impact on the downstream hydrology and associated environmental receptors.	Installation of culvert and/or floodway waterway crossings along access/haul roads to maintain flows. Rock protection included in the design where velocities are expected to be high to prevent scour, erosion and sedimentation downstream.
Direct rainfall runoff from the plant, stockpiles and other disturbed areas may contain suspended sediment/material which could discharge into watercourses downstream and impact on environmental receptors.	Capture direct rainfall runoff from disturbed areas (plant working areas, cleared areas, stockpiles, etc) using internal drains and perimeter and direct it to sedimentation ponds to remove suspended sediment prior to discharge to the environment. This will prevent direct discharge of suspended sediment loads into the environment.
The jetty is raised so will not impede surface water flows. The transfer of material to/from vessels to the jetty has the potential to result in accumulation of sediment on the jetty, which could discharge to the marine environment during rainfall events.	The conveyor transporting clinker to vessels is covered to prevent deposition of sediment on the jetty. Material handling on the jetty should be performed using methods to prevent accumulation of sediment on the jetty. If there are any areas at risk of accumulating significant volumes of sediment, then surface water drainage on the jetty should be designed to direct runoff to sumps to remove sediment prior to discharge to the environment (only if required).
Potential impact of plant site development on surface water flows and surface water recharge to Uaimatabai and Uaisa Springs.	The proposed diversion routes do not impact on the watercourses flowing into the Uaimatabai and Uaisa Springs which are important sources of potable water supply for local villages. The plant and jetty sites are downstream of these springs so do not discharge to the spring areas and therefore do not pose a risk to the water quality at the springs. Recharge to the springs is from regional rainfall recharge to the karst Baucau Limestone over extensive catchment areas (Furness, 2015). The diversion of minor drainage lines in

Potential Impact	Mitigation Measure
	the plant area is not expected to impact on regional recharge maintaining the spring flows (personal communication Furness, 2015).
Potential discharge of hydrocarbons off site to downstream environmental receptors.	Implementation of the mitigation measures presented in Table 5-1 to minimise impacts.

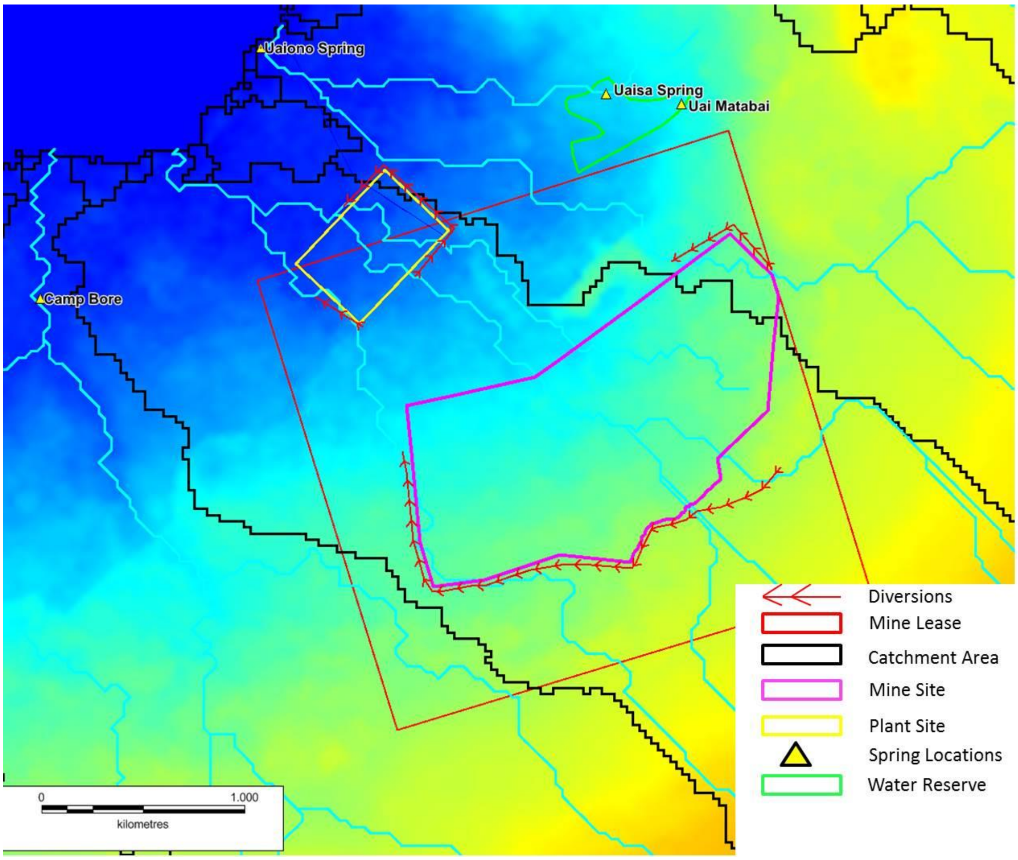


Figure 5-1: Location of conceptual mine pit and plant diversions

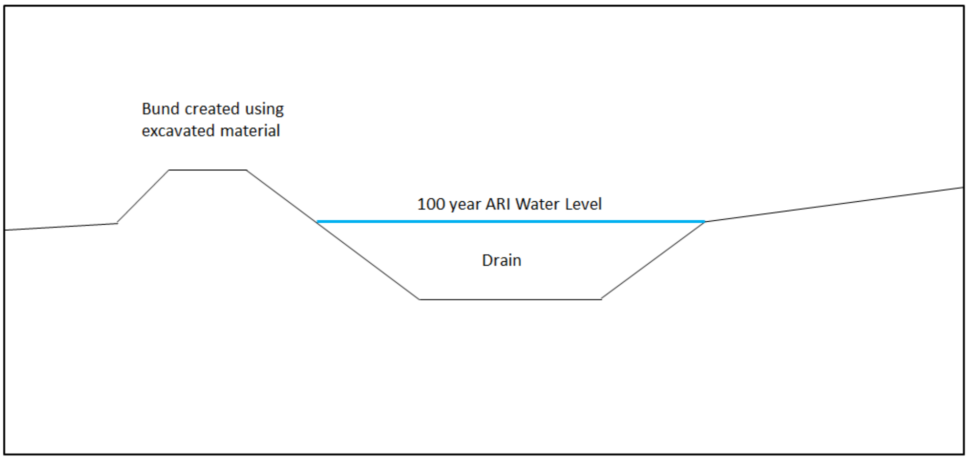


Figure 5-2: Conceptual design for diversions (drain and bund)

5.3 Mine Site

The site specific surface water risks at the Mine site are presented in Table 5-2 along with the mitigation measures to minimise impacts to the environmental receptors identified in Section 4.

Table 5-3: Potential impacts and mitigation measures specific to the Mine area

Potential Impact	Mitigation Measure
The proposed mine pit boundary intersects 4 significant ephemeral drainage lines/streams (Figure 3-8 and Figure 3-9). These watercourses pose a potential flood risk to the mine pit. There is also a risk that uncontrolled streamflow through the mine pit area could scour the site, mobilise suspended sediment which could discharge into watercourses downstream and impact on environmental receptors.	The 2 diversion routes presented in Figure 5-1 are recommended for the mine pit to: ▪ Direct clean runoff from undisturbed catchment areas around the pit and to prevent mixing with runoff from disturbed areas; ▪ Protect the pit from flooding during extreme rainfall events. It is recommended that the diversions are designed to protect the pit from flooding during the 100 year ARI event. A concept design for diversion drains and bunds is provided in Figure 5-2. Rock protection is to be included in the diversion design where velocities are high to prevent scour, erosion and sedimentation downstream. Diversions designs should not increase flood risk to local communities.

Potential Impact	Mitigation Measure
A reduction in the volume of runoff is expected from the pit area as all direct rainfall runoff will be captured in the pit, where it will be either recharged to groundwater or reused on site for mining and dust suppression activities. This reduction in runoff has the potential to impact on the volume and frequency of flows to watercourses downstream.	As the mine pit area (1.8 km^2) is only 6.0% of the total contributing catchment area (29.2 km^2), the impact of the mine pit on the total runoff from the catchment and hydrological flow regime is considered negligible. This is supported by rainfall runoff calculations in Section 6. Runoff during extreme rainfall events may be pumped from sumps in the pits to sedimentation ponds for removal of suspended sediments prior to discharge to the environment to maintain flows in downstream watercourses.
Mine access and haul roads have the potential to block surface water flows which could impact on the downstream hydrology and associated environmental receptors.	Installation of culvert and/or floodway waterway crossings along mine access/haul roads to maintain flows. Rock protection included in the design where velocities are expected to be high to prevent scour, erosion and sedimentation downstream.
Discharge of rainfall runoff containing suspended sediment/material from waste dumps, stockpiles and other disturbed areas to watercourses downstream. This sediment may build up in watercourses and impact on environmental receptors. Potential for watercourses to flood and scour waste dumps which can also lead to sedimentation of watercourses.	Capture direct rainfall runoff from these areas using internal drains and perimeter bunds and direct it to sedimentation ponds to remove suspended sediment prior to discharge to the environment. This will prevent direct discharge of suspended sediment loads into the environment. Divert clean runoff in watercourses and drainage lines around waste dumps using diversions (Figure 5-2).
Potential impact of mining activities on surface water flows and surface water recharge to Uaimatabai and Uaisa Springs.	The mining activities do not impact the catchments providing surface water flows to the Uaimatabai and Uaisa Springs. Recharge to the springs is from regional rainfall recharge to the karst Baucau Limestone over extensive catchment areas (Furness, 2015). The diversion of minor drainage lines and capture of small volumes of rainfall in pits is not expected to impact on regional recharge maintaining the spring flows (personal communication Furness, 2015).

Potential Impact	Mitigation Measure
Potential discharge of hydrocarbons off site to downstream environmental receptors. Previous hydrogeological assessments (Furness, 2015) suggest that the presence of highly transmissive karst features may provide some hydraulic connection between the mine pit and the Uaimatabai and Uaisa Springs. Accidental spillage of hydrocarbons in the pit poses a significant risk to the water quality as this may be rapidly transported in surface water flow and recharge during rainfall events.	Implementation of the mitigation measures presented in Table 5-1 to minimise potential impacts.

6 Catchment Yield Analysis

The hydrology of the study area was modelled using SWMM modelling software to simulate daily runoff under the following scenarios:

- **Pre-Development Scenario:** Representing existing conditions;
- **Operational Scenario:** Based on ultimate mine plan and with all project infrastructure and diversions in place. The location of diversions is shown in Figure 5-1. This assessment will evaluate the impacts of the plant & jetty and the mine site separately as well as a combined impact assessment; and
- **Closure Scenario:** With the site rehabilitated in accordance with the Mine Closure Plan developed by Holtec (2015). The closure scenario assumes that the plant site is rehabilitated and of the total mine pit area (1.82km^2):
  - 1.33 km^2 will be backfilled;
  - 0.38km^2 will be left as a water reservoir (surface water runoff capture area); and
  - 0.11km^2 will comprise rehabilitated benches.

The model calculates rainfall runoff for delineated catchment areas and routes the runoff through the drainage network. The software can account for storage effects, infiltration losses based on soil type and is able to estimate runoff from both pervious and impervious areas.

Without the availability of appropriate calibration data however, the models have been set up using typical values for the principal hydrologic loss parameters and using anecdotal evidence of catchment response to rainfall (personal communication L. Furness, 2015). The results presented are intended to focus on the differential effects on surface water flows expected to be produced by the proposed developments rather than absolute values for flow and volume.

6.1 Model Inputs

6.1.1 Catchment Parameters

Topographic contour data and mine, plant, mine and other infrastructure layouts were used to delineate catchment areas and mainstream lengths for each scenario (Figure 3-7). The effects of the jetty were not included as the construction of the jetty and conveyor is not expected to impact on surface water flows. The impacts of each model scenario were evaluated by assessing the estimated total daily flows at the downstream end of the catchment where it discharges into the ocean.

For the plant site area, an equivalent impervious fraction of 90% was assumed to account for areas that have been cleared and compacted, for roof areas and for areas that are paved. The remaining parts of the catchment also contain significant areas of outcropping limestone, so an impervious fraction of 15% was assumed across the catchment and this runoff routed through the pervious karst limestone areas.

Infiltration losses were applied to all remaining pervious areas using the Green Ampt Method with representative soil parameters adopted as shown in Table 6-2. The soils are predominantly shallow limestone soils, so the equivalent SWMM soil type adopted for simulations was Sandy

Clay Loam. An initial loss (depression storage) of 10mm was applied to pervious areas and 5mm to impervious plant site areas.

The catchment characteristics for each of the scenarios are listed in Table 6-1.

Table 6-1: Catchment characteristics adopted for model scenarios

Sub-Catchment Description	Contributing Catchment Area (km^2)	Mainstream Length (km)	Catchment Slope (%)	Percent Impervious
Scenario: Existing Conditions				
Main catchment	29.2	17.2	4.2%	15%
Scenario: Operations – Mine				
Main catchment	27.4	18.8 *	3.9%	15%
Pit area	1.8	-	-	No runoff as direct rainfall is intercepted by pit
Scenario: Operations – Plant				
Main catchment	28.9	18.3 *	4.0%	15%
Plant site area	0.30	0.5	5.0%	90%
Scenario: Operations –Plant and Mine				
Main catchment	27.1	19.0 *	3.9%	15%
Plant site area	0.30	0.5	5.0%	90%
Pit area	1.8	-	-	No runoff as direct rainfall is intercepted by pit
Scenario: Closure				
Main catchment	28.8	18.8 *	3.9%	15%
Water reservoir	0.4	-	-	No runoff as direct rainfall is intercepted by reservoir

* Slight increase in mainstream length due to diversions.

Table 6-2: Adopted Green-Ampt Infiltration parameters (SWMM Runoff Variables)

Soil Type Equivalent *	Average Capillary Suction (mm)	Saturated Hydraulic Conductivity (mm/hr)	Initial Moisture Deficit
Sandy Clay Loam	218.5	3.0	0.250

* Soil types selected from available list in SWMM

6.1.2 Daily Rainfall Data

Daily rainfall recorded between April 2010 and March 2014 at the Baucau Meteorological Observatory in East Timor (Section 3.1) was used as input into the model. Each daily rainfall total was distributed uniformly over a nominal 6 hour period in each day (ie. Each daily rainfall total was assumed to fall within a 6-hour period).

It is recommended that a pluviometer rainfall gauge is installed on site to collect rainfall at 5 minute intervals to improve the accuracy of rainfall data and runoff estimates.

6.2 Results

SWMM modelling was completed for each of the scenarios presented in Table 6-1. The SWMM model results were used to estimate the runoff coefficients over the 5 year simulation period. The average runoff coefficients presented in Table 6-3 show the average simulated runoff coefficient was approximately 1% for all scenarios. The total number of simulated daily flow events greater than 1 m^3/day is also provided. The runoff coefficients and number of flow events was considered reasonable for comparison of relative runoff for each scenario and consistent with the anecdotal evidence of rainfall response. Modelling predicts that only 10% of the rainfall events generated any streamflow over the 5 year period with the remaining events completely infiltrated to the karst limestone (ignoring daily runoff less than 1m^3).

Additional groundwater, rainfall and streamflow monitoring data are needed at the site to confirm the runoff coefficients, catchment yields and recharge to the aquifer.

Table 6-3: Estimated runoff coefficients over the 5 year modelled period

Scenario	Average Runoff Coefficient (%)	Number of Flow Events *
Existing Conditions	0.8%	66
Operations – Mine	0.8%	66
Operations – Plant	0.9%	70
Operations – Plant and Mine	0.9%	70
Closure	0.8%	66

* The total number of rainfall days over the simulation period was 650

The results of SWMM modelling for the scenarios listed in Table 6-1 were used to generate total daily flow frequency plots in Figure 6-1, to allow direct comparison of flow statistics. The plots present the exceedance probabilities for total daily runoff volumes (m^3) at the SWMM catchment outlet for each scenario.

The results show the proposed mine and plant developments have little effect on the frequency and magnitude of streamflow events for all scenarios. This is due to the impacted areas at the mine and plant sites (1.8km^2 and 0.3km^2 respectively) comprising only a small proportion of the total catchment area (29.2km^2).

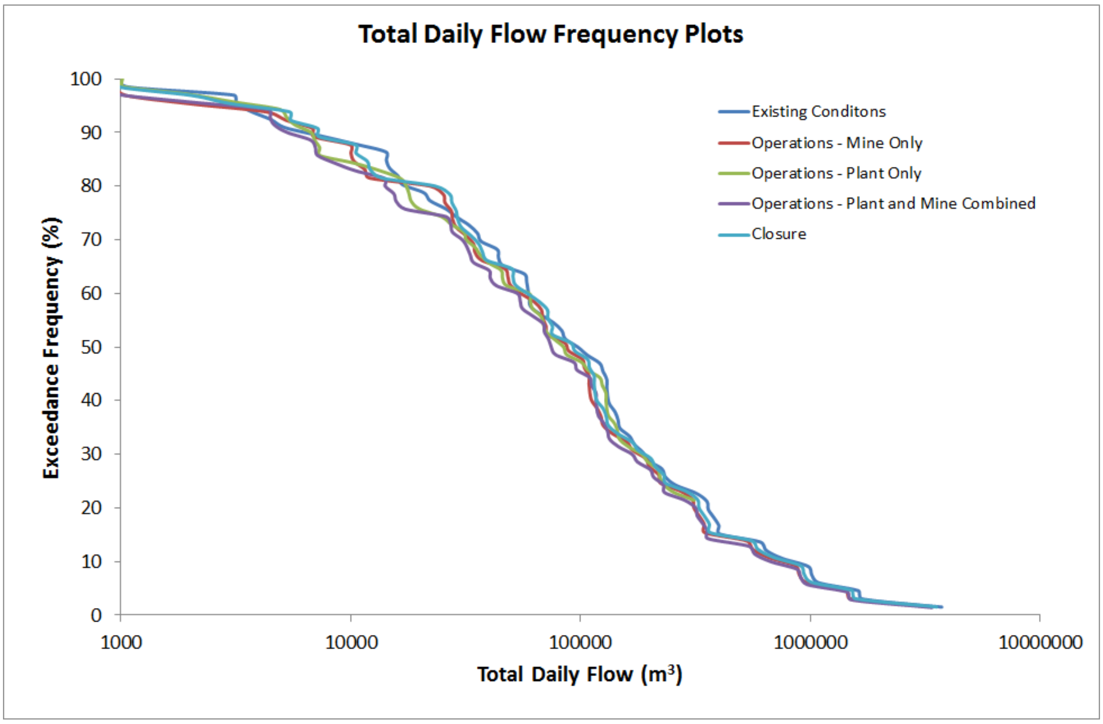


Figure 6-1: Total Daily Flow Frequency Plots: SWMM modelling (April 2010 - March 2014)

7 Conclusions and Recommendations

The results of this surface water assessment suggest the proposed developments associated with the Baucau Cement Project are not expected to have a significant impact on the quantity and quality of streamflow or on the associated environmental receptors in the study area subject to the recommended surface water management measures being put in place.

Areas of social and ecological value that are dependent on runoff, such as the springs used for public water supply, Closed Tropical Forest vegetation identified along watercourses and drainage lines and the associated fauna species will be protected by implementing the surface water management measures outlined in this report. These measures are intended to reduce the risk of changes to the flow regimes and water quality in the local watercourses as a result of the proposed development.

SWMM hydrological modelling of the proposed development area was conducted using 5 years of daily rainfall data. The model was used to generate total daily flow frequency plots for existing, operational and closure scenarios. The results show the proposed mine and plant developments have negligible effect on the frequency and magnitude of streamflow events for all scenarios. This is due to the mitigating effects of the runoff management measures proposed and the relatively small proportion of the total catchment area that is impacted by the proposed development.

The proposed diversion routes around mine and plant infrastructure do not impact on the watercourses flowing into the Uaimatabai and Uaisa Springs which are important sources of potable water supply for local villages. Surface water quality management measures are also presented in this report to minimise the risk of potential contamination of spring water from surface water flows off plant and mine sites.

Although the presence of highly permeable karst limestone limits the volume of rainfall-runoff generated in the catchments areas, there is still some risk of flash flooding during extreme rainfall events. Therefore diversion drains and bunds are proposed in this report to divert floodwater around mine and plant areas. Further hydrological investigations are needed to design diversions, internal drainage systems and culvert-floodway crossings in the mine and plant areas.

The jetty and conveyors are raised so will not impede surface water flows. The conveyors are covered to prevent runoff from cement clinker while being transported to the jetty to minimise impacts on surface water quality.

Monitoring of surface water flows and water quality in watercourses and drainage lines is recommended to establish baseline conditions and for compliance monitoring. It is recommended that a pluviometer rainfall gauge is installed in the catchment as well as water level loggers in watercourses to collect rainfall and streamflow data at sub-daily increments to improve the accuracy of rainfall data and runoff estimates. This data can also be compared with water level logger data in groundwater bores and at springs to improve the understanding of surface-groundwater recharge to the springs.

8 References

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Appendix 4 Preliminary Groundwater Study

WorleyParsons Consulting

TL Cement

TL CEMENT, LDA

Baucau Cement Project

Preliminary Groundwater Study

301012-02135-EN-REP-0004

7 January 2016

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PRELIMINARY GROUNDWATER STUDY

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PROJECT 301012-02135 - BAUCAU CEMENT PROJECT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
0	Issued for Use	L Furness	L Siraz	D Hunter	7-Jan-16		

CONTENTS

Appendices

1. INTRODUCTION

The following report is an assessment of the impact of the proposed Cement Plant and Mine at Baucau, Timor-Leste on the groundwater resources of the Baucau region.

1.1 SCOPE OF WORK

The following scope of work was used as a basis for the study:

1.1.1 Desktop Review

A desktop review of existing hydrogeological and geological reports and data, including information obtained through consultation with the BESIK Rural Water Program manager. This shall include available drilling and borehole logs, pump testing and water quality data (and other data such as the recent airborne geophysics survey in the Baucau region).

1.1.2 In country meetings (data gathering)

Attend meetings with representatives from BESIK Rural Water Program (ie Craig McVeigh) the following people to identify and agree on the number and location of water supply bores that will be assumed as the basis for the ESIA (including construction and operational supplies at plant and mine sites):

Attend meetings with representatives from H2O drilling company to obtain knowledge of any historical/current groundwater drilling activities within the project study area and/or the Baucau region. Other stakeholders may be identified and consulted if applicable.

The results of the desktop hydrogeological assessment and meetings with drillers, client and BESIK Rural Water Program manager will be used to inform the development of a conceptual hydrogeological model for the study area.

A summary of all the collected groundwater information from this field investigation is contained in Appendix 3 - .

1.1.3 Site visit

A site reconnaissance / walkover to understand location(s) of proposed infrastructure, potential groundwater sources and to generally get an appreciation of the land formation and probable geo hydrology of the site;

If available, collection of groundwater quality samples.

1.1.4 Impact Assessment

A qualitative assessment of the potential impacts associated with abstraction of groundwater from bores to meet the project water demands will be undertaken. The impact assessment will be based on estimates of drawdown using empirical equations and development of a conceptual hydrogeological model.

The Hydrogeological Impact Assessment report will contain the applied methodology, results of the qualitative impact assessment (including characterization of site hydrogeology) and will also include a groundwater management plan developed for the Project. The report will also have site photos and any applicable maps and figures.

1.2 PROPOSED DEVELOPMENT

According to the Timor-Leste Cement Plant Overview presentation TL CemA a subsidiary of BGC Australia proposed to produce 1.5 million Tons/Year (MTPY) comprising 1.0 MTPY of Clinker bulk and 1.5MTPY Cement for Timor-Leste domestic supply at Baucau. The location of the Plant and Mine areas is shown in Figure 1.

Figure 1 Location of Cement Plant and Mine Facilities

Stage 1 of the site development comprises a new port, industrial complex, cement plant and Mine 1 areas.

The make-up water demand for the operation will be:

Table 1 Daily Consumption of Water

Component	Water Consumption Megalitres/day (Ml/d)
Cement Plant	1.4
Drinking and Sanitation	0.35
Mines and Greenbelt	0.1
Waste Heat Recovery	0.3
Captive Power Plant	1.0
TOTAL	3.15

The total daily make-up requirement is equivalent to 1.15 Gl/yr (Gigalitres per year) or 35 l/s (litres/second) continuous. The source of water has not been defined but could come from a combination of the following possible types:

Table 2 Potential Water Sources

Source	Features
Coastal Alluvium	Yields of 10-30 l/s and mostly salty, fresh in larger catchments
Karst Springs	Fresh water yield of 10 l/s used for irrigation and village water supply
Karst Limestone Aquifer	Large yields of (10-30 l/s) but requires investigation to locate well sites and to define impacts on springs.

Some small rivers flow through the area, mainly during the wet season and tend to stop flowing in the dry season and are not considered suitable as full time water sources. There are a number of coastal swamps containing fresh water from rain and groundwater discharge, but these dry up in the dry season.

1.3 GEOLOGY

The proposed cement plant, facilities and mine areas lie within the Baucau Limestone and some coastal alluvium, underlain by mostly Viqueque Formation and Bobonaro Clay. According to Audley- Charles (1968) the Baucau Limestone is a series of terraced reef limestones that crop out about the town of Baucau. The lithology is a hard, vuggy, cavernous, white coral-reef limestone that weathers to a pale grey colour. The top of the plateau is characterized by karst topography and dark reddish soil. Audley-Charles (1968) divided the formation into four distinct lithologies;

- Coral-reef limestones, insitu growths of coral and calcareous algae.
- Calcirudities, massive poorly bedded conglomerates, composed of reef debris cemented by micrite and sparry calcite.
- Calcarenites, interbeded with the insitu reefs and calcirudites comprised of sand grains of the fragments of corals.
- Submature greywache-pebbly sandstone. Poorly sorted gravels, sands and silts.

The thickness of the Baucau limestone has been identified from geophysics as reaching a maximum of about 80 metres on the plateau. Core drilling by Timor Cement on the flanks of the plateau indicate limestone thickness up to 100 metres. The highest elevation on the Baucau Plateau is about 730 metres, dropping down to about 330 metres at Baucau and then plunging down the escarpment to the sea.

The Baucau Limestone generally unconformably overlies the Viqueque Formtion (marine clay forming an impermeable basement) and is considered to have a maximum age of the Pleistocene (2,588,000 to 11,700 years ago). The limestone has terraces (raised beaches) that decrease in elevation to the present shore-line and therefore ranges from the lower Pleistocene to the Holocene (11,700 years to present).

Underlying the Baucau Limestone are the folded sediments of the Pliocene Viqueque Formation (5.33 million to 2.58 million years ago) comprising mainly white clay. There is evidence now from geophysics that volcanics may occur north of the Baucau Airport, and these may be blocks within the Bobonaro Clay.

The coastal alluvium is up to 60 metres thick and comprises of river alluvium from the major rivers in the area, interbeded with marine deposits from eroded coral and shells, and marine clay.

1.4 HYDROGEOLOGY

1.4.1 Baucau Limestone

The Baucau Limestone karst aquifer has been studied from 2004 to the present to identify the karst features that are likely to supply water to Baucau, New Baucau, the airport, Triloca and the Timor- Leste Cement Plant. It has been observed that the limestone has karst features of springs, caves, collapsed caves, sink holes, and sharp outcrop. A hydrogeological map of Timor-Leste was developed by Geoscience Australia (2010) from the geology map and ground-truthing and is shown in Figure 2. The Baucau Limestone is identified in the study area as the green karst limestone (fissured aquifer (karst) high yield).

Geoscience Australia carried out a review of the groundwater in Timor-Leste and the potential impact of climate change on groundwater resources.

Coastal alluvium is indicated in Figure 2 in dark blue and is located to the west of the proposed Baucau cement mine. In the west the karst is in contact with the coastal alluvium at low elevations and probably recharges the alluvium with discharge from concealed springs. However, on the plateau area the karst aquifer discharges through springs around the edge of its outcrop. This water may re-enter permeable alluvium downslope.

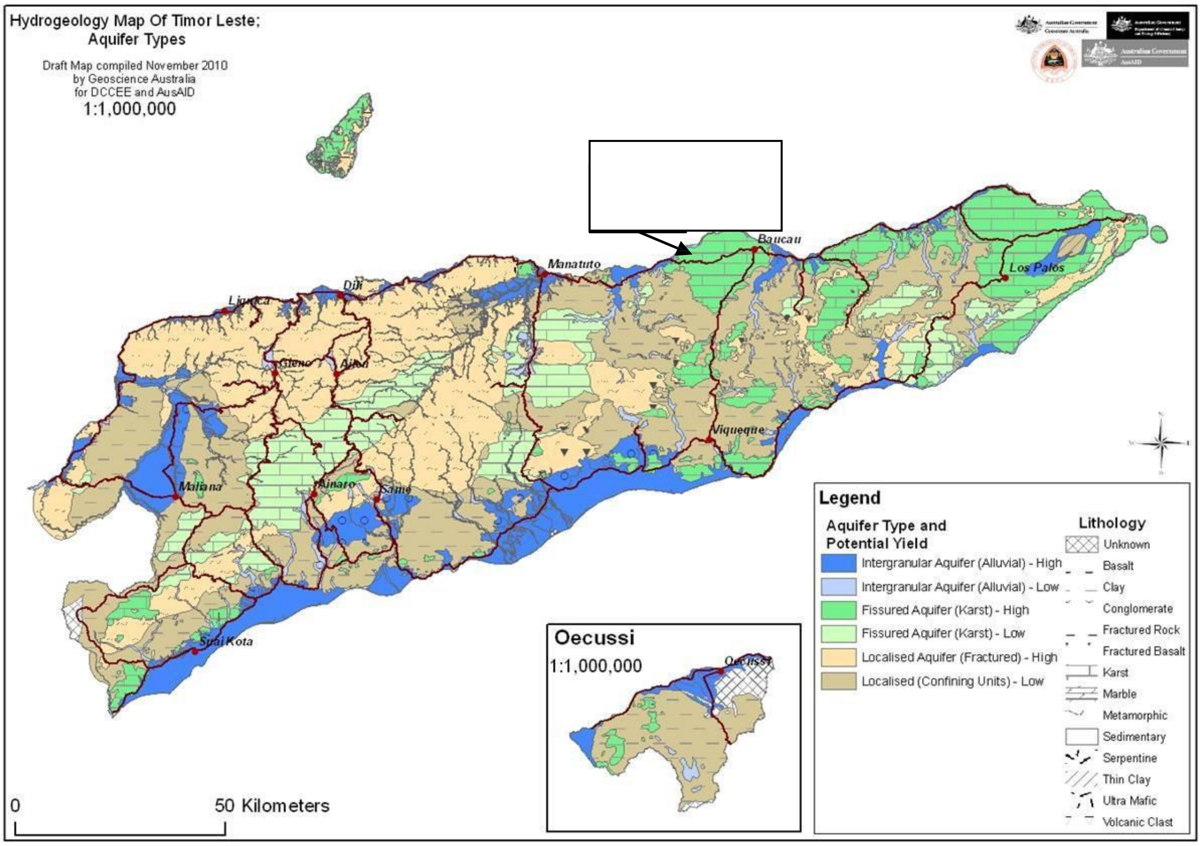

Figure 2 Hydrogeological Map of Timor-Leste (Geoscience Australia, 2010)

1.4.2 Karst Features of the Plateau

The main karst features of the Baucau Plateau includes springs (triangles) and caves (circles) shown on the following Figure 3.

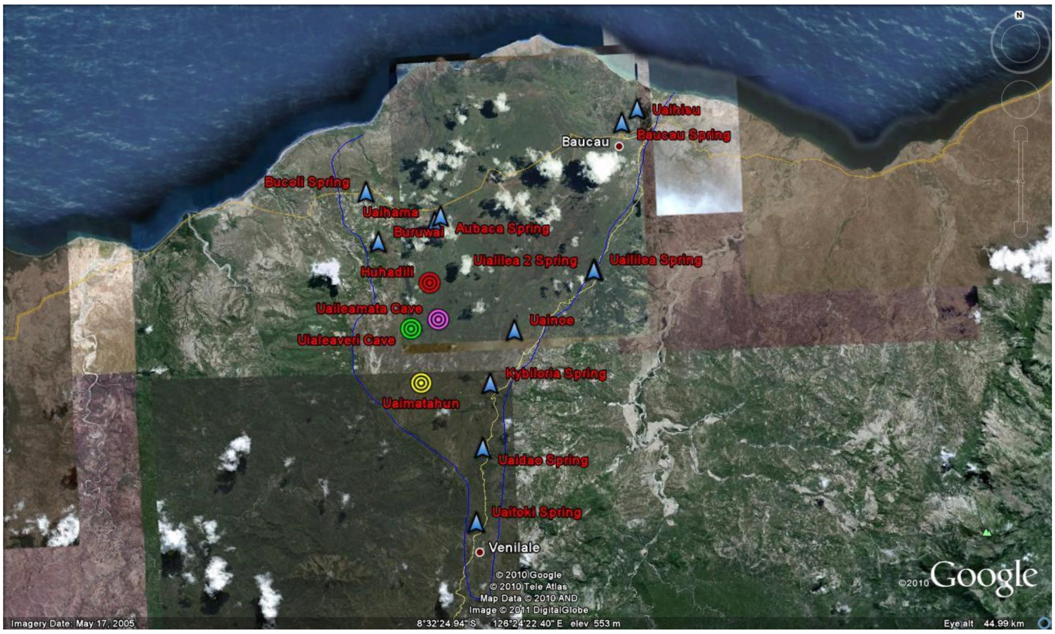

Figure 3 Karst Features of the Baucau Plateau (Furness, 2011, unpublished)

The two largest springs are Uaisarake and Uaililia (Figure 4 & Figure 5) on the eastern side of the plateau and produce 200 l/s and 50 l/s, respectively.

Figure 4 Uaisarake Spring in Baucau

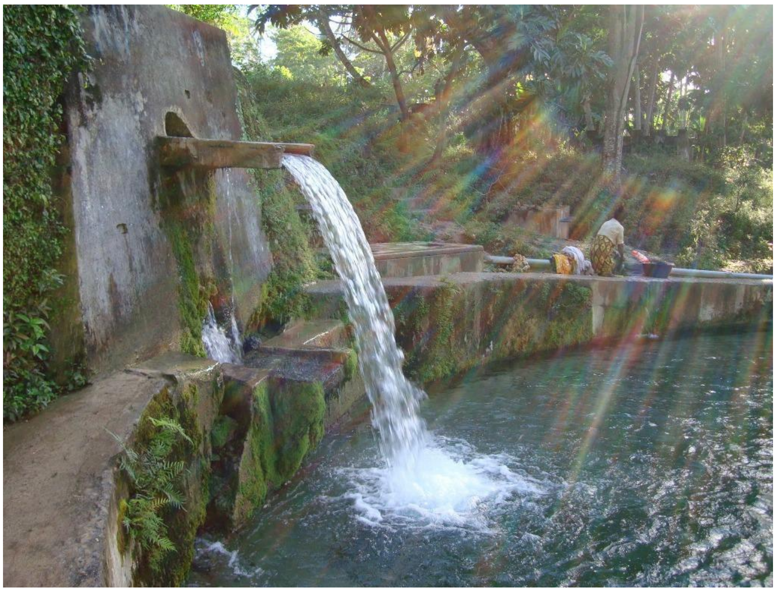

Figure 5 Uaililia Spring

1.5 Recharge, Flow and Discharge

The aquifer is recharged by infiltrating rainfall on the plateau during the wet season. The infiltration rate is very high (c.f. Jocson et al 2014) due to the exposed karst features and probably about 40% of the annual rainfall that varies from about 1,200 mm in Bacau (1956 – 1992) to 1,764 mm on the plateau (Venilale 1952 – 1974). Recharge has been observed by monitoring cumulative rainfall and cave river levels at Uaileaveri Cave. Recharge only takes an hour or two in a storm to infiltrate to the cave stream (about 6 metres (m) below ground level (mbgl)).

Discharge at the main spring in Baucau has been monitored over several years and has been observed that there is a delay of about 9 months between the wet season rainfall and peak flow of the spring. This observation supports the theory that the karst aquifer is bimodal in storage and transmission of water. Fast recharge and flow occurs through fractures and caves whereas very slow flow occurs in the low porosity of the limestone rock mass into the caves.

The flow of the Baucau plateau has been conceptualised based on observations of the elevations of the ground surface and the elevation of water in caves and springs. The general flow pattern of groundwater in the karst is from the high in the south-west to the low in the north-east at Baucau, but also there is lateral movement to the springs in the east and west of the plateau.

A dye tracing experiment was designed and performed (Furness 2011) to test which cave streams were connected to which spring discharges. Four different coloured fluorescent dyes were introduced on the same day to the Uaileaveri, Uaileamata, Huhadili and Uaimatahun caves in the central to upper plateau (Figure 6 & Figure 7). Monitoring for minute traces of dye was carried out on a weekly basis using activated carbon granules that adsorb dye in approximately 12 springs over a 3 month period.

Figure 6 Mixing Dye Powder at Uaimatahun Cave

Figure 7 Introducing Dye in Uaileaveri Cave

The results showed that Eocene dye (yellow) was traced from Uaimatahun cave to Uainoi spring with a travel time less than a week (4 km). Fluoroscene dye (green) in Uaileaveri cave passed through Uaileamata cave in less than a week (1 km) and travelled to Ualilea together with Rhodamine dye (pink) from that cave to Uaililea spring with peak concentration at 2 weeks (7 km). The Sulfrhodamine dye (red) mixed with cave water in the Huhadili cave did not show up in any of the monitored springs. None of the dyes arrived in the Baucau town spring over a 6 month period.

The dye tracing experiment was followed up with time domain EM surveying at Uaileamata Cave and Uaileaveri Cave by CSIRO. The results (Figure 8) show 3 distinct layers of dry limestone (dark blue) at the surface, then wet limestone (light blue) underlain by Clay (orange to red). The thickness of saturation is variable, but is thought to be mainly a thin layer at the base of the limestone.

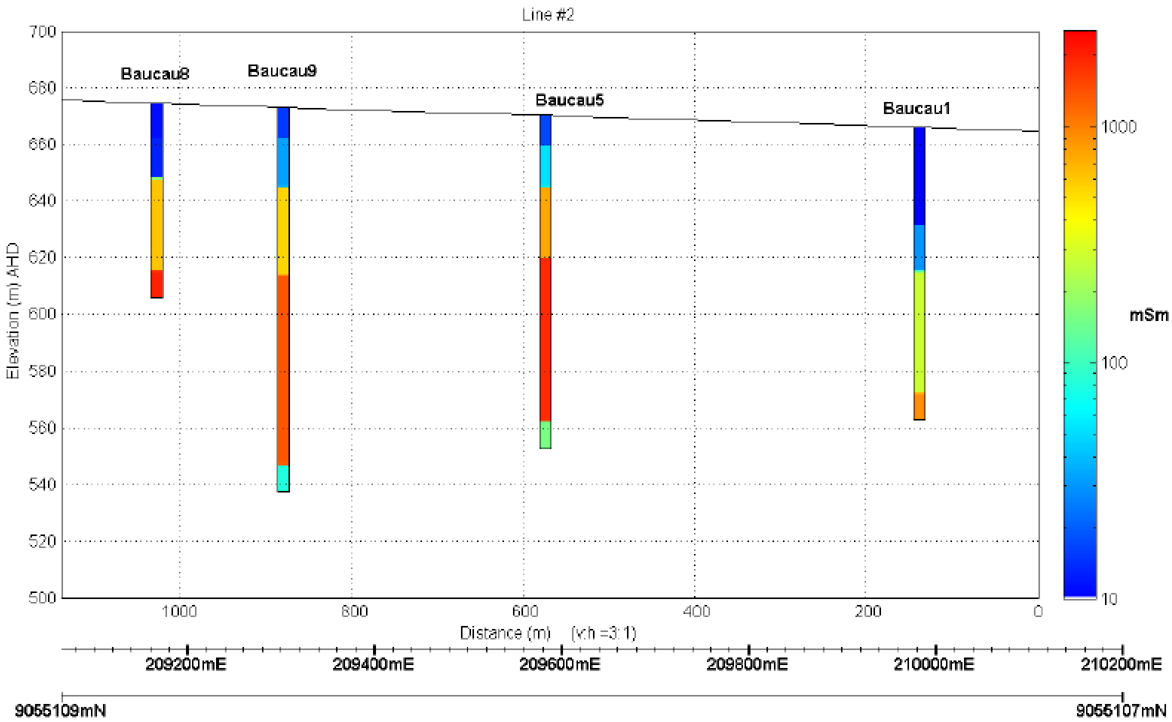

Figure 8 TEM survey results at Uaileaveri (Baucau 8) and Uaileamata (Baucau 1) Caves (CSIRO, 2012)

1.6 Airborne Geophysics

Based on the results of the dye tracing experiment (Furness 2011) and the TEM study (CSIRO 2012) at the caves, it was decided that an airborne geophysical survey of the Baucau Plateau might reveal the features of the karst aquifer and the flow lines of the main fractures and caves. The airborne geophysical study (Furness 2011, Fugro 2012) was planned due to the failure of a number of new bores to locate any water in the limestone around Baucau.

The survey plan included flight lines at 200 metre intervals along the main axis of the Baucau Plateau and extending to the edges of the plateau. The frequency domain electromagnetic method was chosen based on previous experience with the method. The approximate area surveyed by helicopter using the Fugro resolve equipment is shown in Figure 9.

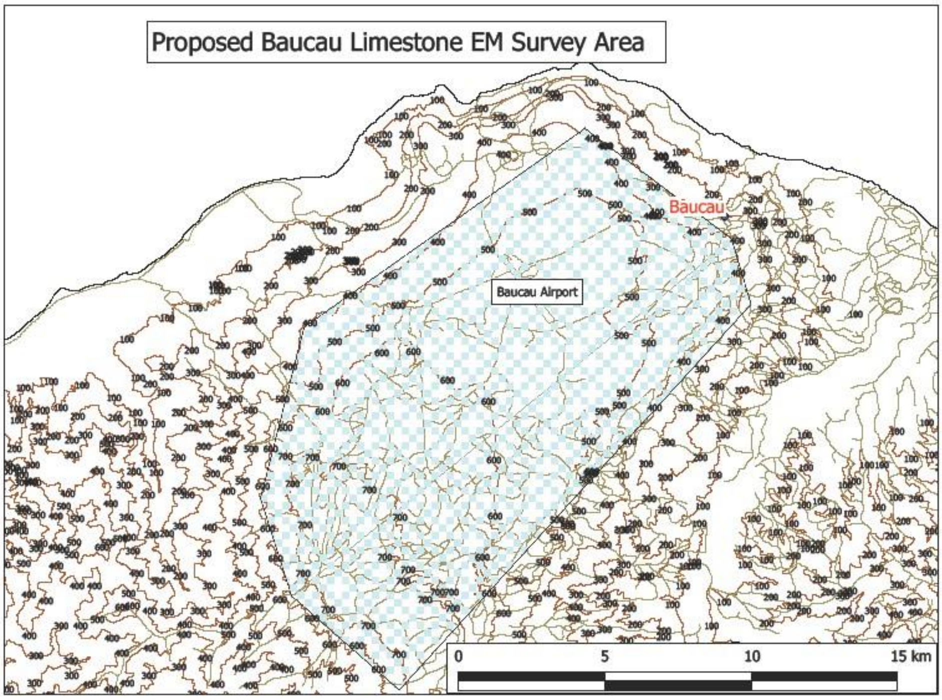

Figure 9 EM Survey Area

The survey lines were flown with the aircraft (Figure 10) at 60 metres above the surface and the survey instrument at 30 metres above the ground. The instrument carried coils that transmit at 6 different frequencies, and a magnetometer, while the aircraft contained a precision altimeter, navigation and recording equipment.

Figure 10 Aircraft and Instrument Pod

1.7 Geophysical Results

The data sampling rate of the survey was about every 4 metres along the flight paths with cross lines every 2 km to check on data integrity. Output from the survey include a precision digital elevation map, vertical and total magnetic fields, 6 frequencies of EM measuring resistivity at successively deeper intervals and a flight location video.

The EM data were inverted to produce a two layer model showing the isopachs of the Baucau Limestone and the elevation of the underlying Viqueque Formation. The results are presented below as a series of maps and cross sections.

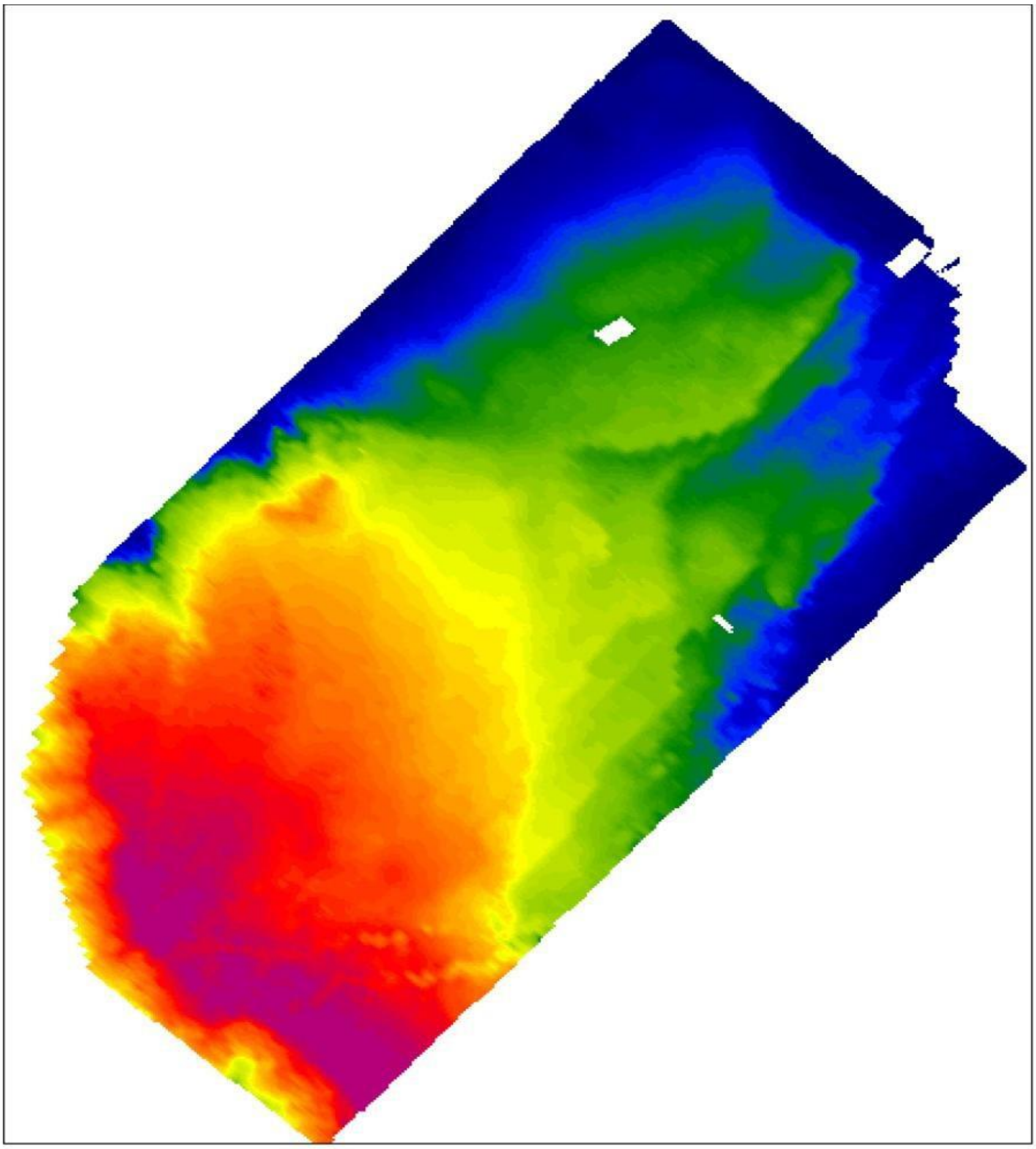

Figure 11 Laser Elevation Map (pink = 730m dark blue = 330m) (Fugro, 2012)

Figure 11 shows the topographic shape of the Baucau Plateau as a series of terraces from 330 m to 730 m elevation above sea level. In the south of the figure there are two collapsed caves (now canyons) in an east-west orientation.

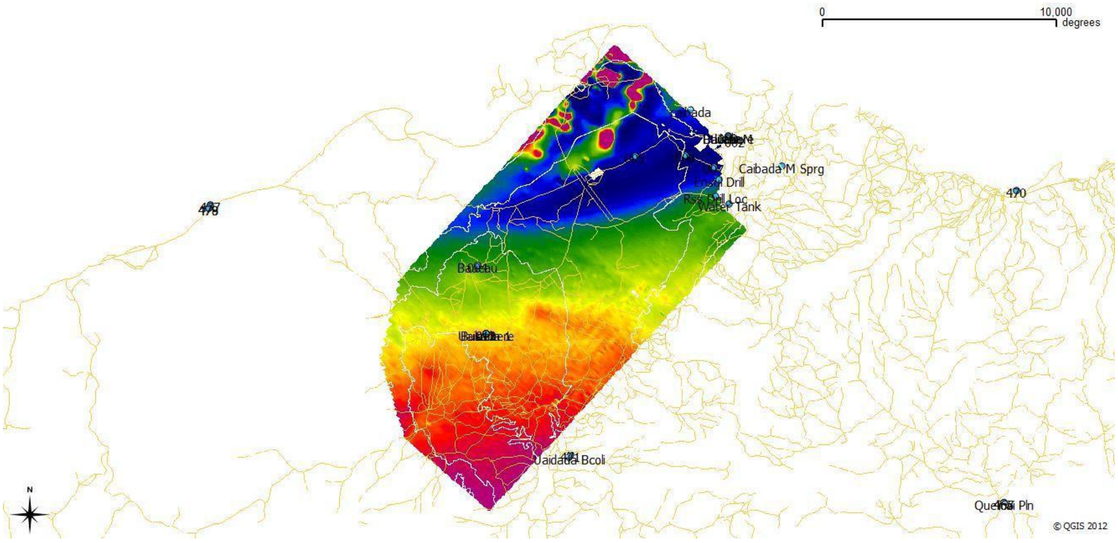

Figure 12 Magnetic Field indicating possible volcanic basement in north (Fugro, 2012)

The magnetic field (Figure 12) show zones of high magnetic contrast in the north that are interpreted to be a volcanic basement.

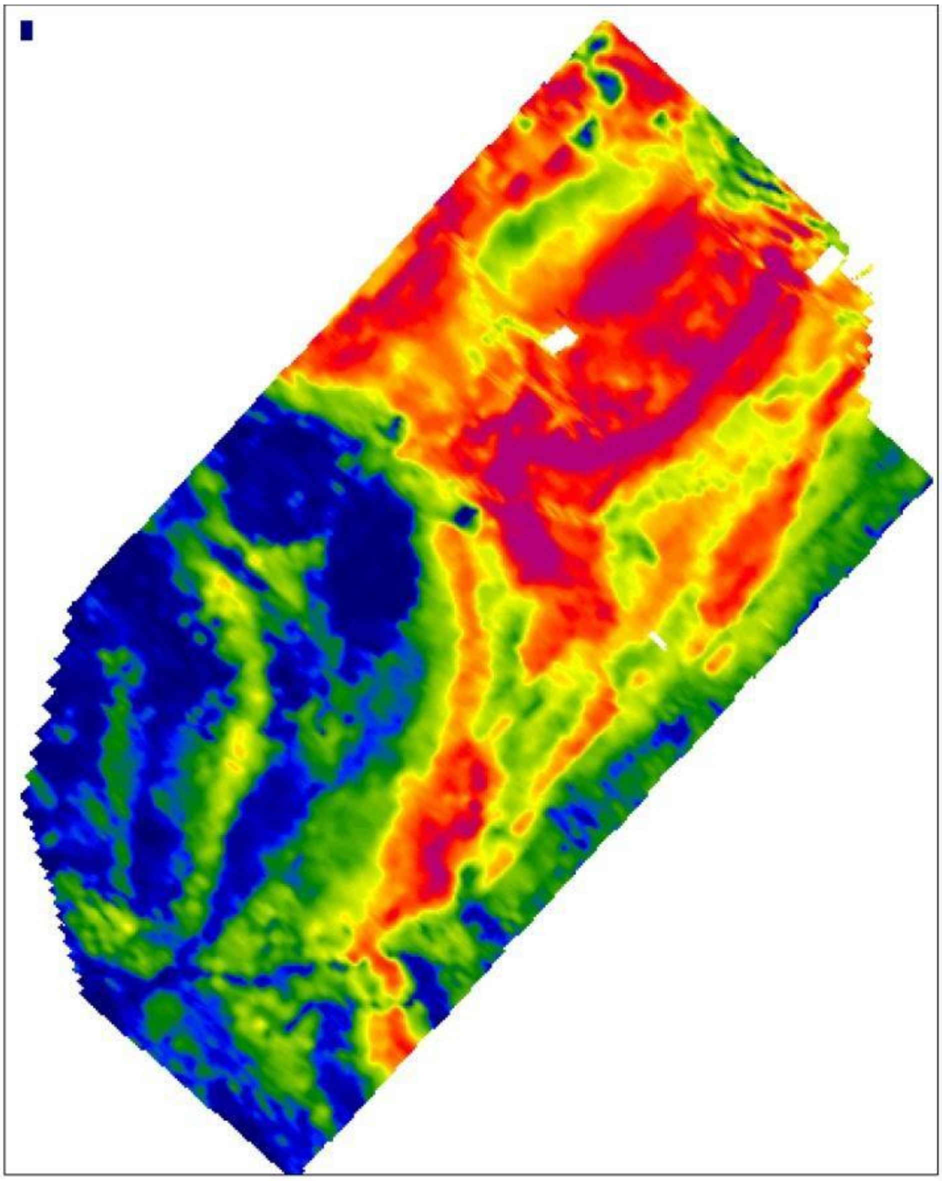

Figure 13 Shallow Apparent Resistivity (140 khz) – (Fugro, 2012)

Legend : blue = low resistivity, purple = high resistivity

Figure 13 shows the apparent resistivity from the 140 khz coil indicating very low resistivity (blue) in south-west in the clay soils and high apparent resistivity (purple) in dry limestone outcrops in the north-east.

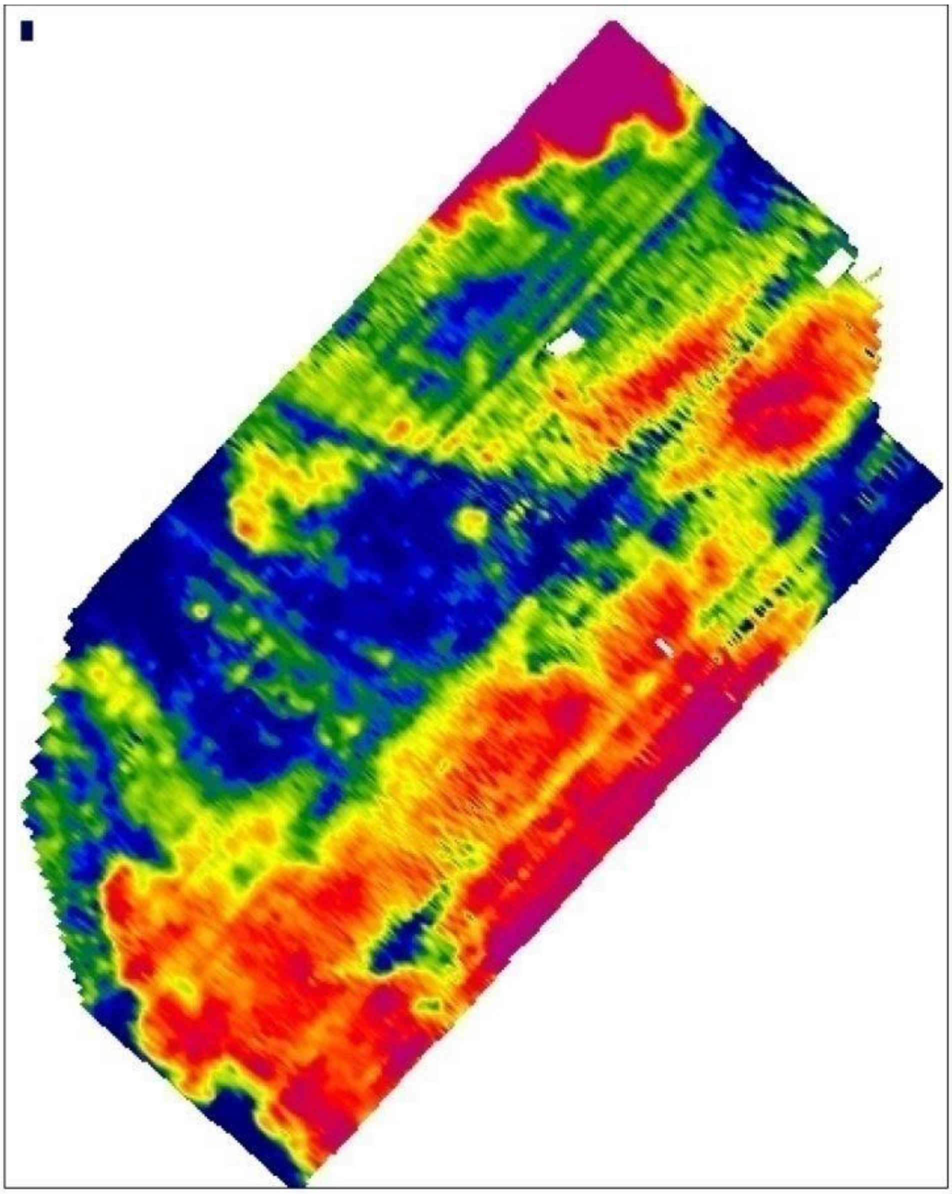

Figure 14 Deep Apparent Resistivity (400 hz) (Fugro, 2012)

Figure 14shows the deepest apparent resistivity from the 400 hz coil mostly in the Viqueque Formation below the Baucau Limestone.

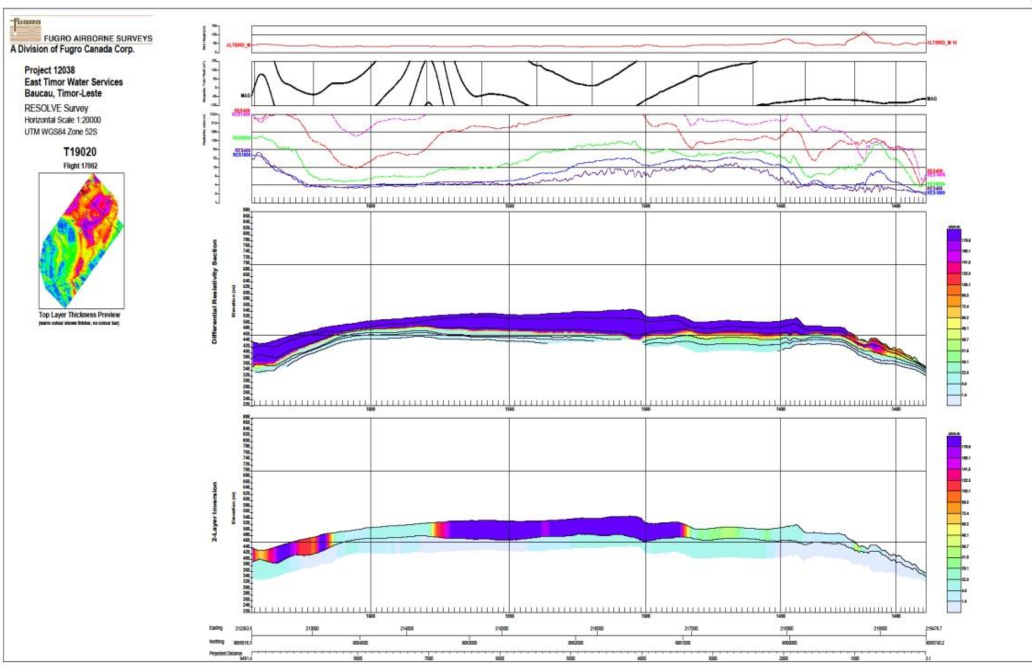

Figure 15 Flight Line 19020 Inversion

Figure 15 shows a cross section of the Flight Line 19270 which was flown south-east to north-west. The upper panel shows the height of the instrument pod with a kick in elevation as the survey crossed high tension electric wires. The second panel is the magnetic field, the next panel is the six coil responses (apparent resistivity). The middle panel shows the apparent resistivity of the Baucau Limestone (purple) clearly draped over the Viqueque Formation. The lowest panel shows the inversion model of the Bacau Limestone indicating highest resistivity in purple. Note the dips in the lower surface of limestone suggesting palaeo drainage lines.

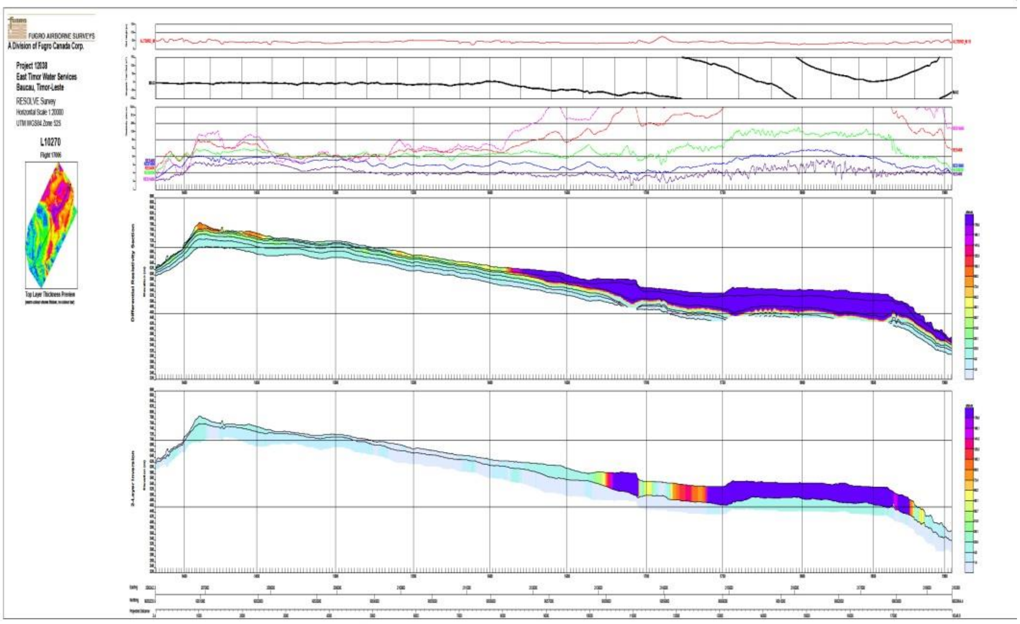

Figure 16 Flight Line 10270 (Fugro, 2012)

Figure 16 is the cross section along flight line 10270 oriented from south-west to north-east showing very thin limestone at highest point and changing abruptly to a thicker limestone in the middle of the section to the Baucau escarpment in the north. In this section there are three distinct dips in the bottom surface of the limestone suggesting drainage channels. (CSIRO offer an alternative interpretation that these may be fractures in the Viqueque Formation caused during tectonic uplift of Timor_Leste (pers. Com.)

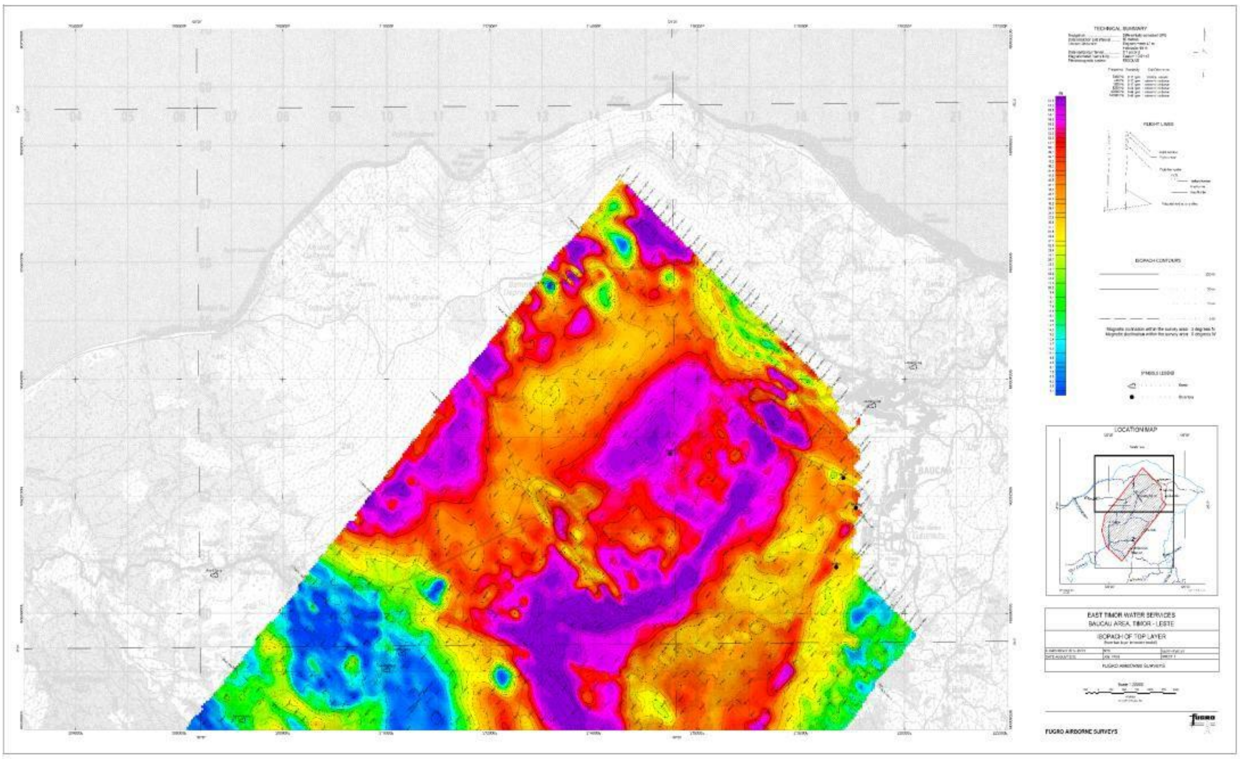

Figure 17 Isopach of Top Layer (north) (Fugro, 2012)

Figure 17 & Figure 18 show the interpreted thickness of the Baucau Limestone with purple the thickest and blue mostly absent (clay soil). The limestone shows a thick-terraced pattern. There are anomalous blue circles in the north suggesting sink holes in the limestone. One of these coincides with the large sinkhole (400 m diameter) known as Cekungan Baninau (Figure 20). The others can be recognized by the soil anomaly on satellite imagery.

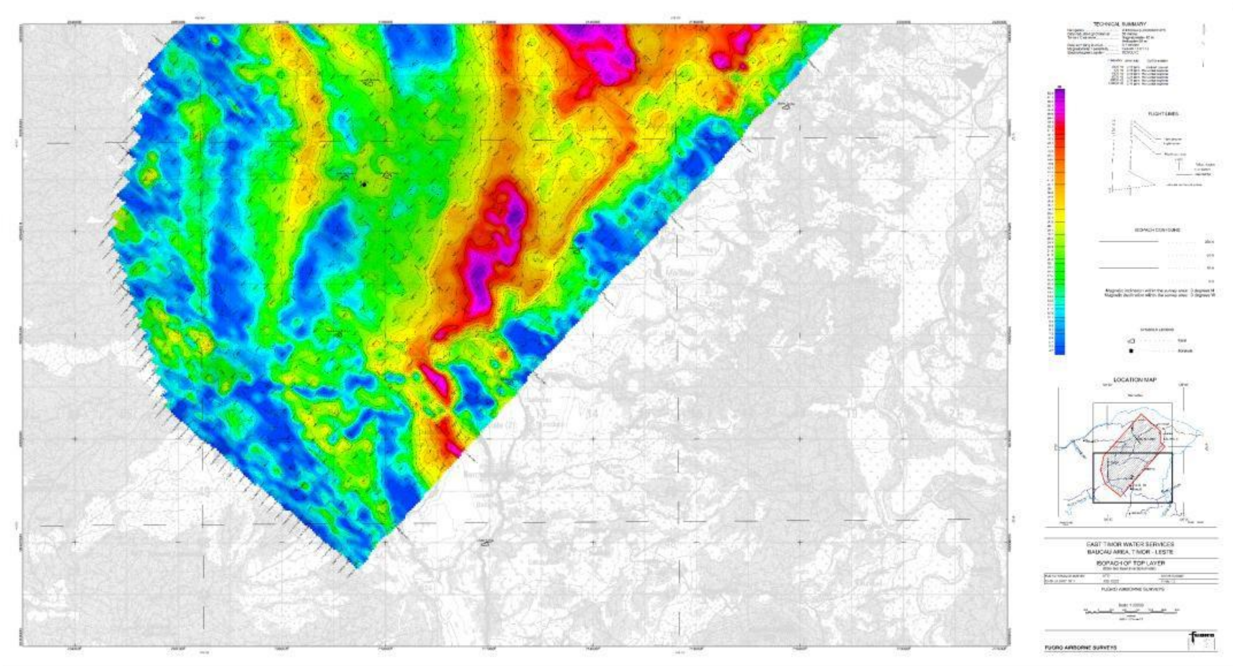

Figure 18 Isopach of Top Layer (south) (Fugro, 2012)

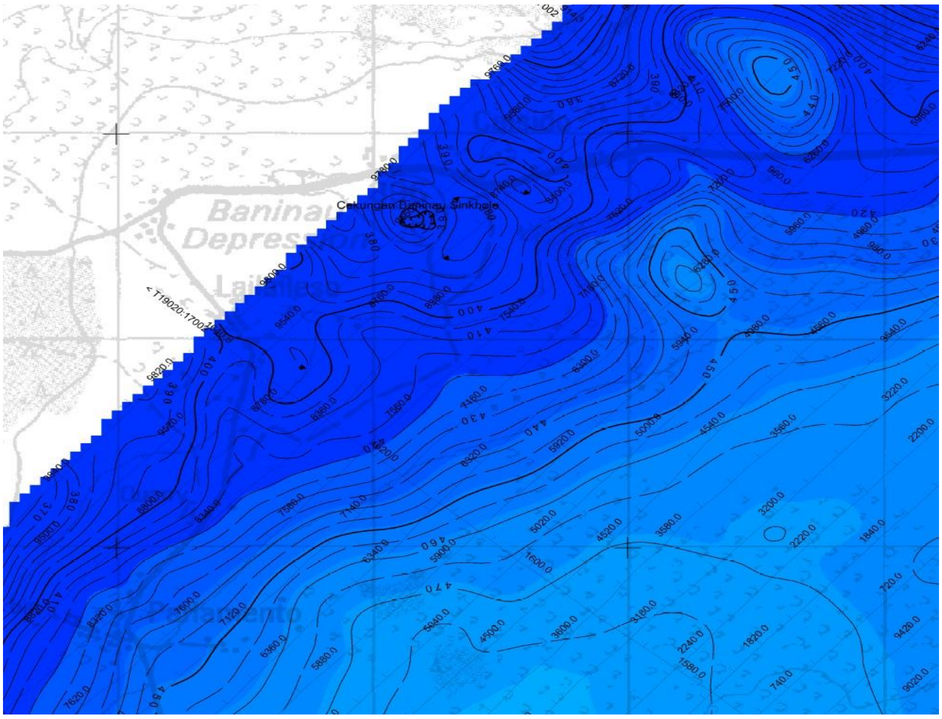

Figure 19 Cekungan Baninau (Fugro, 2012)

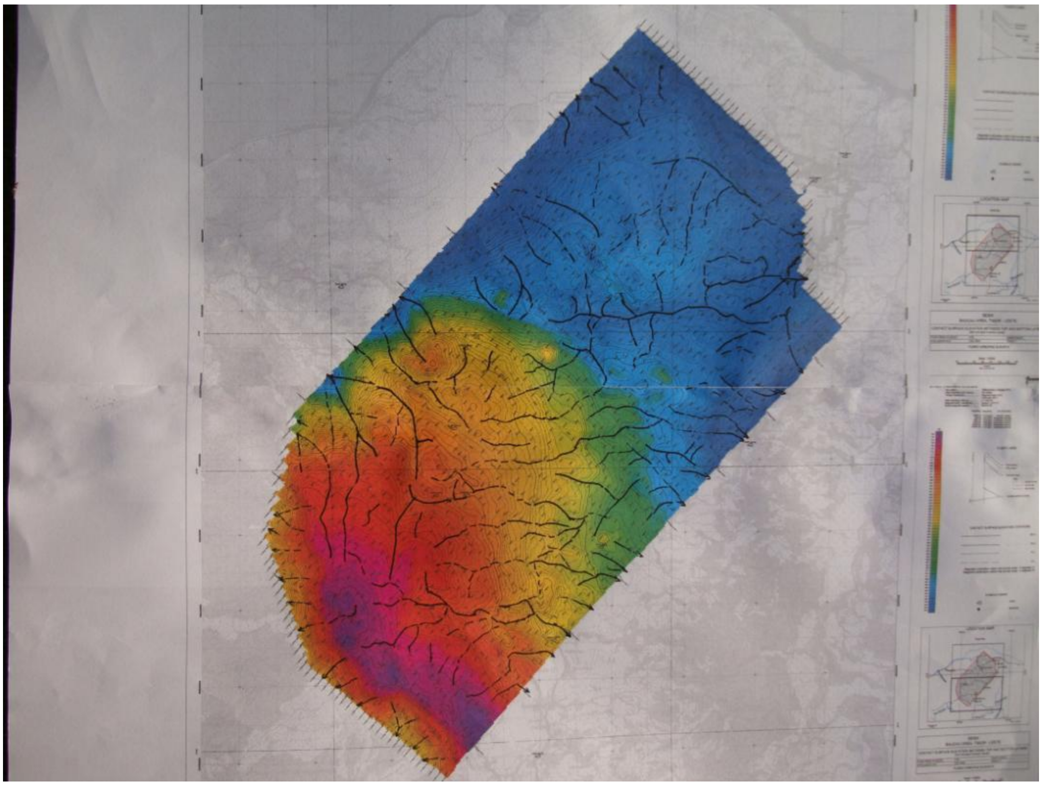

Figure 20 Interpreted Palaeo Drainage Channels (Furness, 2010)

Figure 20 is an interpretation of the inferred palaeo drainage channels from the inversion model of the data. These channels appear to flow in west to east direction or a north-westerly direction from a flow divide running roughly along the middle of the survey area oriented south-west to north-east. The channels also coincide with the known caves, canyons and springs and are therefore suggested as flow paths for the main discharge of the karst aquifer.

1.8 FLOW ESTIMATE

From the interpreted inversion model of the geophysical survey (Figure 20) it is estimated that approximately 10 km^2 collects recharge and drains towards the mine area. With an annual rainfall of 1,200 mm and an estimated recharge rate of 0.4 this is equivalent to 4.8 Gl/yr and is sufficient to meet the mine demand of 1.15 Gl/yr with sufficient through flow to meet village water supplies and environmental requirements. The pathway(s) of the water flow and flow rates of individual streams are not known. It is clear that recharge occurs across the plateau and that discharge occurs around the edges of the plateau where the limestone thins and springs surface.

Usage of the karst water occurs whenever there is a spring discharge that can be tapped. The water is used for domestic purposes and agriculture. There are no known successful bores in the karst area and only one bore in the alluvium at Karavelha. A multi-village water supply is pumped from the Uaileaveri Cave to the Triloca area. Mining in the proposed area could impact on discharge of springs and could introduce contaminants.

1.9 WATER QUALITY

The karst water is very fresh (Timor and WHO standards) and is suitable for all uses except for boiler where it will need treatment to remove calcium and possibly silica. A typical analysis of metals and metalloids from Uailia Spring at Baucau is:

Table 3 Water Quality Analysis, Uailia Spring, Baucau

Sample Description	Aluminium mg/L	Boron mg/L	Barium mg/L	Beryllium mg/L	Calcium mg/L	Cadmium mg/L	Cobalt mg/L	Chromium mg/L
Baucau Uidasime/Uailili Spring	0.01	<0.04	0.008	<0.0002	51	<0.004	<0.005	<0.004
Baucau Town Uailia Spring	0.01	<0.04	0.008	<0.0002	84	<0.004	<0.005	<0.004

Copper mg/L	Iron mg/L	Mercury mg/L	Potassium mg/L	Magnesium mg/L	Manganese mg/L	Molybdenum mg/L	Sodium mg/L	Nickel mg/L	Phosphorus mg/L
< 0.005	0.007	<0.01	0.63	13	<0.001	<0.005	3	<0.005	<0.1

Lead mg/L	Sulphur mg/L	Antimony mg/L	Selenium mg/L	Silica mg/L	Tin mg/L	Strontium mg/L	Titanium mg/L	Vanadium mg/L	Arsenic mg/L	Zinc mg/L
<0.01	3.2	<0.07	<0.04	8.2	<0.02	0.26	<0.004	<0.003	<0.04	<0.004
<0.01	1.2	<0.07	<0.04	6.1	<0.02	0.5	<0.004	<0.003	<0.04	0.009

(Timor and WHO applicable standards refer to Appendix 1 -)

A second more detailed analysis is provided from Caravelha Bore in Appendix 1 - . Showing water meets the standards, except for turbidity and coliform bacteria (treated by chlorine).

1.10 CAISIDU SPRINGS

Figure 21 Uaimatabai Spring

Figure 22 Uaisa Spring

The village of Caisidu lies at the northern end of the proposed Mine area 1.1. There are 4 sub-villages located close to the karst water springs. The karst water discharges below the main escarpment along a spring line, probably associated with a major fault in the Baucau Limestone. At highest elevation is the Uaimatabai Spring (Figure 21) emerging from a limestone cave (170 m elevation) along an overhang. The discharge is about 5 l/s and the water is fresh although probably hard.

The major spring discharge (142 m elevation) is located about 400 m downslope along the spring line. It is called the Uaisa Spring (Figure 22) and is close to the Caisidu School and surrounded by very tall breadfruit and rainforest trees. The discharge is approximately 10 l/s and the water is fresh at 633 µScm. Water is piped and run in open channels to the sub-villages at lower elevation. The third spring in the line is Uaiono (Figure 23) and this discharges into the sea at the proposed port area through a fracture in beach rock. It is only observed at low tide and is not practical as a water supply. The karst limestone probably discharges along the coast line, either below sea level or through alluvium and is thus not visible, except at this spring occurrence. The discharge of the spring is likely to be several litres per second and therefore negligible in the total groundwater resource calculation.

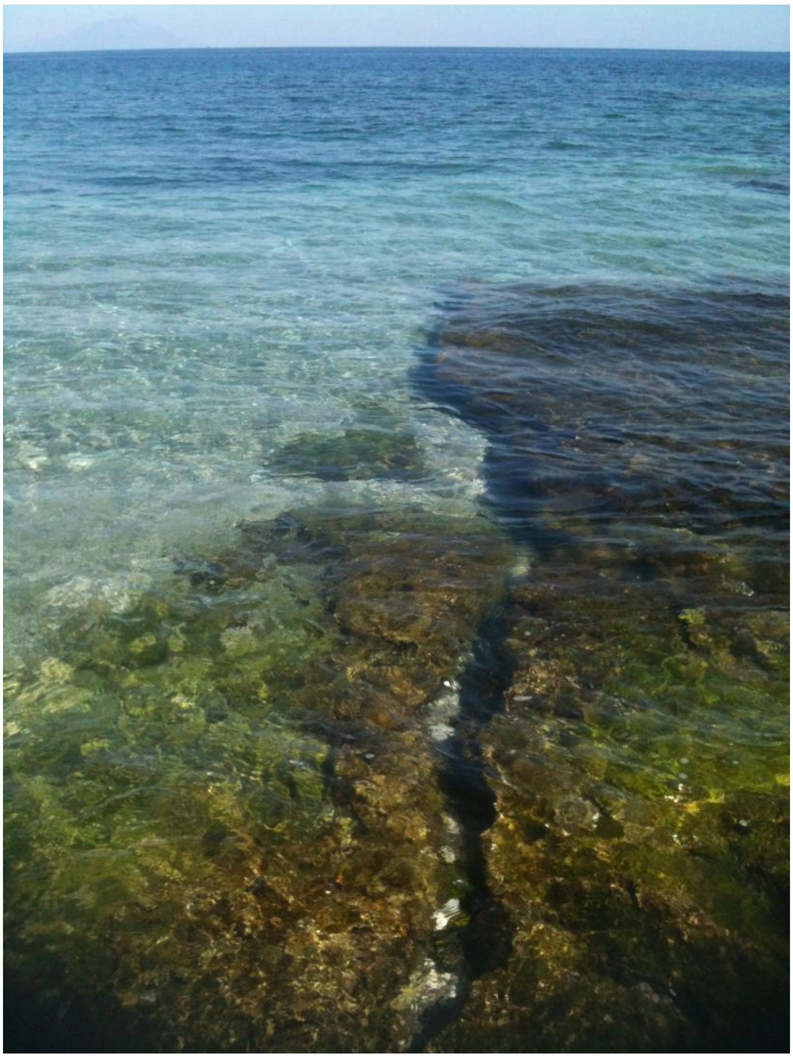

Figure 23 Uaiono Spring

1.11 COASTAL ALLUVIAL AQUIFER

The hydrogeology map (Figure 2) of Timor-Leste shows coastal alluvium in dark blue. From a survey of wells along the north coast it was found that the aquifer contains fresh water where there are significant rivers and karst water recharging the aquifer. Elsewhere, the aquifer is salty due to the limited recharge area, high evaporation and direct connection with the sea. Most of the alluvial aquifer in the vicinity of the proposed mine and cement plant is likely to contain fresh water based on monitoring of shallow wells near Caravelha and measurements of salinity in the coastal streams and swamps.

A review of borelogs from H2O Drilling revealed that the coastal alluvial aquifer near the Manulede River contains fresh water in gravel aquifers. A water supply bore for the village of Caravelha was constructed near the bridge over the Manulede River to a depth of 54 metres and the drilling log indicated two gravel layers separated by marine clay formations (Appendix 2 -). The water in the aquifer was fresh (743 µScm) and was tested by a step pumping test indicating a specific capacity of 1 l/s per metre of drawdown, establishing that the bore could continuously pump about 30 l/s. The bore is fitted with a pump capable of 10 l/s, but this is only used for about 1 hour per day to meet the needs of the small village of Caravelha.

Figure 24 Caravelha Bore at Manulede River

The Manulede River is quite extensive and drains the western side of the Baucau Plateau collecting the karst aquifer discharge. The river is approximately 14 km long with a catchment of roughly 100 km^2. It is concluded that the alluvial aquifer is recharged by the Manulede River and would be capable of supplying the water for the plant at 3.15 Ml/day or 35 l/s continuously without impacting on the village water supply, provided that sufficient separation (400 m) is made between bores. It is likely that the mine could use one bore for water supply and a second bore for backup (TC1 and TC2 Figure 25). The Manulede River is about 9 km from the proposed cement plant and this would necessitate a major pipeline. An alternative site has been located within 1 km of the site on the Uaidei River alluvium based on interpretation of satellite imagery and a field inspection together with an assumed similarity to the Caravelha bore site. .

Figure 25 Loction of Caravelha Bore Potential Plant water supply

A camp water supply may be possible close to the plant area on the Uaidei River at the location marked on Figure 26, if successful an additional 1 or 2 bores could supply the whole water demand. The Uaidei River was flowing at 10 l/s at the site at the time of inspection 06 May, 2015 with fresh water (409 µScm). During the dry season, this river is likely to stop flowing and aquifer salinity increase (additional monitoring will be required to ascertain the annual variability).The river is about 6 km long, originating upslope of Bucoli and has a catchment area of about 10 km^2.

Figure 26 Site for Camp Bore

1.12 IMPACTS OF THE PROJECT

The hydrogeological assessment and preliminary impact analysis is based on previous regional studies undertaken to date. No site specific downhole investigations and/or groundwater assessments have been undertaken as a part of the current study.

1.13 Potential Impacts of mining

The proposed mining method is by truck and shovels and is expected that it will be carried out down to the water table and may not impact on the groundwater. Figure 27 shows inferred groundwater flow paths around mine areas 1.1 and 1.2, however the exact locations are currently unknown. It is a feature of karst aquifers that contamination of the groundwater by spillage of pollutants (especially fuels) can occur very rapidly and the contaminants can be transported in hours or days to public water sources. Therefore, it will be necessary to adopt management procedures and strict protocols to prevent the spillage of fuels, lubricants and chemicals which could rapidly pollute public water supplies.

Figure 27 Inferred Groundwater Flow Paths

In mining area 1.1 it is possible that mining could impact the springs of the Caisidu four sub-villages if mining extends below the water table. The depth of water table is not known, but limestone core drilling indicates it could be greater than 100 metres. It is recommended that a Special Water Resources Reserve (Figure 28) be established at Caisidu to protect the sacred springs of Uaimatabai, and Uaisa, and the sacred trees surrounding the springs.

Figure 28 Special Water Resources Reserve

Mining area 1.2 is located on the northern part of the Baucau Plateau, to the north of the airport. The karst aquifer there flows to the west and to the north away from a groundwater mound near the airport. The discharge from the aquifer is in two springs (Wai Spring and Dubeti Spring in Figure 3) and beneath the sea. If mining proceeds below the water level, near the base of the limestone then the springs could be impacted.

Mining area 2 is located in the eastern part of the Baucau Plateau to the south of the airport. This is the most sensitive part of the karst aquifer as it supplies water to Baucau, and a number of villages, schools and college on the eastern side of the plateau. It also contains four known caves and numerous sink holes. This part of the karst aquifer has also been selected for future water supplies to New Baucau and the army camp at the airport.

Mining of area 2 would need to be preceded by investigations to clearly identify the major cave streams that supply water to the public and irrigated agriculture to prevent the disruption of these supplies or the contamination of the water. In some parts of this area, the karst water is known to be relatively shallow, at less than a few metres in some of the caves, and mining in these areas should be avoided.

1.14 Potential Impacts of Water Supply

The processing of clinker and the use of groundwater totals 1.15 Gl/year. It is calculated that this is about 25% of the annual recharge on the western side of the Baucau Plateau. If the mine water supply is taken from the discharge areas of the karst, i.e. from springs, there will be no impact on groundwater within the karst aquifer. However, if the water supply is obtained from water bores in the plateau region, i.e. at the Cekungan Baninau sinkhole area, then there may be an impact on certain spring discharge, provided those springs are physically connected to the aquifer and the karst features connected to the bores.

The impact of the water supply from the karst aquifer cannot be assessed by conventional hydrogeological methods (groundwater modeling) and other suitable methods will need to be applied. The use of dye tracing is a suitable method to positively identify the connection of karst features such as cave streams and springs as has been demonstrated in the Baucau Plateau.

Obtaining the required water supply from the coastal aquifer is considered a better option than from the karst aquifer due to predictable impacts that do not affect other users, springs and groundwater dependent ecosystems. If possible, this should come from the Camp Bore Site (Figure 26) subject to water quality and quantity. It is likely that 2 to 3 bores will be required at 400 m intervals along the river valley. An alternative is the Caravelha bore area, where supplies have been tested, but this would necessitate a 9 km pipeline. The radius of impact would probably be less than 200 metres from each bore and therefore not impact on other users.

Appendix 3 - shows the groundwater receptors that may be potentially impacted from the proposed development. .

2. RECOMMENDED ACTION

Based on the study the following recommendations are made: :

- Two test bores (200 mm nominal casing) be drilled at the Camp site at spacing of 400 m and each to a depth of 50 m. Upon satisfactory completion of the bores, test pumping should be performed including a 4 step increasing pumping rate test (4 hours) and a minimum of 24- hour constant rate test with observations of water levels and flow rates. Water quality should be monitored during the test and water samples taken at the end of pumping. Water level recovery should be measured until 80% recovery. Water level and water quality should be monitored by data loggers and probes at hourly intervals.
- A water monitoring program should be established at Uaisa and Uaimatabai Springs measuring flow rate and water quality at 3 month intervals.
- A Special Water Resource Reserve be declared around the Uaisa and Uaimatabai Springs and the associated sacred trees. This should be clearly signed posted and marked with survey pegs and fluorescent paints. No mining activity should occur within this reserve or upslope.
- This study has been a preliminary statement on the impact of mining on groundwater. For the karst aquifer little is known about the depth and flow patterns of karst water. Therefore, it will be necessary to have an ongoing study to review mining plans and to monitor water depths and water quality.
- The mining plans will need to demonstrate that mining is not occurring upslope of the springs that supply village water, to prevent loss of supplies and accidental contamination.
- The underlying imperative is that mining does not continue below the water table as it occurs during the wet season. Therefore, as mining progresses each water intersect needs to be noted and mapped on a progressive update of karst conditions.
- Mining should not proceed deeper than the water cuts and water quality monitoring established at each water cut.

3. REFERENCES

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Appendix 1 - KARST WATER QUALITY

TL CEMENT, LDA

BAUCAU CEMENT PROJECT

PRELIMINARY GROUNDWATER STUDY

Sample Location	Sample No.	Cond	pH	Total Hardness	Temp Hardness	Alkalinity	Residual Alkalinity	Total Ions	TDS	Colour	Turbidity	pH Sat	Saturation	Mole R	SAR	FMR	Na+	K+	Ca++	Mg++	H+	HCO3-	CO3--	OH-	Cl	F-	NO3-	SO4--	Fe	Mn	Zn
Baucau Uailili	TIM1	364	8.2	183	173	173	0	293	196	<1	<1	7.5	0.7	0.4	0.1	24	4	0.7	51	13	0	207	2	0	2.8	0.94	0.5	10.2	<0.01	<0.01	<0.01
Baucau Uailia	TIM2	429	7.72	218	209	209	0	360	238	<1	1	7.2	0.5	1	0.1	24	4	0.7	85	1.5	0	253	0.8	0	4.6	0.11	6.1	3.9	<0.01	<0.01	<0.01

Appendix 2 - CARAVELHA BORE RN 287

THE NORTHERN TERRITORY OF AUSTRALIA
Control of Waters Act

FINAL STATEMENT OF BORE

Name of Owner	BEBIK	Registration No	287
Name of Bore	CARAVELHA	caravelha	
Intended Use		Advice No	
Location	CARAVELHA (BAUCAU REGION)	Permit No	

From	To	Particulars of Strata
0	3	Top soil
3	6	Gravels, River rocks
6	21	Seamud mix coral
21	28	Seamud only
28	29	Coral
29	33	Gravels, coral and rocks
33	38	Clay only
38	41	Gravels, black color
41	43	Clay/mud only
43	44	Gravels
44	48	Clay only
48	52	Gravels mix rocks
52	54	Clay only

Name of Contractor	Pump & Power
Name of Driller	Natalino Mendes
Date Commenced	24/6/2013
Date Completed	28/6/2013
Depth Drilled	54 (m)
Completion Depth	53 (m)

METHOD OF DRILLING

■ Rot ☐ Rev. Cir. ☐ Cable ☐ Other

HOLE DIAMETER			DRILLING FLUID
From	To	Diameter	Type
0	6	12¼"	Bentonite
6	54	8½"	CR-650
			Liqui-poll

PARTICULARS of CASING

From	To	Diam (ID)	Type
0	6	10"	UPVC Surface Casing
+1	29	6"	UPVC
35	47	6"	UPVC Blank

PARTICULARS of PERFORATIONS or SCREEN STRINGS

From	To	Diam (ID)	Aperture	Type
29	35	6"	1.5 mm	PVC Machine Slotted
47	53	6"	1.5 mm	PVC Machine Slotted

Casing Suspended ☐ Yes ■ No
Method :
Hight of Casing above GL : 1 (m)

Top of Packer set at : (m)
Length of Packer : (m)
Method of Packer Connection :

CEMENTING / GRAVEL PACKING

From	To	Type
0	6	Cement Grout
6	28	Gravels Pack
28	29	Bentonite Pellet
29	53	Gravels Pack

WATER BEARING BEDS

Depth (m) From	To	Yield (L/s)	SWL (m)	Duration (hr)	Quality	EC	ph	Bottle No

STRATA and WATER SAMPLES
✓ Have been ☐ Will be
Left at DNSA Laboratory

Completion Yield : 10 (L/s) Method : Airlift Duration : 12 (hr)
Completion SWL from GL : 2 (m) Depth of lift : 53 (m)

MINISTÉRIO DAS OBRAS PÚBLICAS
SECRETARIADO DO ESTADO
ÁGUA, SANEAMENTO E URBANIZAÇÃO

DIRECÇÃO NASIONAL DOS SERVIÇOS DE ÁGUA (DNSA)

Request for Water Quality Testing

Sample analysis reference : 000003857
Requesting Organization : H_2O PUMP & POWER
Description of the organization: H_2O DRILING COMPANY
Contact Person : Ms. OVY | Telephon : 77236399
On behalf of organization, I agree to pay the cost of test request below: Signature: √
Data and time sample was taken : 24/07/2013 | Date and Time sample was received: 24/07/2013
Sample location specification : BAUCAU / CARABELA
Water Source: River | Mountain stream | Spring | Well √ | Others
Sampled by : Ms. OVY | Received in laboratory by: MARIO SOARES
Approved to test by: ESTELA SALDANHA

Cost (US$)	Parameter	Unit	Request test	Result	WHO/East Timor Guideline	Testing method
Physical test						
1.00	pH value	-	√	8.4	6.5-8.5	pH Meter
1.00	E.conductivity	(µs/cm	√	743	NS	Conductivity meter
1.00	TSS	(mg/L)	√	0.06	NS	Gravimetry
1.00	TDS	(mg/L)	√	372	1000	Gravimetry
1.00	Salinity	(‰)	√	0.4	NS	Conductivity meter
1.00	Temperature	(°C)	√	23.7	NS	Conductivity meter
1.00	Turbidity	NTU	√	**49.6**	5 (NTU)	Turbidity meter
Chemical test						
2.00	NH_3-N	mg/L	√	0.6	1.5	Spectrophotometer
2.00	NO_3-N	mg/L	√	0.2	10 (as NO_3-N)	Spectrophotometer
2.00	NO_2-N	mg/L	√	0.030	1 (as NO_2-N)	Spectrophotometer
1.00	Iron (Fe)	mg/L	√	0.2	0.3	Spectrophotometer
2.00	Manganese (Mn)	mg/L	√	0.5	0.5	Spectrophotometer
1.00	Fluoride	mg/L	√	1.1	1.5	Spectrophotometer
2.00	Free chlorine	mg/L	√	ND	0.5	Comparator,
2.00	Ca hardness	mg/L	√	220	NS	Titration
2.00	Arsenic	mg/L	√	ND	0.01	Comparator
2.00	T. Hardness	mg/L	√	**260**	200	Titration
2.00	Total alkalinity	mg/L	√	280	NS	Titration
2.00	Sulphate (SO_4^{2-})	mg/L	√	120	250	Spectrophotometer
Bacteriological test						
16.00	Total Coliform	CFU/100mL	√	**TNC**	0	Membrane filtration
16.00	E.Coli	CFU/100mL	√	0	0	Membrane filtration

Total cost	Remark	
$.61.00 USD	**- Total Coliform is problem !** **- Turbidity, T. Hardness is high !**	**Inspected by:** **Head of DN-SA Laboratory**

Legend: 1. NS: not set; ND: not detectable; NT: not tested; NR: not result; CFU: Colony Formed Unit; TNC: too numerous to count.

Appendix 3 - GROUNDWATER CENSUS

Feature Name/ Potential Receptors	Type	Latitude	Longitude	Location	Significance	Figure reference (if applicable)
Waiono Spring	Spring	8.44819	126.345360	Proposed Port Area	Brackish water spring flowing to the ocean	23
Uaisa Spring	Spring	8.447002	126.358069	< 100m from the mining area	Local water supply for villages of Caisidu and 4 sub-villages within 100m	22
Uai Matabai	Spring	8.447480	126.361462	< 100m from the mining area	Local water supply for villages of Caisidu and 4 sub-villages within 100m	21
Cekungan Baninau Sinkhole	Sinkhole	8.444532	126.395214	3km east of the mining area	Possible major recharge area, no development of karst water	27
Wai Spring	Spring	8.434049	126.386989	3km north-east of the mining area	Karst discharge used for several houses, most likely connected to Cekungan	27

Feature Name/ Potential Receptors	Type	Latitude	Longitude	Location	Significance	Figure reference (if applicable)
					Baninau Sinkhole	
Dubetu Spring	Spring	8.4344049	126.386989	3km north-east of the mining area	Karst discharge used for several houses most likely connected to Cekungan Baninau Sinkhole	27
Camp Bore	Borehole	8.456221	126.332647	1km west of the mine area	River alluvium Potential source of water supply for the project	27, 26
Manulede Bore	Borehole	8.489722	126.256778	>5km west of the mine area	Water Supply bore in the Manulede River Alluvium Local water source for Karavelha village and sub-villages	25

Feature Name/ Potential Receptors	Type	Latitude	Longitude	Location	Significance	Figure reference (if applicable)
Huhadili Cave	Cave	8.5054	126.3852	>5km south of the mine area	Appears to be not connected to any of the monitored springs locally	3
Uaileamata Cave	Cave	8.5403	126.3585	>5km south of the mine area	Connected to Ulaleaveri Cave, Uaililea spring and ultimately, to Uainoi Spring, located >10km from the mine area 1	3
Ulaleaveri Cave	Cave	8.5262	126.3913	>5km south of the mine area	Connected to Uaililiea Spring which feeds into Uainoi Spring, which is >10km from the mine area 1	3
Uaimatahun Cave	Cave	8.5581	126.3579	>5km south of the mine area	Connected to Uainoi Spring, >10km from the mine area 1	3

Feature Name/ Potential Receptors	Type	Latitude	Longitude	Location	Significance	Figure reference (if applicable)
Uainoi Spring	Spring	8.5528	126.3991	>10km south of the mine area	Water source for irrigation area	3
Uaililea Spring	Spring	8.5157	126.4398	>10km south of the mine area	Water source for several villages around Gariuri	3

Appendix 5 Vegetation and Fauna Survey Report


BAUCAU CEMENT CLINKER PLANT VEGETATION AND FAUNA SURVEY

Colin R. Trainor & Brett Easton

Report to WorleyParsons, August 2015






Acknowledgements

Thanks to Cypriano Belo (Aldeia chief of Lia Lai Leso), Manuel Freitas (Aldeia chief of Parlamento), Pedro da Costa (Aldeia chief of Osso-wa), Carlos Assis Bento (Aldeia chief of Cai-Sidu) in the village of Tirilolo for field help at the Jetty, Plant and Mine. We also thank Daniel Correia and Alexandre Boavida for help in the field at Wailicama.

Thanks to Kyle Armstrong of Specialised Zoological for identifying bat calls and preparing a report (cited here as Armstrong & Konishi 2015; and included here as Appendix 9) on the bats of the study area; Hinrich Kaiser for identifying several lizards and Vince Kessner for provisional identification of landsnails. Thanks also to Daniel Hunter and Oktavio Araujo for facilitating field contacts and other help in preparing for fieldwork.

Contents

Summary

Background: Preliminary environmental studies were conducted during May 2015 at four study sites associated with a proposed cement mine and plant in the village areas of Tirilolo and Wailicama, near Baucau, Timor-Leste. The sites were: Jetty (0.05km^2), Plant Site (1 km^2), Mine I-I (5.76 km^2) and Clay Mine (4.0 km^2). Local community members assisted with all aspects of the field survey. The main potential environmental impacts made during construction and development of the mine would include site clearing, levelling and excavation causing loss or disturbance to native vegetation and habitats, and associated loss of habitat for native wildlife.

Methods: The vegetation assessment included surveys of a combination of initial random points within the key test sites that were then further expanded to include any different neighboring vegetation assemblages based on direct field observations. The vegetation assessment focused on systematic survey of each survey site using quadrats (25m x 25m= 625m^2). In total 22 different quadrat sites were sampled over 13,750m^2. Within each quadrat sample, the dominant vegetation types were assessed and sampled at the upper, middle and lower stratums. Additional information recorded at each site included disturbance, basal area, height range, weed-introduced species abundance, canopy cover, litter cover, gravel extent, bare earth and soil types. At a floristic level, any unusual plant specimens that could not be identified in the field were also collected for identification later. Vegetation assemblages were described in terms of “structural formations”. Fauna survey consisted of general observations, informal interviews with local field assistants, a total of 24-10 minute point count searches and counts of birds, reptiles, amphibians and mammals; nocturnal spotlighting and Acoustic bat recording. Fauna habitat assessment was done at each point count including measuring or estimating fauna habitat (canopy cover, vegetation structure, rock cover, litter cover, presence of logs, caves, rock outcrops and other significant fauna habitat features). The quality of fauna habitat was subjectively assessed as either Low, Moderate or High for each point count site.

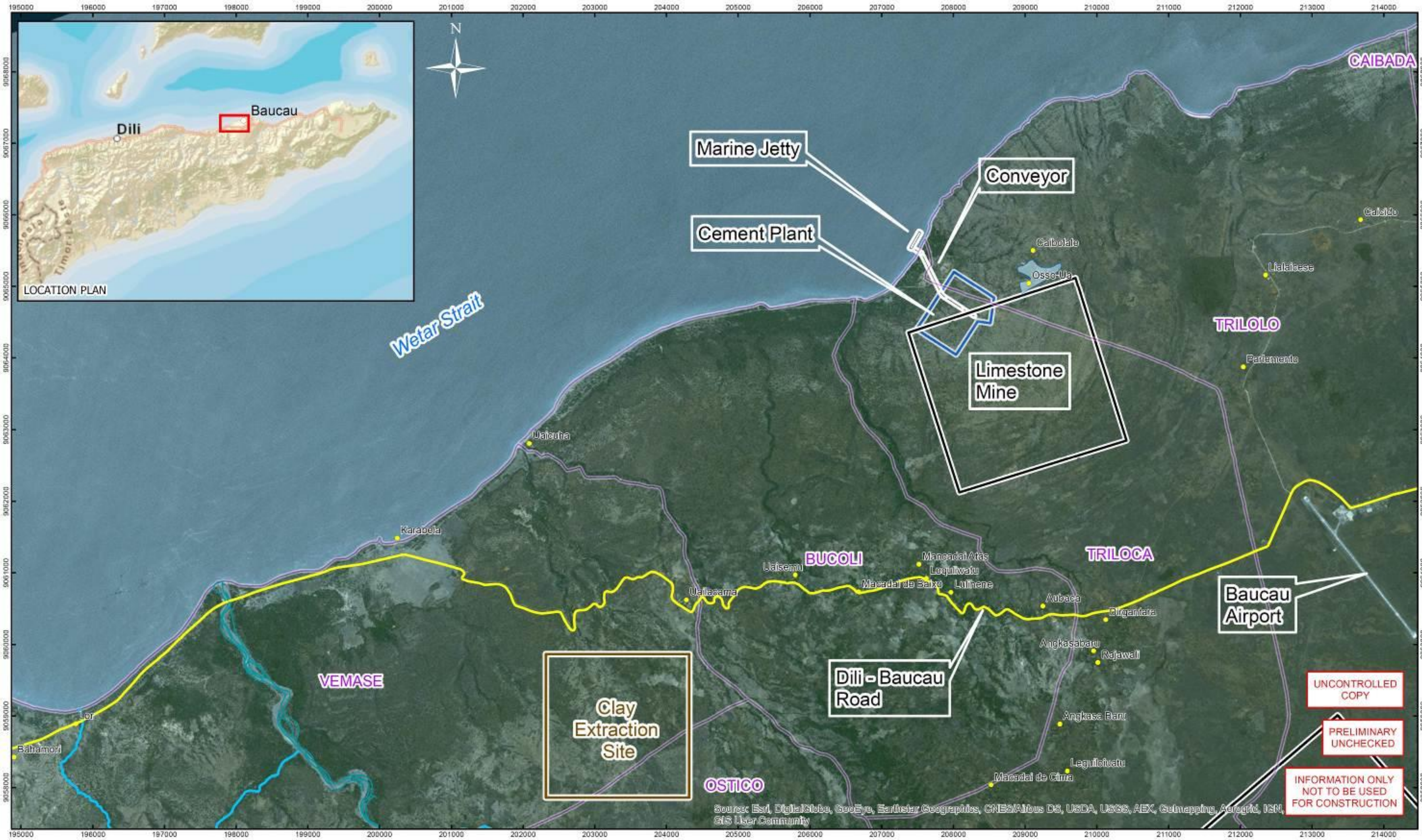
Results:

Local land use at the study sites included housing, small-holder agricultural plots, livestock grazing and hunting. The presence of old stone fences on the mine (in open woodland) and at the Clay mine in Closed tropical forest was evidence of long-term agricultural landuse (at least 50-100 years previously) and of significant regeneration of tropical forest at the Clay mine site. There are no protected areas or Important Bird Areas identified in or near the study areas, and a gap filing exercise did not identify any national priority sites in or near the study areas. The key vegetation structural formations surveyed can be broadly described as either Closed Tropical Forest systems or open woodland systems. The Closed Tropical Forest systems predominantly occurred in the drainage lines, gullies and more sheltered areas and exhibit a higher soil moisture level, compared to the adjacent open woodland. At the mine and plant sites the majority of the Closed Tropical Forest occur as small isolated patches in gullies dominated by *Peltophorum pterocarpum*. The Clay mine site had significantly more extensive contiguous Closed Tropical Forest, particularly on the eastern side of the site. These areas were not however uniform vegetation assemblages but rather variants, including bamboo forest areas, reflecting the influence of elevation, soil, aspect and past and present-day land uses.

A total of 71 plant species were identified during the survey including three species of conservation concern listed under the IUCN Red List as Vulnerable. These were Sandalwood (*Santalum album*) recorded at the Mine in Open forest and Closed Tropical Forest, Rosewood (*Pterocarpus indicus*) recorded at Clay Mine in Closed Tropical Forest and Borneo Teak (*Intsia bijuga*) also recorded at the Clay mine in Closed forest. These three trees and an additional four plant species are listed as “protected” on the Timor-Leste draft Interim List of Protected species, and a further four species are listed as “Alien” – or weeds - on the Interim List of prohibited Invasive species.

A total of 87 vertebrate fauna species were recorded including two amphibians (an undescribed species of Rice Paddy Frog *Fejervarya* sp 1 and the introduced Black-spined Toad *Bufo melanostictus*), eight reptiles including two apparently undescribed *Carlia* skinks (*Carlia* sp ‘lowland’ and *Carlia sp* ‘Baucau’) and four other native species, 22 mammals (10 insectivorous echolocating bats [microchiropteran], one fruit bat [megachiroptera], two native terrestrial species and nine introduced or livestock species) and 56 bird species (all native). A total of 10 different bat call types (=species) was distinguished, and four of these call types could be allocated to a species through comparison with available unpublished reference calls. Three landsnail taxa were also collected.

Study area



Baucau
Dili
LOCATION PLAN
N
Wetar Strait
Marine Jetty
Conveyor
Cement Plant
Limestone Mine
CAIBADA
TRILOLO
TRILOCA
BUCOLI
VEMASE
OSTICO
Baucau Airport
Dili - Baucau Road
Clay Extraction Site
UNCONTROLLED COPY
PRELIMINARY UNCHECKED
INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION

To provide national context for vertebrates these results represent c.33% of the amphibians known from Timor-Leste, 16% of the reptiles, c.42% of the mammals and 44% of the resident landbirds (excluding waterbirds, migrant and visiting birds) known from Timor-Leste. One reptile (Tokay Gecko *Gekko gecko*), four echolocating bats and 27 bird species are listed on the Timor-Leste draft Interim List of Protected species. The Black-spined Toad is the only fauna species listed as "Alien" on the Timor-Leste draft Interim List of prohibited Invasive species.

Table. Summary of vegetation communities, flora and fauna species of conservation significance at the study sites.

Main Vegetation communities	**IUCN status**	**Sites**			
		Jetty	**Plant**	**Mine**	**Clay**
Closed tropical Forest	Na		Limited extent; good condition	Limited extent; good condition	Extensive; good to excellent condition
Open Woodland	Na		Extensive; degraded to good condition	Extensive; degraded to good condition	Extensive; highly degraded to good condition
Palm forest/beach forest	Na	Present; degraded			
Agricultural land/ricefields	Na	Present		Present	extensive
Plant species					
Sandalwood *Santalum album*	Vulnerable			X	
Rosewood *Pterocarpus indicus*	Vulnerable				X
Borneo Teak *Intsia bijuga*	Vulnerable				X
Fauna					
Rice Paddy Frog *Fejervarya* sp 1 [c.f. Kaiser *et al*. 2011]	?				X
Carlia sp 'lowland' [c.f. Kaiser *et al*. 2011]	?	X			
Carlia sp 'Baucau' [c.f. Kaiser *et al*. 2011]	?		X	X	X
Canut's Horshoe Bat *Rhinolophus canuti*	Vulnerable	X		X	X
Kai Horseshoe Bat *Rhinolophus celebensis*	Data Deficient	X			X
Pink-headed Imperial Pigeon *Ducula rosacea*	Near threatened				X
Olive-shouldered Parrot *Aprosmictus jonquillaceus*	Near threatened			X	X
Cinnamon-banded Kingfisher *Todiramphus australasia*	Near threatened		X	X	X
Orange-sided Thrush *Geokichla peronii*	Near threatened			X	X
White-bellied Bush Chat *Saxicola gutturalis*	Near threatened			X	X
Timor Sparrow *Lonchura fuscata*	Near threatened		X	X	X

Birds dominated the systematic point count surveys with 284 of the 315 independent fauna records (species x point counts). There was a single point count record of an amphibian (Black-spined Toad), 21 independent point count records of reptiles, and just six point count records of mammals (all livestock or Timor Deer *Cervus timorensis*). There were only two observations of Rice Paddy Frog at the Clay Mine. The two undescribed *Carlia* skink species were recorded widely. The results were typical of open woodland habitats in lowland ecosystems of Timor-Leste, with records of about half the resident landbird species of Timor. A large proportion of the recorded fauna, especially among amphibians, reptiles and mammals consisted of introduced/tramp or invasive non-native species. The invasive and toxic Black-spined Toad has been implicated in the decline of a range of herpetofauna species, and common introduced geckos such as Tokay Gecko (*Gekko gecko*) and House Gecko (*Hemidactylus frenatus*) may be similarly involved in decline of native gecko species. Livestock species such as Water Buffalo, Banteng/cattle, horse and sheep were regularly observed at the Mine and Clay mine sites and obviously impacted the quality of vegetation and fauna habitat through grazing and dispersing invasive weeds.

Extensive Closed Tropical Forest at the Clay mine was important habitat for Near threatened, restricted-range and forest specialist bird species. All forest specialized bird species recorded at the Jetty, Plant and Mine were also recorded at the Clay mine, but 14 forest specialist bird species were only recorded at the Clay mine, highlighting the conservation significance of tropical forest at this site. This included six bird species listed by the IUCN as Near threatened. Of particular interest were records of the IUCN Near threatened Pink-headed Imperial Pigeon *Ducula rosacea*, a large forest specialized pigeon which is threatened by hunting and forest loss in Timor-Leste. The Indonesian Short-nosed Fruit Bat and 10 insectivorous bat species were recorded, and local villagers reported that Long-tailed Macaque (*Macaca fascicularis*) was present at the Plant, Mine I-1 and Clay Site.

Many flora and fauna species would be absent from the study areas because they have small distributions in Timor-Leste, through lack of specific habitat features while other taxa may need specialized survey techniques to record their presence.

Recommendations: The main impacts of the proposed project will include conversion and loss of vegetation communities, removal of trees and conversion of habitat for fauna species. We found that the *Eucalyptus alba* and Ceylon Oak *Schleichera oleosa* dominated woodlands on the Mine and Plant was generally in good condition, but compared to Closed Tropical Forest are clearly not as biologically significant. Woodland or open woodland communities occur widely in Timor-Leste, perhaps covering c. 3,983km^2 of the nation and woodlands dominated by *Eucalyptus alba* are relatively restricted covering c.5-7% of the country (<c.600 km^2). The status of *Eucalyptus alba* woodland in Timor-Leste remains little known but may need further consideration given that the species occurring in Timor-Leste is apparently different from populations occurring in northern Australia.

Closed Tropical Forest in the Mine, Plant and Clay sites hosts IUCN listed threatened tree species, the globally Vulnerable Canut's Horshoe Bat *Rhinolophus canuti* and Near threatened, the Data Deficient Kai Horseshoe Bat *Rhinolophus celebensis* and forest specialized bird species. Key threats to Canut's Horshoe Bat and Kai Horseshoe Bat would include disturbance at cave roosts, loss of roosts, and loss of optimal foraging habitat through clearing of forest. Up to a maximum of eight out of ten echolocating bat species recorded during the survey use caves for daytime roosting. Aggregations of cave roosting bats are vulnerable to disturbance and increased rates of mortality in these refuges.

Closed Tropical Forest in the survey sites is of high biological significance despite historical and ongoing human use. In Timor-Leste the loss or conversion of Closed Tropical Forest is the prime driver of decline in populations of forest trees, IUCN listed Near threatened forest birds at least. Ensuring that Closed Tropical Forest habitats in the Clay Mine are not cleared would be the most important action to minimize risk from the project. Similarly, where possible maintenance of the small patches of Closed Tropical Forest mapped in the Mine and Plant areas would also be valuable.

Background

An Environmental Impact was requested for a proposed Cement Project in the vicinity of Bucoli, Bacau sub-district, Baucau Municipal, Timor-Leste. Details of the proposed development and potential environmental impacts are described in a project document by TL Cement LDA (2014). The proposed construction is for a 1.65 million tonnes per annum capacity cement project. The TL Cement LDA (TLC) Plant is proposed to be located in Suco (village) Tirilolo, Aldeia Ossoolla near Baucau in Baucau sub-district, about 120 km east of Dili, Timor-Leste.

There are five main sites: 1) Jetty is a coastal site in Suco Tirilolo; 3) Plant site in Suco Tirilolo; 4) Mine (Bucoli North Area 1 [Mine I-1]) in Suco Tirilolo is proposed as the source of limestone, and 5) Clay mine is located in Suco Wailicama and is proposed as the source of clay.

The main potential environmental impacts will be made during construction and development of the mine. In this report we are largely considering terrestrial environments roughly to the low tide mark:

- Site clearing, levelling and excavation (Jetty including conveyor belt, Plant, Mine and Clay Mine): disturbance or loss of native vegetation and habitats and associated loss of habitat for native wildlife.

The Operation phase of the Proposed cement plant will mainly consist of the following activities (TL Cement LDA (2004):

- excavation of limestone, sandstone and clay from the captive mines;
- Crushing of limestone, sandstone and clay;
- Transportation of limestone from mine/s to plant;
- Transportation of other correctives to the plant site;
- Preparation of raw meal by adding correctives to limestone;
- Clinkerisation of raw meal;
- Cooling and heat recovery;
- Blending and grinding of clinker by adding additives;
- Packing and dispatch;
- Ship traffic;
- Transportation of raw material like coal, additives etc to plant by belt conveyor;
- Transportation of outbound clinker by belt conveyor.

Field surveys were required for 4 main sites:

1. Jetty (0.05 km^2)
2. Plant site (1 km^2)
3. Mine I-1 (5.76 km^2)

4. Clay mine (4 km^2)

The following report is based on field surveys at the project sites during c. 20-26 May 2015. It includes an assessment of the potential environmental impacts of the proposed development of the mine on vegetation communities and fauna.

Limitations to interpretation of biological surveys in Timor-Leste

There is no national mapping of vegetation communities, and there are very few site-specific surveys of vegetation communities that are useful for comparisons. This makes it difficult to characterize the relative biological importance of vegetation types. The IUCN has assessed the conservation status of plant and fauna species which have been described, but undescribed species have not yet been assessed. Of the c.60 amphibian and reptiles species recorded to date from Timor-Leste, approximately 26 (43%) are yet to be described (O'Shea *et al.* 2015). Additionally there are undescribed species of, at least, shrews, rodents (extinct and possibly extant taxa) and bats. Very little is known of the national distribution and habitat use patterns of these species. Among fauna groups birds are the richest and by far the best known, with relatively detailed information on distribution, habitat use and status (via IUCN and national) available.

While the global conservation status of some plant and fauna species occurring in Timor-Leste have been assessed, there is no national biodiversity database or Atlas scheme, and no formal Timor-Leste assessment of the conservation status of vegetation communities, plant and fauna species. However, Annexure 1 of the proposed Biodiversity Decree Law provides an "Interim list of protected species" in Timor-Leste including birds, mammals, amphibians, reptiles and plants, and Annexure 2 is an interim list of "Prohibited Invasive Alien Species" (see www.laohamutuk.org/Agri/EnvLaw/div/SpeciesLists.pdf). This is not yet law but provides an indicative list of flora and fauna species considered important by the Timor-Leste Government, and flora and fauna species which have the potential to harm biodiversity.

The Status of Timor-Leste Flora and Vegetation

The flora of Timor is poorly known, but a review of available data was given by Cowie (2006) with at least c. 1,488 plant species listed for Timor (I. Cowie *pers. comm*.). The flora is transitional between those of the tropical rainforests of Sundaland and the Australo-Papuan region (Roos *et al.* 2004). A large proportion of the dry tropical forest plants of Timor occur also in northern Australia, and often more widely in Malesia (Cowie 2006). A small number of Timor or Lesser Sunda endemic plants are from predominantly Australian families or genera (e.g. *Diuris freya* [Orchidaceae], *Eucalyptus urophylla*, *E. alba, E. orophila* [Myrtaceae], and *Casuarina junghuhniana timorensis* [Casuarinaceae]) (Monk *et al.* 1997; Cowie 2006).

Consideration of vegetation types, structure and floristic composition on Timor has been given by:

- Meijer Drees (1951) "*Distribution, Ecology and Silvicultural Possibilities of the Trees and Shrubs from the Savanna-Forest Region in Eastern Sumbawa and Timor (Lesser Sunda Islands)*" which describes vegetation types and their floristic components, particularly in open woodlands-savannas;
- Martin and Cossalter (1977): "*The Eucalyptuses of the Sunda Isles*" describes the status, taxonomy, distribution, floristic composition of *Eucalyptus* woodlands on Timor and the Lesser Sundas islands.
- Metzner (1977): "*Man and environment in Eastern Timor: a geoecological analysis of the Baucau-Viqueque area as a possible basis for regional planning"* which describes plant species composition, vegetation structure and maps vegetation types in the Baucau region including the study area;
- Monk *et al*. (1997) "*The Ecology of Nusa Tenggara and Maluku*" provides a vegetation classification based on literature review, and plant species composition and structure of vegetation types.
- Whistler (2001) "*Ecological Survey and preliminary botanical inventory of the Tutuala beach and Jaco Island*" described the vegetation types, structure and composition in the far east of Timor-Leste.
- Cowie (2006) "*Assessment of floristic values of the proposed Jaco-Tutuala-Lore National Park, Timor-Leste (East Timor)"* The most detailed consideration of vegetation communities in Timor-Leste, but focusing mostly on Closed tropical forest types.
- Grantham *et al.* (2011) "*Timor-Leste: interim national ecological gap assessment*". An attempt at an environmental classification using "geoformations" based on a geological classification map, a Land use classification (mixed in with elevation and other environmental data) from the ALGIS Unit (Ministry of Agriculture and Fisheries), in the absence of a detailed information on the distribution of vegetation communities. This was part of a conservation activity to conserve "representative examples of geophysical settings".
- WorleyParsons (2012) "*Suai supply base Environmental Impact Assessment, attachments: Flora and Fauna Final Technical report*" describes vegetation types, and provides a botanical inventory of the Suai supply base area on the south coast of Timor-Leste.

The dominant natural vegetation types are broadly savanna woodlands (often dominated by *Eucalyptus*, *Acacia*, *Borassus* and *Corypha*), open forest, Closed canopy tropical forest ("monsoon forest", "rainforest"; from high rainfall evergreen forest to drier types, typically driven by interactions of elevation-rainfall-geology and topography). Closed Tropical Forest is biologically rich with diverse tree and shrub communities. It also provides habitat for rich communities of endemic bird, mammal, and reptile communities. Historically much Closed Tropical Forest on Timor has been converted to agriculture, harvested during colonial times, or converted during Indonesian administration to reduce safe havens for resistance fighters.

In Timor-Leste loss or conversion of Closed tropical forest is the major driver of population loss and decline of biologically significant tropical forest and species listed by the IUCN as threatened with extinction. This includes at least three tree species, a species of shrew, the Vulnerable Western Naked-backed Bat *Dobsonia peronii*, one Critically endangered bird (Yellow-crested Cockatoo *Cacatua sulphurea*) three Endangered birds (Timor Green Pigeon *Treron psittaceus*, Wetar Ground Dove *Gallicolumba hoetdi* and Timor Imperial Pigeon *Ducula cineracea*) and an additional 13 Near threatened bird species. Loss or conversion of tropical forest is the most important driver of population decline of most of these species, but hunting and or trade has been important driver of population decline for several species such as the Yellow-crested Cockatoo and pigeons. Recent invasions are also driving declines: the Black-spined Toad *Bufo melanostictus* has been implicated in the decline of some native snakes and amphibians, but remains very poorly known.

The *Eucalyptus* woodlands have typically been given little conservation attention in Timor-Leste, as they have been assumed to be less biologically significant than Closed Tropical Forests. In terms of tree and plant richness, bird and bat richness this clearly is the case. *Eucalyptus alba* was originally described as a species from specimens collected on Timor, and under present-day taxonomy occurs widely in northern Australia, as well as Flores, Alor, Wetar and other islands in the Lesser Sundas. Martin and Cossalter (1977) state that "*E. alba* does not pose any problem of botanical nomenclature; the species present in the Sunda Isles is exactly the same as the one found in the north of Australia". However, *E. alba* on Timor and neighboring islands is clearly a different species to the tree present in northern Australia (I. Cowie pers. comm. 2010), and may consist of several endemic islands forms. Quite extreme morphological variation in *E. alba* is described for the Timor-Leste region by Martin and Cossalter (1977), and further research might recognize taxa within Timor.

The Status of Timor-Leste's Fauna

Timor has a classical island fauna characterized by low overall species richness and high levels of endemism. A feature of Timor is the high proportion of wildlife that are strongly associated with tropical forest. Timor's present-day fauna is the result of natural colonization by overwater dispersal and more recent human-mediated introductions (from the Orient, Australo-Papuan, Wallacea and Old World, with some tramp ants from Africa and South America), subsequent in-situ speciation and extinctions over the last 4 My.

Historical collecting and observation of Timor's birds was summarised in a major monograph *The Birds of Wallacea* (White and Bruce 1986) with 212 birds listed. Subsequent field observations including species status and habitat use have been summarized in a field guide (Trainor *et al.* 2007a). Endemism is high. There are 126 resident landbirds (excluding migrants/visiting birds and waterbirds). On current information there is at least seven species endemic to Timor Island, at least 39 species (31% of resident landbirds) are globally restricted-range (with distributions of less than 50,000km^2) and 44 species (35%) are endemic to the Wallacean region (CRT unpubl. data). About 80 birds are considered forest specialists and these species particularly susceptible to forest loss and conversion.

At least 52 mammal species are known from Timor, but remarkably, other than bats few native land mammal species have been recorded since 1800 – the Thin Shrew *Crocidura tenuis* and

Timor Rat *Rattus timoriensis* and undescribed shrews. The Long-tailed Macaque (*Macaca fascicularis*) has long been considered as an introduced species, but recent molecular work shows that it has existed on Timor for c. 930,000 years (range 740,000-1,240,000 years: Liedigk *et al.* 2015). Bats are the most speciose group, with at least 28 species accepted for Timor-Leste, and possibly as many as 35+ taxa present (Armstrong & Konishi 2015). A single monograph covers the bats of Timor (Goodwin 1979) but a series of surveys by the Western Australian Museum (Kitchener *et al*. 1992, 1995), and more recently (Helgen 2004; Armstrong 2006) has added new island records and clarified the taxonomic status of some species including endemic and undescribed taxa. Greater effort of trapping and collecting specimens, and recording of bat calls while releasing live bats is needed to advance knowledge of bats in Timor-Leste. At least 17 mammals have been introduced to Timor (Glover 1986).

Knowledge of the taxonomic status amphibian and reptile faunas has improved greatly over the past 10 years. Of c.55 species listed in 2015 (excluding marine species/turtles), approximately 26 species may be undescribed (O'Shea *et al*. 2015). This includes at least two amphibians, eight geckos, 14 lizards and two snake species (O'Shea *et al*. 2015). The habitat use, distribution and status of most amphibian and reptiles species remains very poorly known. Current knowledge suggests that many species may be highly localized on Timor (O'Shea *et al*. 2015) but this may also be caused by low survey effort. Habitat use patterns are also poorly known making conservation assessments, and assessments of environmental impact, somewhat problematic.

Conservation planning and policies in Timor-Leste

The history of protected area establishment in Timor-Leste is brief. In 1967 two forest reserves were established by the Portuguese colonial government at Tilomar (Suai district) and Lore (Lospalos), with the aim of protecting Sandalwood *Santalum album* (FAO/UNDP 1982). In 1982, nine West Timor and eight East Timor sites, including Tilomar and Lore, were identified as key representative natural areas as part of the Indonesian-wide *National Conservation Plan* (FAO/UNDP 1982). In 2000, the UNTAET administration prepared interim legislation 'protecting designated areas, endangered species, coral reefs, wetlands, mangroves areas, historic, cultural and artistic sites, conservation of biodiversity and protection of biological resources of Timor-Leste' by designating 15 'Protected Wild Areas' (*Regulation NO. 2000/19 On Protected Places* (UNTAET 2000). The 15 sites included all of those proposed by the FAO/UNDP in 1982 covering at least 1,868 km^2, or about 13% of the nation's land area but boundaries were not defined and the 15 sites have not been recognized in land use planning (Trainor *et al.* 2007b). In collaboration with the Timor-Leste government, BirdLife International conducted field surveys, which were published as an Important Bird Areas directory for Timor-Leste, including 16 site accounts (Trainor *et al.* 2007b). This included many sites previously gazetted under the United Nation's interim legislation. In August 2007 the nation's first protected area - Nino Konis Santana National Park - was declared, and since then many additional sites have been identified as conservation areas.

Timor-Leste became a party to the Convention on Biological Diversity in 2007, the UN Convention to Combat Desertification, and the UN Framework Convention on Combating

Climate Change. The Biodiversity Decree Law 2012 is a means to fulfilling Timor-Leste's obligation under the Convention on Biological Diversity to provide the legal framework for "conserving biodiversity, sustainably using biological resources and equitably sharing benefits generated from genetic resources". More specifically:

> *The State shall define and implement a strategy to ensure conservation of biodiversity: a. The protection and conservation in situ and ex situ populations of species and their habitats, and ecosystems; b. Reproduction in quality and quantity of the species, especially threatened and endangered species; c. The rehabilitation and restoration of degraded habitats and ecosystems and recovery of threatened or endangered species; d. The creation and maintenance of a national system of protected areas ensure the ecological coherence of the territory and the continuity of species and ecosystems; e. Access and equitable sharing of benefits arising from sustainable use of genetic resources and traditional knowledge.*

Some of the most relevant guiding principles relating to environmental assessments in the draft Base Law on Environment:

- *Preventive principle: Programs, plans or projects with environmental impact must anticipate, prevent, reduce or eliminate the primary causes and correct the effects which may alter the quality of the environment.*
- *Precautionary principle: the lack of full scientific certainty of the existence of a risk of serious or irreversible damage to the environment should not be used as a reason for postponing the adoption of effective measures to prevent or minimize the change in quality.*

Environmental Licensing Decree Law No. 5/2011

The main guiding principles of the regulation of the Environment Licensing Decree Law are:

- *Ensuring the participation of the community and of the public in the Environmental Assessment process.*
- *Identifying and assessing the consequences of the development proposals for the environment;*
- *Creating the conditions for minimizing or eliminating the environment and social negative impacts arising from the implementation of projects;*
- *Determining the environmental and social protection measures to be applied at the time the projects are implemented;*
- *Instituting a process for issuing environmental licenses resulting from environmental assessment that can truly contribute to environmental control.*
- *Overseeing and monitoring the projects according to the provisions of the Environmental Management Plan (PGA).*

This report:

- *Identifies vegetation communities, describes the structure, plant composition and broad environmental relationships of vegetation communities at the study sites*
- *Identifies plant species of conservation concern (ie IUCN listed species), describes their location and habitat affinities.*
- *Describes the terrestrial fauna of the study sites – including abundance, composition, habitat relationships and conservation status.*
- *Makes recommendations to minimize environmental harm caused by the proposed mine.*

Methods

Local participation by Timor-Leste workers

During the field survey of flora, vegetation and fauna four local hamlet chiefs (Cefe aldeia) worked in the field with consultants at Mine-I-1, Jetty and Plant, and two local villagers worked with consultants at the Clay site (Figure 1).

Figure 1. Local assistants Cypriano Belo and Pedro da Costa search for fauna species under rocks, rockwalls and logs during the survey.

Flora and Vegetation survey

A representative assessment of the dominant plant types and their abundance and associations was undertaken throughout the key development zones, Plant Site (1km^2), Mine I-I, hereafter "Mine" (5.76km^2; see Figure 2), Clay Mine (4.0km^2) and Jetty (0.05km^2) during 20-25 May 2015. The assessment methodology included a combination of initial random points within the key test sites that were then further expanded to include any different neighboring vegetation assemblages based on field observations.

Each survey site consisted of individual 25m x 25m (625m^2) quadrat sampling zones. Within each of these zones, the dominant vegetation types were assessed and sampled at the upper, middle and lower stratums. Additional information recorded at each site included disturbance, basal area(m^2), height range (m), weed cover abundance, canopy cover (%), litter cover (%), gravel extent (%), bare earth (%) and soil types. At a floristic level, any unusual plant specimens that could not be identified in the field were also collected for identification later. In total 22 different sites were sampled over 13,750m^2. Individual site survey reports are provided as Appendix 1, and a full list of plant species is given as Appendix 2. Vegetation quadrat sample locations and tracks are shown graphically in Figures 3 & 4.

Vegetation assemblages in this report are described in terms of “structural formation” in accordance with the widely accepted Australian National Information System (NVIS) standards (ESCAVI) Department of the Environment and Heritage, 2003) at Level II. The vegetation community definitions used in NVIS fit well with many of the woodland and Closed Tropical Forest environments of Timor-Leste and both countries share many similar species. In compiling this report attention was also given to previous recognized works in classifying vegetation in Timor-Leste including: Cowie (2006); Meijer Drees (1951) and Monk *et al*. (1997).

Figure 2. View of Mine site and Plant site looking North West.

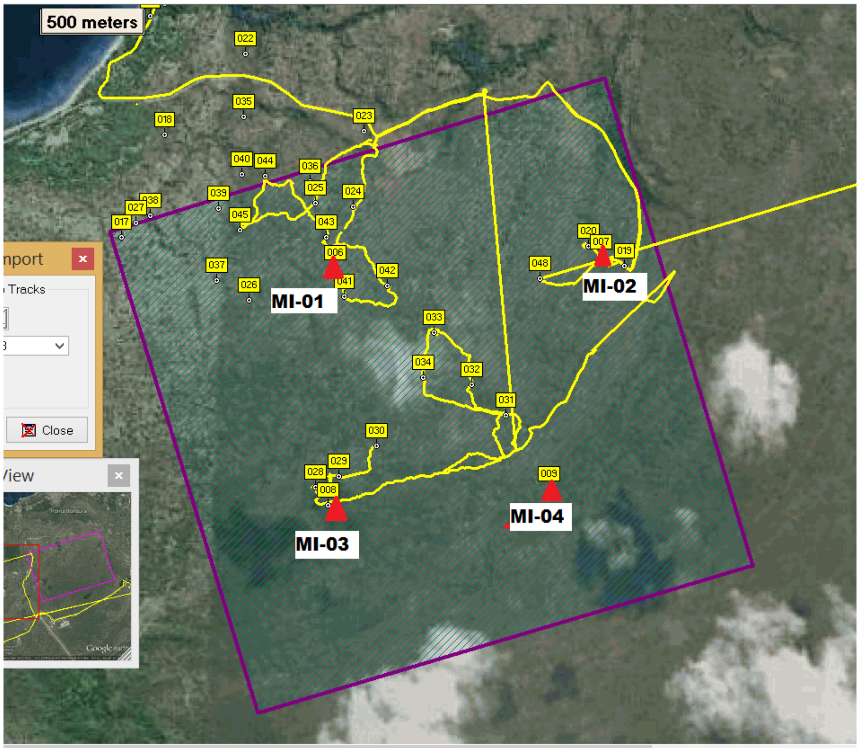


Figure 3. Vegetation quadrat survey and GPS tracks on the Mine site, Plant and Jetty.

Figure 4. Vegetation quadrat survey and GPS tracks on the Clay site.

Fauna survey

Bird Survey
A total of 25 Point counts were carried out through each of the study areas, mostly in the morning when birds are most actively vocalizing. All birds seen or heard within a 50 m radius of the sample center point would be recorded on a proforma, and birds recorded beyond approximately 50 m would be noted separately. At the same time 10 minute searches for reptiles, amphibians and mammals were conducted by either one or two local assistants.

Acoustic Bat Recording
Recording units convert ultrasonic echolocation signals produced by bats into audible electronic signals, which are later analysed for species specific calls. Four recording units were set up in the main habitats in several sites particularly targeting significant bat habitat such as Closed Tropical Forest, caves and cliffs. Units were left in place for 2-5 night nights at Site I-1 and Clay site for a total of 26 recording unit x night sessions. There was a technical issue with the compatibility of microphones and recording devices in the May survey. After these were resolved an additional 2-day repeat survey in late June was done to ensure a substantial set of data was collected (Table 1). Bat calls were analysed and assigned to species or call types by Specialised Zoological (see Armstrong & Konishi 2015).

Opportunistic Searches
Opportunistic searches were carried out to target specific habitats (e.g. cliffs, caves, rock outcrops, Closed Tropical Forest) potentially supporting fauna of conservation significance. Active searching involved raking through leaf litter, overturning rocks and logs, and investigating overhangs.

- Birds – opportunistic records of all bird species (and other fauna) were written in a notebook, together with coordinates, habitat and elevation data.
- *Nocturnal Spotlighting* - Spotlighting and head torching at night on foot is an important surveyed nocturnal fauna, such as snakes, geckos, owls and nightjars. Spotlighting was done at the Mine and Clay sites for one night over 2 hrs each.
- *Targeted but opportunistic bat searches: caves, escarpment and overhangs.* Coastal palms were also searched for palm tree roosting species.

Fauna Habitat assessment
Fauna habitat was characterized by filling in a proforma including coordinates, elevation, major vegetation structural features such as estimates within a 50 m radius of a central point for percentage canopy cover and canopy height, and percentage cover of various vegetation layers, rock and litter cover, number of logs and estimates on a one to five scale of relative disturbance level (fire, livestock grazing, agriculture and weeds).

A fauna species list by site is included as Appendix 4 and fauna for each of the 25 point counts included as Appendix 5; individual fauna habitat proformas are included as Appendix 6, and a summary of coordinates, habitat and elevation for each of the 25 point counts included as Appendix 7. A summary of acoustic bat recordings are given as Appendix 8, and a report on analysis and identification of bat recordings is given as Appendix 9 (Armstrong & Konishi 2015).

Results

Vegetation and Flora

JETTY SITE

The Jetty is located at the nearby beach and will include a conveyor belt to the plant site. The area is flat and already highly modified by temporary dwellings, grazing and some agriculture. The general environment is characterised by sandy soils and established breadfruit *Artocarpus altilis* and *Corypha sp* palm groves. The area is also severely infested with weeds (Figure 6).

The overall site is dominated by a relatively uniform coastal Closed Tropical Forest (70%) which is most likely a combination of existing forest and mature plantation trees. The remaining area (30%) is cleared grazing land and residential farms.

Figure 6: Jetty site

Vegetation type, abundance and height range

The coastal Closed Tropical Forest is dominated by *Borassus flabelifer, Corypha utan* and *Artocarpus integer*. Additional examples of *Artocarpus atilis, Cocos nucifera, Persea americana* and *Tamarindus indica* were recorded for the upper stratum. The height range within the

Closed Tropical Forest systems is 20 to 30m. The middle stratum was largely absent but included some juvenile representatives of the upper stratum. The lower stratum is primarily dominated by a heavy infestation of the weed *Lantana camara* with other areas characterised by high leaf litter from the overhead palms.

Qualitative description

Overall, the Jetty site is a heavily modified plantation environment with a severe infestation of *Lantana camara* throughout. The biological diversity at these sites was very low and overall the site was not representative of a pristine coastal/beach forest. No plant species listed by the International Union for Conservation of Nature (IUCN) were found at the Jetty site.

PLANT SITE

The plant site is located on NNE facing slopes and plains relatively close to the beach, road and proposed jetty area. The site is characterized by shallow limestone soils with scattered limestone rock outcrops, minor ridges and gullies sloping towards the beach. The site consists predominantly of very open savannah woodland (95%) which has been extensively modified for agriculture and grazing in places. The remaining areas were isolated patches of Closed Tropical Forest systems (5%), occurring in depressions and drainage floors and often surrounded by introduced *Lantana camara* (Figures 7 & 8). For representative purposes surveys were conducted in each of these two systems.

Vegetation type, abundance and height range

The open woodland environment at the plant site is dominated by *Eucalyptus alba* and Ceylon Oak *Schleichera oleosa* (Tetum: Aidak) ranging in height from 8 to 10 m. Canopy cover in this area was very sparse at less than 10%. Native species present in the middle stratum included, *Eucalyptus alba* juveniles, *Canarium vulgare* (Tetum: Kai Tudo) and *Annona squamosa* (Tetum: Ai Ata) but both the middle and lower stratums are primarily dominated by introduced invasive species, including, *Ziziphus mauritiana* (Chinee Apple), *Lantana camara* and *Chromolaena odorata* (Siam Weed). Some grassland is intact with the dominant grass being *Iseilma minutiflorum*. The Closed Tropical Forest environment is dominated by *Ficus* species (unidentified) ranging in height from 10 to 15 m and the invasive *Tecoma stans* (Tetum: Ai funan kinur) as a secondary dominant small tree. The Closed Tropical Forest site had a dense canopy of approximately 70%. Additional native trees recorded at this site include, *Intsia bijuga* (Borneo Teak), *Tamarindus indica*, *Senna timoriensis* and *Streblus asper.* The middle stratum was dominated by juvenile representation of the upper storey with 70% coverage of leaf litter.

Qualitative description

The open woodland site had an 80% level of disturbance from weed infestations and grazing. The Closed Tropical Forest area had a 30% level of disturbance from weeds on its edges but was relatively weed free and undisturbed at its centre. The dominant weeds across the two sites include, *Tecoma stans*, *Lantana camara*, *Jatropha gossypifolia*, *Chromolaena odorata* and *Hyptis suaveolens. Intsia bijuga* (Borneo Teak) was present at survey site P002 (Figure 9) and is listed as Vulnerable by the International Union for Conservation of Nature (IUCN) Red List.

Figures 7 & 8: Mr Carlos Assis Bento sampling vegetation at P002 Plant site

Figure 9. Intsia bijuga was recorded on the Plant site at P002.

MINE SITE

The mine site is located across NE to NW facing stepped slopes and plains on limestone outcrops with higher slopes on the southern edge of the site and flatter plains towards the northern boundary. The site is predominantly uniform woodland to open woodland (95%) with isolated small patches of Closed Tropical Forest (5%) occurring in minor ravines and gullies, and grassland. The site is characterized by shallow limestone soils and extensive scattered, small to medium sized limestone rock outcrops. Nine separate survey locations were undertaken. These sites radiated out from the test drill locations and targeted different vegetation assemblages wherever available.

Vegetation type, abundance and height range

The open woodland environment (95%) at the mine site is dominated by relatively uniform *Eucalyptus alba* and *Schleichera oleosa* assemblages, ranging in height from 8 to 10m (Figure 10). Additional native species occurring in lesser numbers in the upper stratum included, *Acacia sp, Alstonia actinophylla, Gmelina arborea, Dalbergia timoriensis, Miliusa sp, Santalum album, Senna timoriensis and Syzigium nervosum.* The middle stratum is largely absent but includes examples of dominant juveniles and various invasive weeds including, *Ziziphus mauritiana*, *Lantana camara* and *Chromolaena odorata* (Siam Weed). The lower stratum is grassland, predominantly *Iseilma minutiflorum*, with mixed herbs including *Indigofera linifolia* and *Uraria lagopodiodes*.

The Closed Tropical Forest (5%) patches are characterised by canopy cover in excess of 70% and are typically dominated by mature *Schleichera oleosa* but also included lesser examples of *Acacia sp, Cryptocarya foetida, Dalbergia timoriensis, Syzigium nervosum* and *Santalum album*. The height range within the Closed Tropical Forest systems is 8 to 10m. The middle stratum within these isolated Closed Tropical Forest systems exhibited the greatest species richness of all sites surveyed and included examples of *Dichapetalum timorense, Dischidia major, Neoalsomitra podagrica, Tricolor Lindle, var insignis* and *Wrightia pubescens.* The lower stratum within the Closed Tropical Forest patches is characterised by higher than average leaf litter and mixed herbs and grasses including, *Breynia cernua, Imperata cylindrical, Iseilma minutiflorum*, *Justicia procumbens, Phyllanthus virgatus*, and *Uraria lagopodiodes.*

Qualitative description

The mine site open woodland (95%) varies in the degree of disturbance and degradation dependent on physical barriers such as excessive exposed limestone outcrops, which appears to restrict grazing animal access somewhat. However, across the majority of open woodland sites weed species, including *Hyptis sauvleons, Chromolaena odorata, Jatropha gossypifolia, Lantana camara, Tecoma stans* and *Ziziphus mauritiana* were usually secondary dominant species in each of the stratum. The percentage of weed infestation varied from 3% to 45% across the surveyed locations. On average the canopy cover in the open woodland environments is approximately 10%.

Santalum album was present at survey site MI03-001 and is listed as Vulnerable on the International Union for Conservation of Nature (IUCN) Red List. *Indigofera linifolia* was also identified at MI02-001 and is listed as Least Concern.

Figure 10: Representative open woodland site.

CLAY MINE SITE

The clay mine site is located in the Wailacama village area and is characterised by greater topographic relief than the other project locations with steep slopes ranging in aspect from E to WNW, incised rivers and heavy grey clay soils. The overall site is dominated by Closed Tropical Forest (60%; Figure 11) and degraded woodland (40%). However, vegetation communities within the survey localities of the 4 test pit sites included, Closed Tropical Forest (30%), bamboo forest (20%) and degraded open woodland (50%). These survey sites radiated out from the test drill locations and targeted different vegetation assemblages wherever available.

Vegetation type, abundance and height range

The Closed Tropical Forest (30%) patches are characterised by canopy cover in excess of 70% and are primarily dominated by *Peltophorum pterocarpum* but also included lesser examples of *Hibiscus hirtus*, *Terminalia cattapa, Ziziphus oenopolia* and *Ziziphus timoriensis.* The height range within the Closed Tropical Forest systems is 10 to 15m. The middle stratum within the Closed Tropical Forest systems exhibited only moderate diversity with the majority of the stratum taken up by juvenile representatives of the upper stratum. Lesser examples found include, *Citrus sp, poss gracilis*, *Pometia pinnata, Schleichera oleosa* and *Miliusa sp.* The lower stratum within the Closed Tropical Forest patches is characterised by high leaf litter. Both Closed Tropical Forest survey sites were heavily infested with *Lantana camara* and lesser amounts of *Jatropha gossypifolia* and *Chromolaena odorata.*

Figure 11: Closed Tropical Forest example at TP01-001 Clay Mine

The bamboo forest environments (20%) were concentrated in the south of the project area and were usually concentrated in isolated patches with only limited diversity through the middle and lower stratums. The dominant bamboo species present across both sites is a thorny clumping style *Dendrocalamus sp* with a canopy cover between 30 to 45% and a height range from 10 to 15m. Lesser examples of *Acacia leucophloea*, *Peltophorum pterocarpum*, *Pterocarpus indica*, *Senna surattensis* and *Sesbania grandiflora* and *Tectona grandis* are also present. The middle stratum is limited and included examples of small *Acacia nilotica* and *Senna surattensis.* The lower stratum in the bamboo forest systems (Figure 12 & 13) exhibits a higher degree of diversity and included examples of *Ageratina riparia, Brucea javanica, Canavalia papuana*, *Desmodium gangeticum* and *Gliricidia sepum.* Both bamboo survey sites have high levels of *Chromolaena odorata and Acacia nilotica (juvenile)* infestations.

The open woodland environment (50%) across the clay mine site is characteristically located on hills and slopes between sections of Closed Tropical Forest and located largely on the eastern side of the site between Test Pits 01 and 04. The majority of these sites were heavily degraded, particularly through grazing and weed infestations. Of the five survey sites undertaken two had extremely low biological diversity. Canopy cover at these sites was less than 10% with a tree height range from 8 to 15m. In the upper stratum, *Acacia leucophloea* and *Peltophorum pterocarpum* were the dominant species, with lesser examples of *Pterocarpus indicus* (Figure 14) and *Eucalyptus alba.*

Figures 12 & 13: Bamboo Closed Tropical Forest at TP04-001 (Dendrocalamus sp. & Ceiba petandra)

The middle stratum is largely absent or dominated by well-established invasive species including *Acacia nilotica*, *Lantana camara* and *Ziziphus mauritiana.* The lower stratum ranged from exposed soils with scattered limestone outcrops to a relatively diverse grassland of *Iseilma minutiflorum*, with mixed herbs including *Indigofera linifolia* and *Thecanthes concreta*. Most lower-stratum sample sites also included *Acacia nilotica*, *Hyptis sauvleons, Lantana camara* and *Chromolaena odorata.*

Qualitative description

Overall, the clay mine site has a mixture of either Closed Tropical Forest or bamboo forest on the steeper slopes and heavily degraded open woodlands on the hills and rises between. The Closed Tropical Forest environments exhibit a higher than average biological diversity, whereas the open woodland sites had very low biological diversity. Across the majority of open woodland sites weed species, including *Hyptis sauvleons, Chromolaena odorata, Jatropha gossypifolia, Lantana camara,* and *Ziziphus mauritiana* were usually secondary dominant species in each of the stratum. The percentage of weed infestation varied from 10% to 100% across the surveyed locations.

Pterocarpus indicus was identified at survey site TP01-002 and is listed as Vulnerable on the International Union for Conservation of Nature (IUCN Red List: Figure 14). *Indigofera linifolia* was present at survey site TP03-001 and is listed as Least Concern.

Figures 14: Mr Carlos Assis Bento with a Rosewood Pterocarpus indicus tree.

Fauna survey

A total of 87 vertebrate fauna species were recorded during the survey including two amphibians (one native taxon), eight reptiles (six native taxa), 21 mammals (12 native taxa, 9 introduced species) and 56 bird species (Table 2). Three landsnail taxa were also recorded. The fauna was highly typical of lowland woodland habitats on Timor in particular, with some forest specialized birds present, particularly associated with the Clay mine.

A large proportion of the recorded fauna, especially among amphibians, reptiles and mammals consisted of introduced/tramp or invasive species which are not native to Timor-Leste. Some introduced species were common e.g. Black-spined Toad (*Bufo melanostictus*), Tokay Gecko (*Gekko gecko*), with livestock species such as Water Buffalo, Banteng/cattle, horse and sheep regularly observed grazing at the Mine and Clay sites. All 12 bat species recorded were native species.

The greatest number of species was recorded in the largest study sites with 57 fauna species recorded at the Mine I-1 and 72 fauna species recorded in the Clay site, with fewer species at the Jetty and Plant. Only two individual native frogs were recorded, but the invasive Black-spined Toad was frequent in the Mine and Clay areas. At least 10 echolocating bat species were present in the project area, with four species able to be identified to species-level. At least four species of cave roosting bat were recorded and identified to species-level (two species of *Rhinolophus; Hipposideros diadema*, *Miniopterus australis*), with several others likely (other *Miniopterus* spp.; *Taphozous* spp.) to occur (Appendix 9: Armstrong & Konichi 2015). Thus, up to a maximum of eight out of ten echolocating bat species recorded on the survey use caves for daytime roosting (Armstrong & Konichi 2015). The Indonesian Short-nosed Fruit Bat was the only native mammal directly recorded with small numbers observed under palm fronds at the Jetty site. Local assistants reported that the Long-tailed Macaque was present at the Plant, Mine I-1 and Clay Site.

Table 2. Fauna species richness at study sites. The number of introduced or livestock species is shown in parentheses. In addition three landsnail taxa were recorded at Plant and Mine I-1, and two landsnail taxa were recorded at the Clay mine.

	Amphibians	Reptiles	Mammals	Birds	Total
Jetty	0	4(2)	11(1)	8	23
Plant	0	2(2)	4(3)	14	20
Mine I-1	1(1)	3(2)	14(8)	39	57
Clay mine	2(1)	4(2)	18(8)	48	72

Of the 56 bird species recorded, 22 were globally restricted-range species, six species were IUCN Near threatened species (all of these were also restricted-range species) and 23 species are considered as “forest specialists”. The Clay Site had the greatest number of restricted-range species (all 22 species recorded during the survey), Near threatened (all six species) and forest specialist bird species (all 23 species), but the more open habitats of the Jetty, Plant and Mine hosted fewer bird species of conservation concern and were dominated by woodland-open country (non-forest specialist) bird species. Four open-country bird species were absent from the Clay mine (Appendix 4). Patterns of bird species distribution closely follow vegetation patterns, with Near threatened, restricted-range and forest specialized birds strongly associated with Closed Tropical Forest which was unsampled or absent at the Jetty, Plant and Mine site.

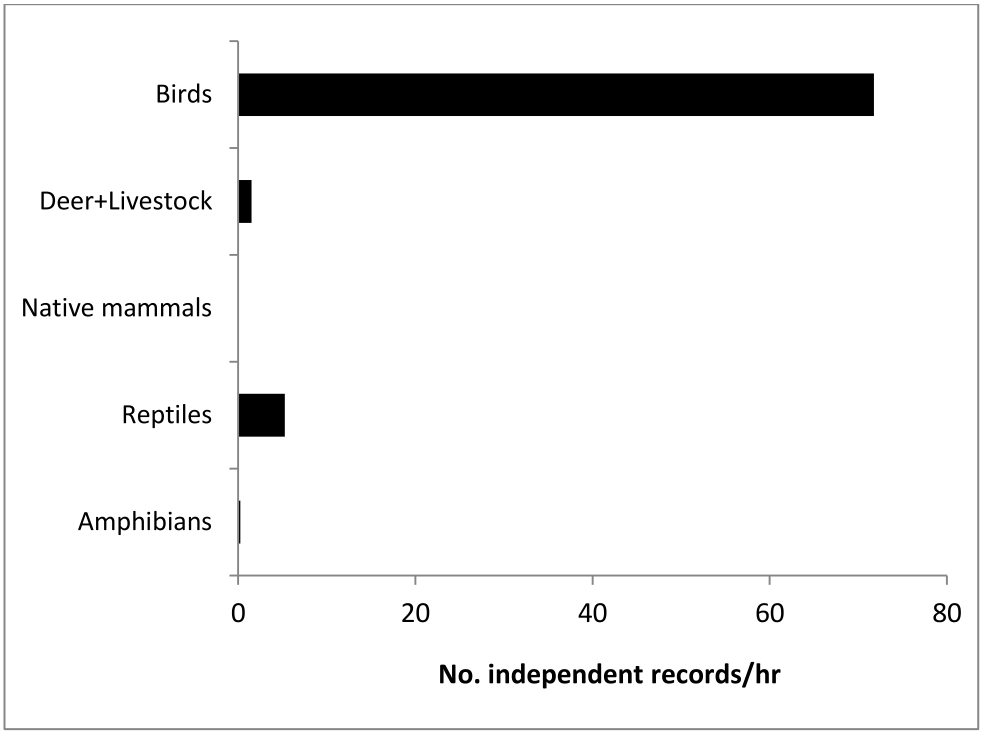


Figure 15. Relative abundance: the mean number (per hr) of independent fauna species records at systematic point counts (from total of 250 mins). Note: acoustic bat recording was not done at point counts.

There was a total of 315 independent fauna records at the 24 point counts (species x point counts) dominated by 287 (91.1%) bird records (Figure 15). There was a single point count record of an amphibian (Black-spined Toad), 21 records of reptiles mostly of Tokay Gecko and House Gecko, and just six point count records of mammals (all livestock or Timor Deer *Cervus timorensis*).

Ten bird species were recorded frequently at nine or more of the 24 point counts (Figure 16): Barred Dove *Geopelia maugeus* (19), Streak-breasted Honeyeater *Meliphaga reticulata* (18), Blue-cheeked Flowerpecker *Dicaeum maugei* (18), Fawn-breasted Whistler *Pachycephala orpheus* (15), Plain Gerygone *Gerygone inornata* (15), White-bellied Bush Chat *Saxicola gutturalis* (14), Timor Friarbird *Philemon inornatus* (13), Zebra Finch *Taeniopygia guttata* (12), Northern Fantail *Rhipidura rufiventris* (11), Timor Figbird *Sphecotheres viridis* (10), Rainbow Bee-eater *Merops ornatus* (10) and Glossy Swiftlet *Collocalia esculenta* (9).

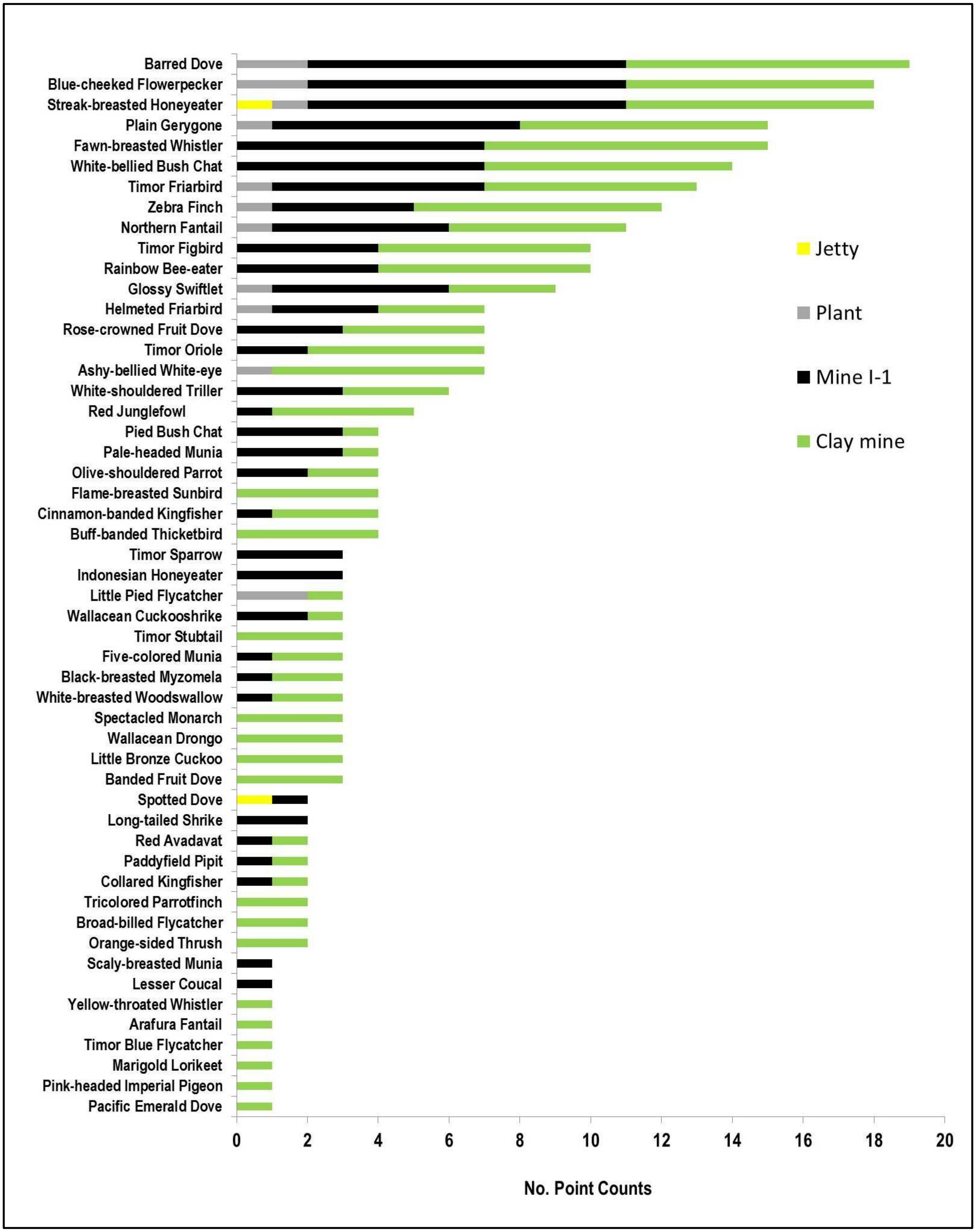


Figure 16. Frequency of occurrence of bird species in 24 point counts at the Jetty, Plant, Mine I-1 and Clay mine.

JETTY SITE

Fauna habitat description

The Jetty site consisted of degraded Beach Forest to 19 m tall with 30-70% canopy cover, dominated by *Corypha* palm, Coconut palm *Cocos nucifera* and breadfruit *Artocarpus* sp, with weedy or bare understorey. There were some logs on ground and patchily extensive leaf litter.

Fauna composition and significance

Nine of the 10 insectivorous microbat species were present. Approximately 30 Indonesian Short-nosed Fruit Bat (*Cynopterus titthaecheilus*) were photographed roosting under *Corypha* palm fronds at the Jetty and the Timor Inornate Bronzeback (*Dendrelaphis inornatus*) snake was observed in litter at the site. Otherwise few bird species were recorded, and it was characterized as having low to moderate fauna habitat quality because of extensive disturbance to natural vegetation.

The following photographs illustrate habitats (Figures 17-28), amphibians, reptiles, mammals and birds in habitat at Baucau sites (Figures 29-46) and landsnail taxa collected (Figures 47-48).

Figure 17. Main habitat types at study sites: Corypha palm dominated Beach forest at Jetty.

Figure 18. Main habitat types at study sites: Eucalyptus alba woodland view across Mine and Plant sites

Figure 19. Typical Eucalyptus alba woodland with a grassy understorey on Mine.

Figure 20. Main habitat types at study sites: Schleichera oleosa dominated woodland with weedy understorey on Mine.

Figure 21. Main habitat types at study sites: well developed Closed Tropical Forest at Clay site.

Figure 22. Old rock wall (red arrow) showing c.50-100+ year old small-holder agricultural boundary in present-day well-developed Closed Tropical Forest at Clay site.

Figure 23. Old rock wall showing c.50-100+ year old small-holder agricultural boundary on Mine site in present day woodland dominated by Scheichera oleosa.

Figure 24. Main habitat types at study sites: bamboo dominated Closed Tropical Forest at Clay site.

Figure 25. Main habitat types at study sites: Irrigated ricefield at Clay site with Closed Tropical Forest background.

Figure 26. Main habitat types at study sites: Heavily grazed shrubland on eroded clay slopes fringed by Closed Tropical Forest at Clay site.

Figure 27. Specific fauna habitat features: Tree hollow in Eucalyptus alba tree at Mine.

Figure 28. Specific fauna habitat features. Bedded limestock rock substrate with few surface-free rocks at Plant site.

Figure 29. Specific fauna habitat features. Hollow tree stem with Tokay Gecko at Plant.

Figure 30. Specific fauna habitat features: Numerous landsnails Parachloritis c.f. newtoni (possibly baucauensis) sheltering under log at Mine.

Figure 31. Indonesian Short-nosed Fruit Bat (Cynopterus titthaecheilus) under Corypha palm frond at Jetty.

Figure 32. A free-range Water Buffalo at wallow on Mine site.

Figure 33. Several horses were seen grazing at the Mine site.

Figure 34. Flocks of sheep were seen grazing at the Mine and Plant sites always accompanied by a shepherd.

Figure 35. Undescribed Rice Paddy Frog (Fejervarya sp 1) at Mine site – the only native amphibian recorded during the survey.

Figure 36. A Black-spined Toad (Duttaphrynus melanostictus) at Mine. This recently arrived alien/introduced and toxic toad was particularly common at the Clay Mine site.

Figure 37. A single White-lipped Island Viper (Trimeresurus insularis) was observed during at the Mine.

Figure 38. The widespread House Gecko (Hemidactylus frenatus) is a vocal species that was commonly recorded at Mine and Plant sites. The photo shows an unusual dark morph individual.

Figure 39. The vocal Tokay Gecko (Gekko gecko) was common at the Clay site and Plant site.

Figure 40. Carlia sp 'lowland' c.f Kaiser et al. (2011), at Mine.

Figure 41. Carlia skink 'Baucau' at mine.

Figure 42. The Near threatened Olive-shouldered Parrot (Aprosmictus jonquillaceus) was recorded regularly at the Mine.

Figure 43. The only grassland specialist recorded during the survey: Paddyfield Pipit (Anthus rufulus) was common at the Clay site.

Figure 44. The Near threatened Orange-sided Thrush (Geokichla peronii) is a forest specialist bird, this juvenile bird was photographed in bamboo at Clay site.

Figure 45. The Near Timor-endemic White-bellied Chat (Saxicola gutturalis) at Mine.

Figure 46. The Near threatened and near Timor-endemic Timor Sparrow (Lonchura fuscata) at Mine.

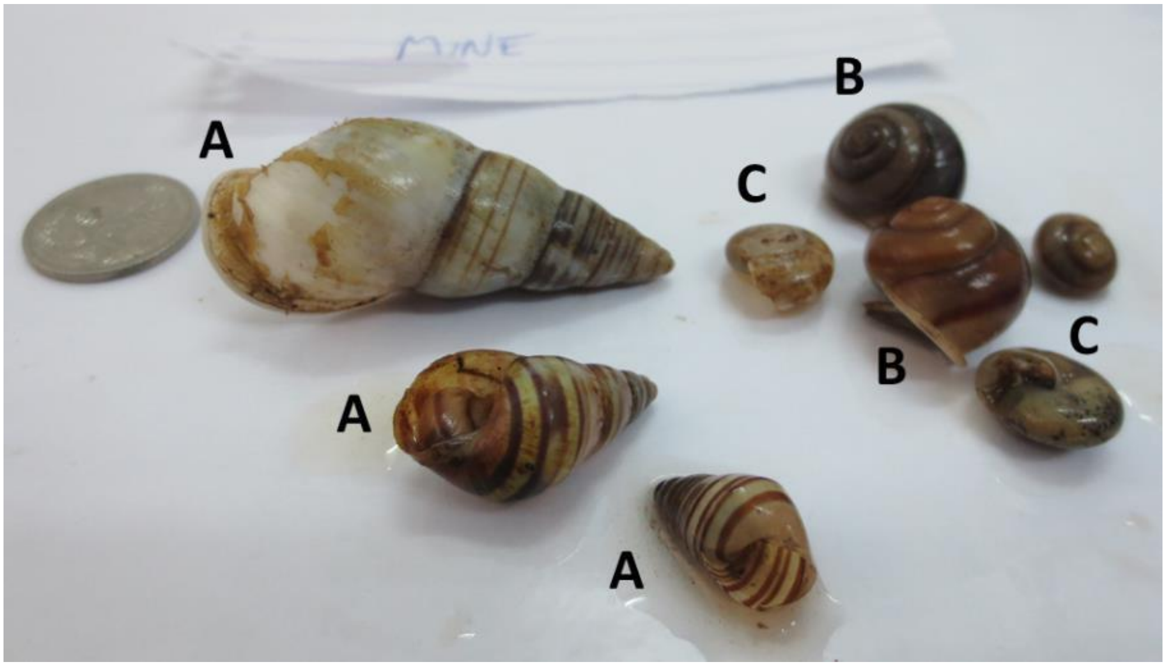


Figure 47. Landsnail taxa collected on the Mine site: A= Amphidromus c.f. contrarius (Family Camaenidae); B= Parachloritis c.f. newtoni (or possibly baucauensis); C= Macrochlamys sp. (Family Helicarionidae).

Figure 48. Landsnail taxa collected on the Clay Mine: A= **Parachloritis** ***c.f.*** **newtoni** ***(or possibly*** **baucauensis*****) (Family Camaenidae); B=*** **Amphidromus** ***c.f.*** **contrarius** ***(Family Camaenidae).***

PLANT SITE

Fauna habitat description

The Plant Site consisted predominantly of open woodland, mainly dominated by *Eucalyptus alba* to 10 m, or mixed woodland with *Schleichera oleosa* with a grassy or weedy ground cover. It was generally under high grazing pressure with large flocks of sheep and free range horses noted in the site. Overall it provided relatively low to moderate fauna habitat quality because it lacked Closed Tropical Forest, had limited vegetation structure, had limited canopy cover and an absence of sharp topographic relief, cliffs, caves, logs and leaf litter.

Fauna composition and significance

The only globally Near threatened species recorded in the Plant was Cinnamon-banded Kingfisher (*Halcyon australasia*) which is generally considered a Closed Tropical Forest specialist, but can also use *Eucalyptus alba* savanna woodland. Otherwise a highly generalized fauna was recorded including open country-woodland birds such as Barred Dove (*Geopelia maugeus*), Streak-breasted Honeyeater (*Meliphaga reticulata*), the two widespread introduced geckos (Tokay Gecko and House Gecko), flocks of about 35 sheep and several horses.

MINE SITE

Fauna habitat description

The Mine site covers approximately 400 hectares over an elevation range of 100-400 m, and is typified by a series of layered platforms. This site was dominated by savanna woodland usually 8-14 m tall with <30% canopy cover particularly dominated by *Eucalyptus alba*, *Schleichera oleosa* or both species, with a grassy or weedy ground cover. In some areas there was increased canopy cover usually of *Schleichera oleosa*. Rock cover was high, but these were often embedded in soil, with no cliffs, caves or particularly rugged rock outcrops observed which can form key refuges for reptiles, mammals and landsnails. Few tree hollows were noted. Weed cover was particularly high in well-grazed woodland (sheep, horse and buffalo).

Fauna composition and significance

The Mine site had a typical woodland-open country fauna comprising mostly introduced or tramp amphibian and reptile species. Five insectivorous bat species were recorded. Microhabitats such as Water Buffalo wallows may increase opportunities for introduced and invasive Black-spined Toad to breed. This invasive toad was commonly observed in the study area, and especially on roads just outside the study area. The bird fauna consisted of a mixture of woodland-open country species and several forest specialized birds. A total of five of the six Near threatened birds recorded during the surveys were recorded on the Mine and in total 14 globally restricted-range species were recorded. Many of these were non-forest species, but the Cinnamon-banded Kingfisher, Timor Oriole *Oriolus melanotis* and Timor Figbird *Sphecotheres viridis* are typically considered as forest specialist bird species.

CLAY MINE

Fauna habitat description

Three main fauna habitats were found on the Clay site: Closed Tropical Forest/bamboo, open shrubland (heavily degraded on clay) and ricefield paddies. The Closed Tropical Forest/bamboo was tall (to 20 m) with extensive canopy (to 80%), with logs, extensive litter, usually low rock cover providing high quality habitat for fauna. Open habitats such as open shrubland and ricefield paddies provided habitat for few bird species, typically open country species, and were categorized as having low to moderate fauna habitat quality. There was infiltration of some forest specialized birds during point counts in open shrubland though this was a scale issue (inclusion of birds within a 50 m radius) rather than shrubland providing habitat for forest birds.

Fauna composition and significance

There was a strong patterns in fauna habitat use, with Closed Tropical Forest/bamboo hosting numerous forest specialized bird species such as Timor Stubtail (*Urosphena subulata*), Black-backed Fruit-dove (*Ptilinopus cinctus*), Pink-headed Imperial Pigeon (*Ducula rosacea*) and Buff-banded Thicketwarbler (*Buettikoferella bivittata*). Twelve forest birds were only recorded on the Clay mine (Appendix 4). Nine of the 10 insectivorous microbats recorded during the overall study were present, mostly in Closed forest, or riverine bamboo thickets. Many forest specialized birds were also recorded from point count samples in open shrubland where in close proximity to fringing Closed Tropical Forest, but these spilled over from Closed Tropical Forest rather than being present in shrubland. Open habitats with little to no canopy cover and few trees such as the open shrubland and ricefield paddies provided low to very low quality fauna habitat. The relatively newly introduced Black-spined Toad occurred widely at the Clay site especially in riparian situations, along stream channels, riparian bamboo thickets and irrigation channels.

Discussion

Vegetation
A total of 22 vegetation surveys were conducted across the four main sites. The key vegetation structural formations surveyed can be broadly described as either "closed forest" systems or "open woodland" systems. The Closed Tropical Forest systems predominantly occur in the drainage lines, gullies and more sheltered areas and exhibit a higher soil moisture level, compared to the adjacent open woodland. The majority of the Closed Tropical Forest systems occurred as isolated patches within the mine and plant site and do not form contiguous bands. *Peltophorum pterocarpum* was the most frequently occurring species in the Closed Tropical Forest environments.

The clay mine site had a significantly higher proportion of contiguous Closed Tropical Forest, particularly on the eastern side of the site. These areas were not however uniform vegetation assemblages but rather variants, including bamboo forest areas, reflecting different elevation, soil and aspect. Across the survey group, the Closed Tropical Forest systems varied in their level of degradation, relative to the edge effects of invasive weeds and whether grazing animals, goats and buffalo, had easy access. All sites were influenced to some degree by invasive weeds. In general, the Closed Tropical Forest systems demonstrated higher plant species richness and diversity and were slightly less degraded than most open woodland sites. The clay mine site was characterised by severely degraded open woodland sections on hills and rises between more species rich pockets of Closed Tropical Forests.

The mine site is predominantly a uniform assemblage of open woodland species, typified by *Eucalyptus alba* (local name Bubu) and *Schleichera oleosa* with limited species diversity. Most survey sites on open woodland had high levels of disturbance from invasive weeds, most notably *Chromolaena odorata* and *Lantana camara.* Grazing pressure was also evident at many locations. The persistence of weeds in the environment has diminished the diversity of the lower and middle stratum throughout most of the open woodland sites.

The open woodland species found during the survey are well represented in Timor-Leste, though the limestone rich nature of soils at the mine site supports a slight variation in assemblage which includes *Acacia leucophloea,* but unfortunately also favours *Lantana camara*.

All survey locations included a high percentage of invasive species, most notably *Tecoma stans* (Yellow Bells)*, Lantana camara*, *Hyptis sauveolens* (Hyptis), *Chromolaena odorata* (Siam Weed) and *Ziziphus mauritiana* (Chinee Apple). Lesser sections of *Acacia nilotica* (Prickly Acacia) and *jatropha gossypifolia* (Bellyache Bush) were also recorded. Four of the introduced species recorded in the survey are listed as "Alien" on the Interim List of prohibited Invasive species (see www.laohamutuk.org/Agri/EnvLaw/div/SpeciesLists.pdf.).

Overall the most diverse sites recorded were at MI04-001 (NW corner of mine site) and at P002 (Plant Site). The highest basal factors recorded, in excess of $4m^2$ per hectare, were in areas with the least amount of weed disturbance (Figure 49). The highest basal factor recorded (highest density of mature trees) was a Closed Tropical Forest at TP01-001 on the clay mine site and at MI01-001 on the mine which was a relatively undisturbed open woodland site.

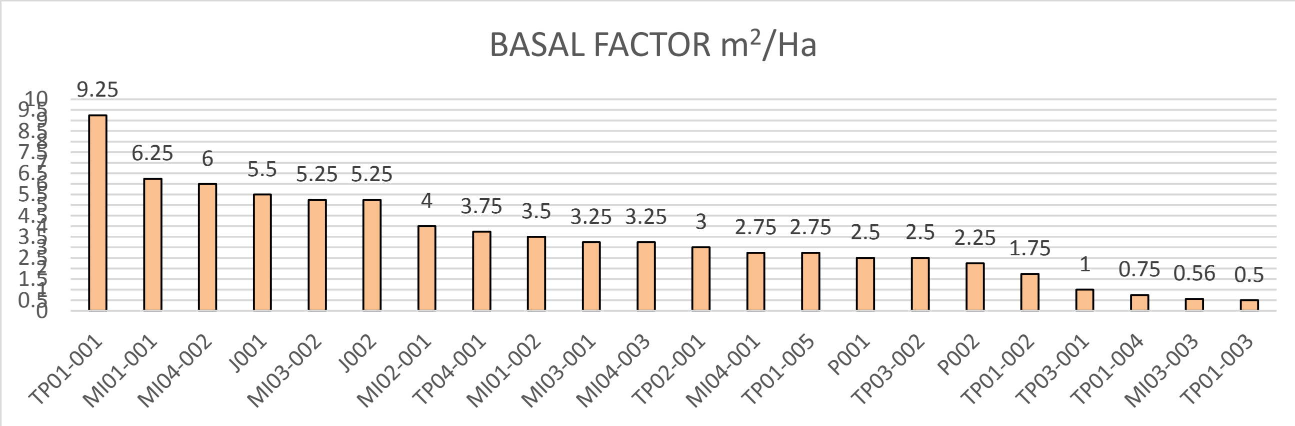


Figure 49. Total basal factor per survey site

Of the 71 plant species recorded during the survey, three species are listed under the IUCN Red List as Vulnerable. These were Sandalwood (*Santalum album*) recorded at the mine, Rosewood (*Pterocarpus indicus*) recorded at Clay mine and Burmese Teak (*Intisa bijuga*) also recorded at the Clay mine. The status of these species is poorly known in Timor-Leste. Sandlewood occurs in the broadest range of habitats, and recently has been widely planted through the country by the Ministry of Agriculture and Fisheries. Rosewood and Burmese Teak were recorded by Whistler (2001) in the Tutuala area; all three species were recorded in Nino Conis Santana National Park by Cowie (2006); and none of these three species were recorded by Worley Parsons (2012) in the Suai area. These three trees and an additional four plant species are listed on the Timor-Leste draft Interim List of Protected species (see www.laohamutuk.org/Agri/EnvLaw/div/SpeciesLists.pdf.).

Most sites exhibited medium to high levels of disturbance from invasive weeds and grazing pressure. The mine site was predominantly open woodland (Figure 50) which is well represented in other parts of Timor-Leste. The mine site includes some species rich patches of Closed Tropical Forest, primarily located within drainage floors, gullies and minor ravines. However, none of the Closed Tropical Forest environments on the mine site are contiguous and preservation would be largely ineffective if mining operations fully surrounded these areas. The woodland on the southern portion of the site is at a higher elevation and is largely contiguous and has a higher basal area than the northern portion of the site.

The Plant site has some isolated patches of Closed Tropical Forest but in general was heavily degraded with invasive weeds (Figure 50). The Jetty site is largely plantation vegetation and is severely degraded from invasive weeds.

The clay mine has the largest stands of relatively intact Closed Tropical Forest systems, especially along the eastern side of the site (Figure 51). The western side of the clay mine site had relatively low species diversity and higher levels of degradation.

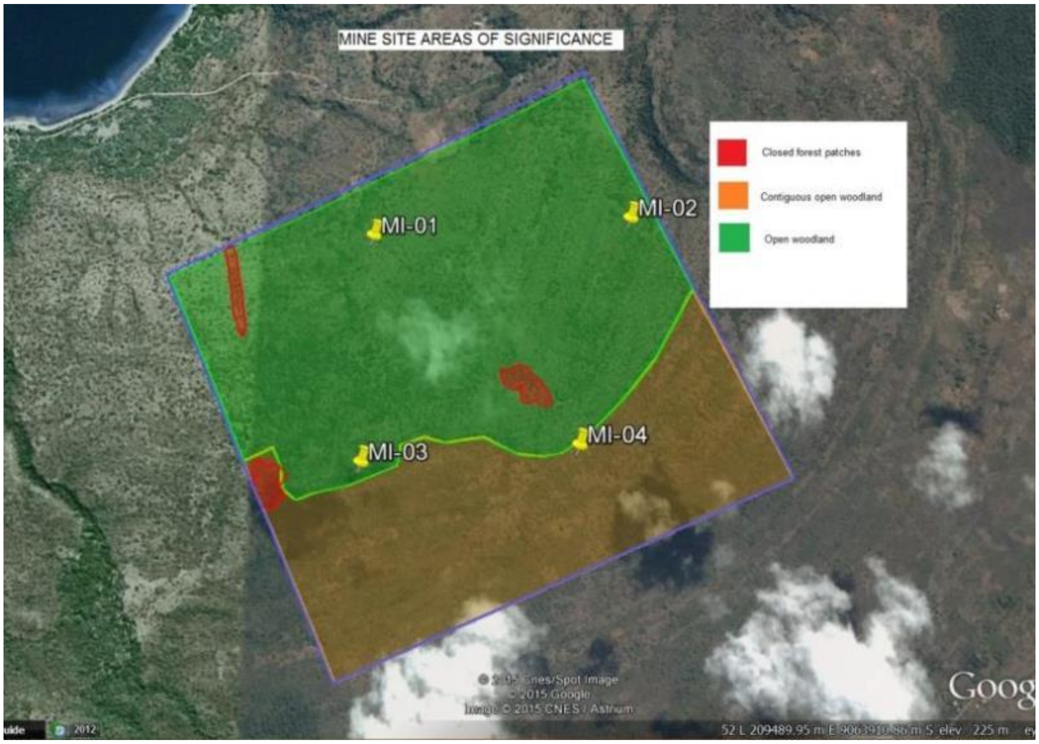


Figure 50: Mine Site Areas of Significance. (Image sourced from Google Earth)

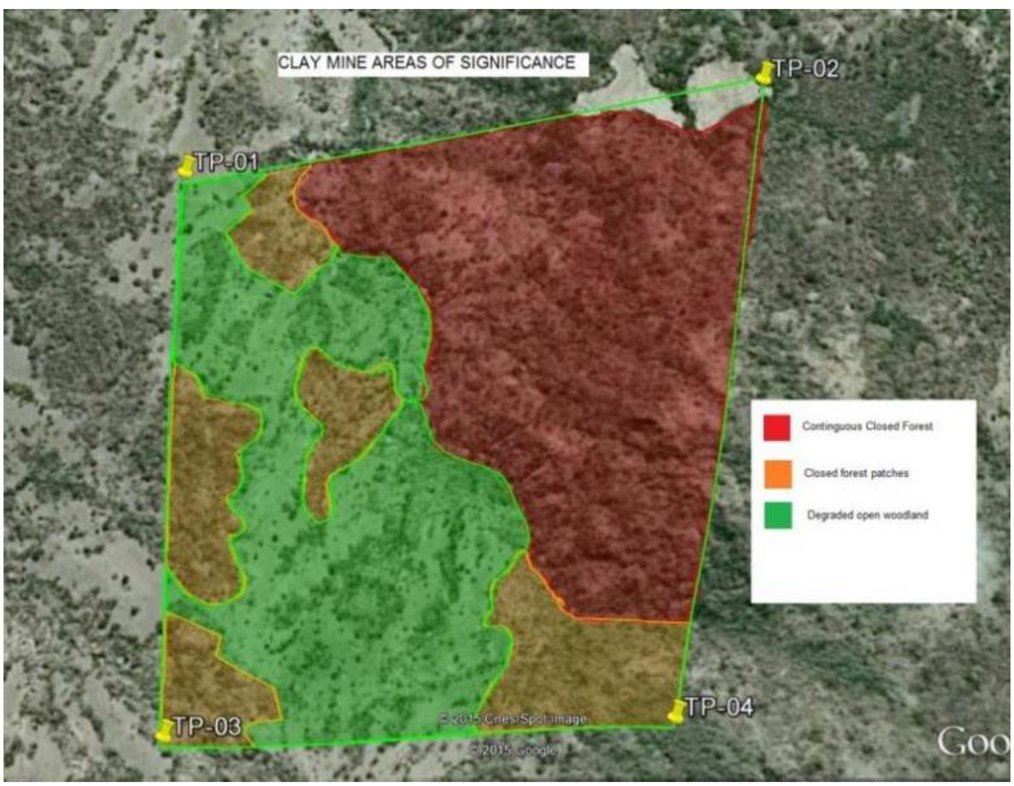


Figure 51: Clay Mine Areas of Significance. (Image sourced from Google Earth)

National and regional context

There has been no national mapping of vegetation communities in Timor-Leste, and relatively few published botanical surveys making it difficult to place survey results into a regional or national context. Woodland or open woodland communities occur widely in Timor-Leste, covering c. 3,933 km^2 (Sustainable Land Management Project: Grantham et al. 2011). Despite description of its occurrence in Timor-Leste by Martin and Cassalter (1977) there has been no specific mapping of *Eucalyptus alba* but it is relatively restricted and covers c.5-7% of the country (<c.600 km^2). Monk *et al.* (1997) state that *Eucalyptus alba* is a "dominant savanna type in Timor". The occurrence of *Eucalyptus* woodlands in the Baucau region was described by Martin and Cossalter (1977):

> *The plateau of Baucau lies in the eastern limit of this vast stretch of E.alba. This species forms near the airport an extensive but not very dense stand, consisting of only 6 to 7 trees to the ha on average. The average height is only about 16 m. The low density is due to the rocky nature of the soil, which is covered in places with a thin, red-brown layer of a clayey type. In association with E. alba there are a few Aleurites moluccana and Sterculia foetida.*

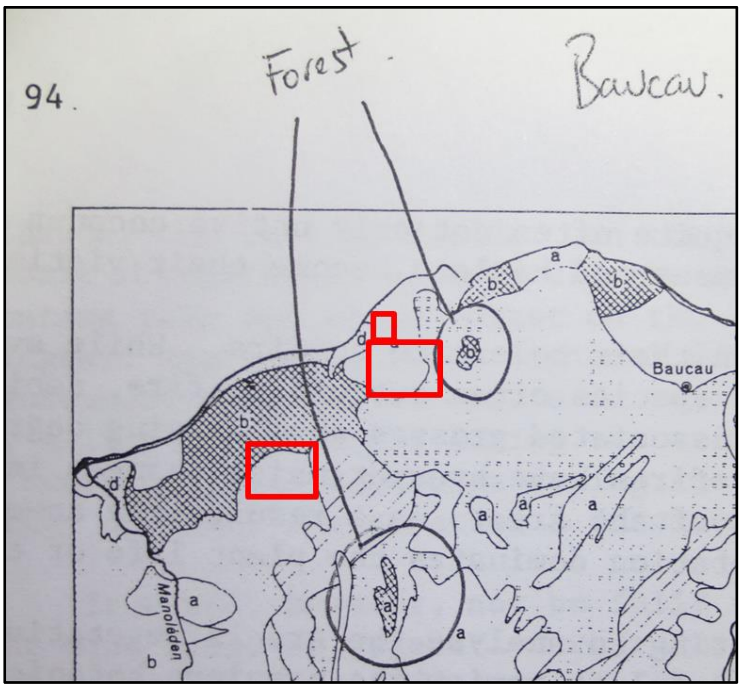


Figure 52. Vegetation classification covering the Baucau study region by Metzner (p.94; 1977; ©Metzner 1977); approximate location of study areas shown in red.

The regional vegetation classification and mapping exercise by Metzner (1977) mapped the general vicinity of the Jetty, Plant and Mine as "*Eucalyptus alba* savanna" and the vicinity of the Clay mine as "Forest-savanna mosaic" (Figure 52). Metzner (1977) notes that the *Eucalyptus alba* savanna was monodominated by an open tree layer of *Eucalyptus* up to 15-20 m tall, which was dominant in regularly burnt areas. The Forest-savanna mosaic was described as forest that has been partially destroyed by fire and cultivation with the proportions of tropical forest or savanna species depending on land use history (Metzner 1977). These habitat characterizations broadly agree with our vegetation classification, with the Forest-savanna mosaic capturing the present-day patchy distribution of Closed Tropical Forest on the Clay Mine.

Fauna

The fauna was highly typical of lowland woodland habitats on Timor in particular, dominated by wide-ranging and non-native amphibians (Black-spined Toad), reptiles (most regularly recorded species were introduced Tokay Gecko and House Gecko), and mammals (particularly livestock), numerous typical native woodland-open country bird species (e.g. Barred Dove, Spotted Dove, Pied Bushchat, White-shouldered Triller *Lalage sueurii*, Plain Fairy-warbler *Gerygone inornatus*, Indonesian Honeyeater *Lichmera limbata*) and a small set of forest specialized birds (Cinnamon-banded Kingfisher, Timor Oriole and Timor Stubtail).

Numerous microbat species were recorded whose taxonomy, habitat use and distribution in Timor-Leste remain poorly-known. There was no evidence in the study areas of the presence of four bat taxa that are potentially new to science—*Harpiocephalus* aff. *harpia*, *Kerivoula* sp., *Murina* aff. *florium*, *Rhinolophus* aff. *philippinensis* (Armstrong & Konishi 2015). We recorded an undescribed species of Rice Paddy Frog *Fejervarya*, which appears to occur widely in suitable ricefield/wetland habitat in Timor-Leste and two species of undescribed lowland *Carlia* skinks whose ecology is essentially unknown (O'Shea *et al.* 2015). Two mammals of conservation significance were recorded - the Vulnerable Canut's Horshoe Bat and Data Deficient Kai Horshoe Bat. The distribution and status of Canut's Horshoe Bat is poorly known but there are records from Nino Konis Santana National Park (Armstrong 2006) and the Suai area (Worley Parsons 2012). Up to a eight out of ten echolocating bat species recorded on the survey use caves for daytime roosting. The fauna survey was dominated by birds which comprised more than 90% of systematic fauna species recorded during point count sample data (Figure 15).

Overall we recorded c.33% of the amphibians known from Timor-Leste, c.16% of the reptiles, c.42% of the mammals and 44% of the resident landbirds (excluding waterbirds, migrant and visiting birds which were unrecorded in the terrestrial habitats of the study area) known from Timor-Leste (Figure 53). Three landsnail species were also recorded: three species at the Mine and two species at the Clay mine (Figs 30, 47 & 48). One reptile (Tokay Gecko *Gekko gecko*), four echolocating bats and 27 bird species are listed on the Timor-Leste draft Interim List of Protected species. In addition, the Black-spined Toad is listed as "Alien" on the draft Interim List of prohibited Invasive species (see www.laohamutuk.org/Agri/EnvLaw/div/SpeciesLists.pdf.)

Many terrestrial vertebrate fauna species would be absent from the study areas because of lack of specific habitat features, because they are geographically restricted to particular localities within Timor-Leste, or because of lack of trapping or particular specialized survey techniques (e.g. pitfall trapping, bat trapping).

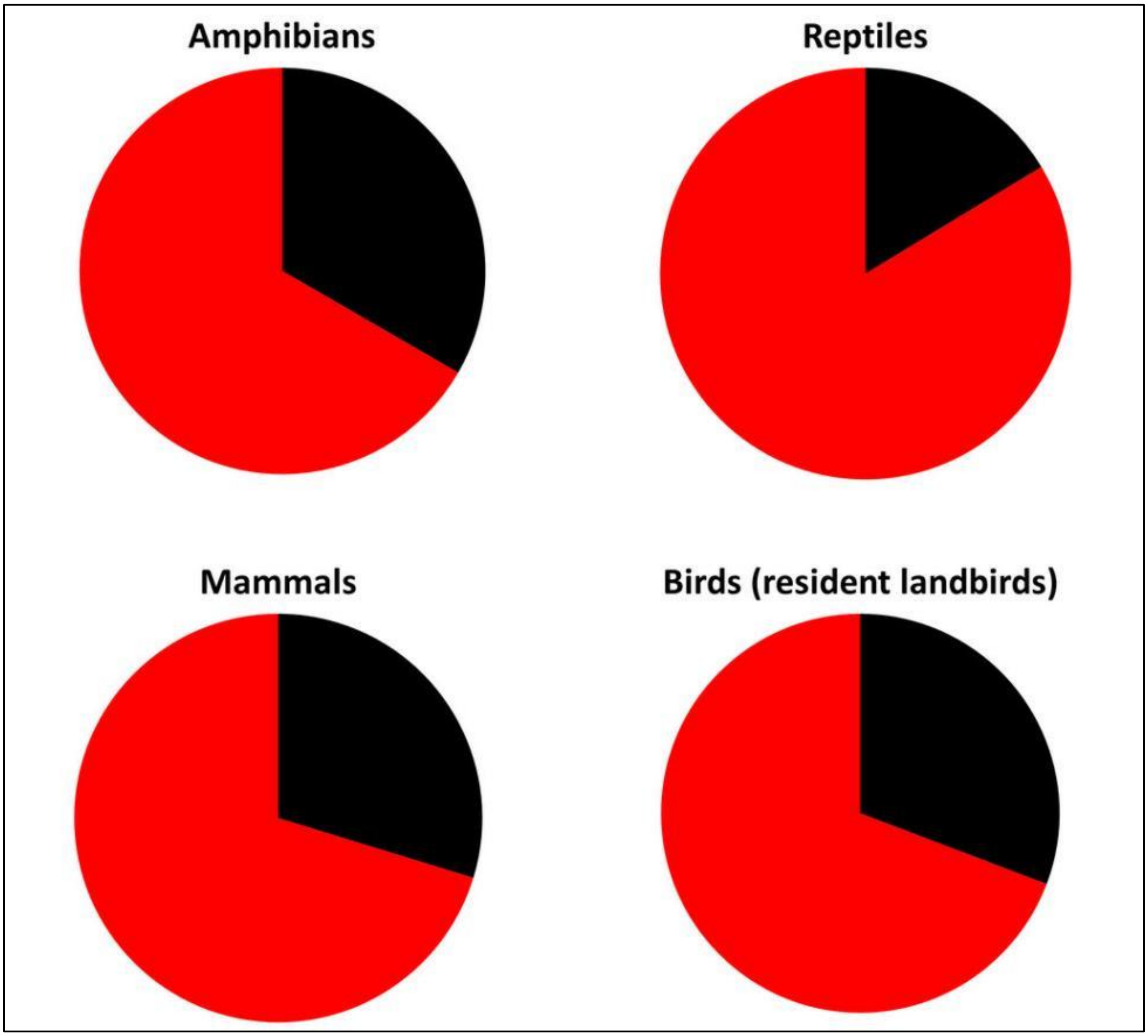


Figure 53. Summary of fauna species recorded: the proportion of amphibians (two of six species), reptiles, (eight of c. 41 species), mammal (22 of c. 52 species) and resident landbirds (56 of 126 species) species recorded during the survey and the number of additional species known from Timor-Leste and Timor Island (total number of species is approximate only for amphibians, reptiles and mammals, in particular, and includes undescribed taxa (c.f. O'Shea et al. 2015).

All bird species recorded at the Jetty, Plant and Mine were also recorded at the Clay mine, but 13 forest specialist bird species (Banded Fruit-Dove *Ptilinopus cinctus*, Pink-headed Imperial Pigeon *Ducula rosacea*, Marigold Lorikeet *Trichoglossus capistratus*, Wallacean Drongo, Timor Stubtail, Buff-banded Thicketwarbler, Timor Blue Flycatcher *Cyornis hyacinthinus*, Arafura Fantail *Rhipidura dryas*, Yellow-throated Whistler *Pachycephala macrorhyncha*, Spectacled Monarch *Symposiachrus trivirgatus*, Broad-billed Flycatcher *Myiagra ruficollis*, Black-breasted Myzomela *Myzomela vulnerata* and Tricolored Parrotfinch *Erythrura tricolor*) were only recorded at the Clay mine, highlighting the importance of Closed Tropical Forest for forest specialized bird species (Figures 15, 54; Appendix 4).

The Pink-headed Imperial Pigeon is probably under greater threat than all of the songbirds (passerines) listed because it is a large-bodied species targeted by hunters. It is also threatened by forest loss.

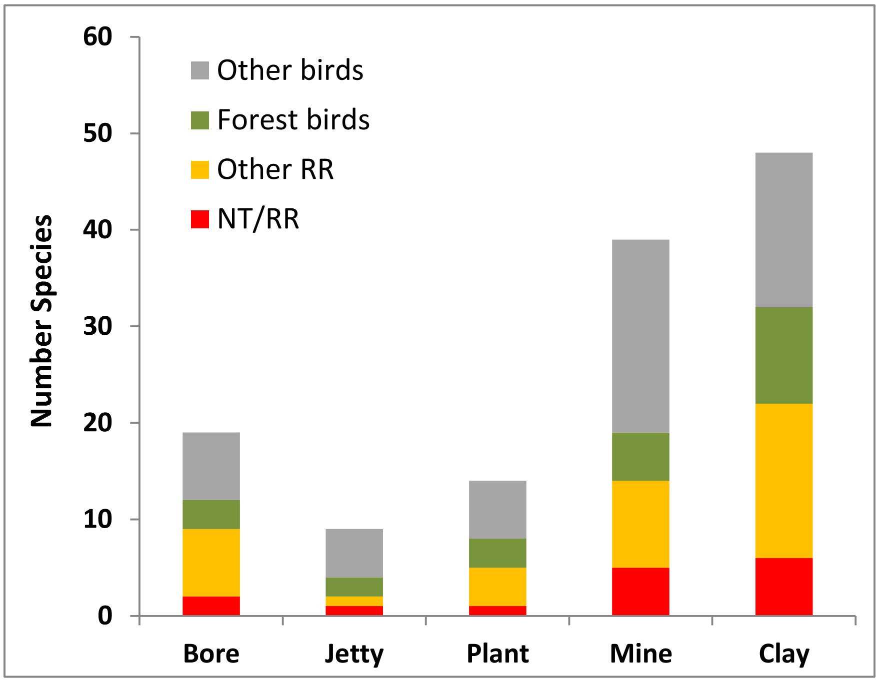


Figure 54. Broad patterns in bird species composition at study sites: NT/RR= Globally Near threatened birds species which are also restricted-range species; Other RR= other restricted-range bird species; Forest birds= forest specialized birds and Other birds= wide-ranging species that are not Near threatened, restricted-range or forest specialized. Note that there was unequal survey effort between sites.

Recommendations

The status of Closed Tropical Forest is poorly mapped and defined in Timor-Leste, but is clearly the richest and most biologically important vegetation type in Timor-Leste (c.f Cowie 2006, Trainor 2007ab). Closed Tropical Forest in the Mine, Plant and Clay sites hosts three IUCN listed threatened tree species and forest specialized bird species including at least six Near threatened species and is therefore of high biological significance. Reducing impacts to Closed Tropical Forest, particularly at the Clay site, would be valuable to avoid or reduce disturbance to more specialized Closed Tropical Forest tree species and associated fauna which are considered threatened or Near threatened primarily by loss or conversion of tropical forest habitat. No caves were located during the survey but several biologically and culturally significant caves (e.g. Bui Cere and Lie Sire) lie just to the east of the study area (Glover 1986). Such caves are vital for cave roosting bats. Aggregations of cave roosting bats are vulnerable to disturbance and increased rates of mortality in these places of refuge.

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The Atlas of Living Australia http://lists.ala.org.au/speciesListItem/list/dr781#grid

The Atlas of Living Australia http://bie.ala.org.au/species/Cryptocarya+foetida

CABI Invasive Species Compendium available at http://www.cabi.org/isc/datasheet/117093

Australian Plant Image Index, Australian National Botanic Gardens Australian National Herbarium http://www.anbg.gov.au/photo/apii/id/rfk/7918

Australian Plant Image Index Australian National Botanic Gardens Australian National Herbarium *https://www.anbg.gov.au/photo/apii/genus/Canavalia*

ABRS Flora of Australia Online

Australian Tropical Rainforest Plants: Edition 6: Trees shrubs vines herbs; grasses, sedges, palms, pandans and epiphytes. © CSIRO 2010 www. keys.trin.org.au:8080/.../Html/taxon/Timonius_timon_var._timon.htm

Canavalia papuana. Family. Fabaceae. Botanical Name. Canavalia papuana Merr.. Leaves. Leaflet blades about 5-18 x 2.5-10 cm, leaflet stalks about 0.5-2.: https://www.google.com.au/search?q=canavalia+papuana+leaves&hl=en&biw=1167&bih=575&site=webhp&source=lnms&sa=X&ei=rnJsVaeuOsLm8AXThIPwAw&ved=0CAUQ_AUoAA&dpr=1.1

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Appendix 1. Vegetation and habitat characteristics at the 23 systematic quadrat samples.

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: Mine Site **DATE:** 22-05-15 **SITE No #** MI01-001

ZONE 52L **UTM COORDINATES:** 0208478 E 9064071 S **ELEVATION:** 120m
VEGETATION TYPE: OPEN WOODLAND
% LITTER <10% **% GRAVEL** <5% **%BARE** <15% **% WEEDS** 45%
SOIL TYPE: Loam **BASAL FACTOR:** 6.25m^2/ha
NOTES: Very open woodland, limestone pebbles, little to no mid storey, mixed grasses, herbs and weeds

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*	<5%	10-12m
MIDDLE	*Chromolaena odorata*, *E. alba* juveniles	<5%	<1m
LOWER	*Hyptis suaveolens*, *Jatropha gossypifolia*	45%	

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Hyptis suaveolens, *Jatropha gossypifolia*

SURVEY SITE NAME: MINE SITE **DATE:** 22-05-15 **SITE No #** MI01-002

ZONE 52L **UTM COORDINATES:** 0208677 E 9064129 S **ELEVATION:** 126m
VEGETATION TYPE: OPEN WOODLAND
% LITTER 20% **% GRAVEL** <10% **%BARE** <10% **% WEEDS** 40%
SOIL TYPE: Loam **BASAL FACTOR:** 3.50m^2/ha
NOTES: Open woodland with grassy weed understory, broken limestone outcrops with exposed platforms

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*, *Schleichera oleosa*,	<5%	6-10m
MIDDLE	*Eucalyptus alba* juveniles , *Ziziphus mauritiana*, *Chromolaena odorata*	20%	
LOWER	*Pithecellobium dulcis*, *Hyptis suaveolens*, *Acacia nilotica* seedlings		

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Ziziphus mauritiana, *Chromolaena odorata*, *Acacia nilotica*, *Jatropha gossypifolia*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 22-05-15 **SITE No #** MI02-001

ZONE 52L **UTM COORDINATES:** 0209399 E 9064168 S **ELEVATION:** 195m
VEGETATION TYPE: OPEN WOODLAND
% LITTER <10% **% GRAVEL** <10% **%BARE** 10% **% WEEDS** 15%
SOIL TYPE: Loam **BASAL FACTOR:** 4.00m^2/ha
NOTES: Open woodland, very representative, slightly degraded with frequent limestone outcrops

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*, *Schleichera oleosa*	<5%	8-10m
MIDDLE	*E. alba* juveniles,		<1m
LOWER	*Iseilema minutiflorum*, *Hyptis suaveolens*, *Indigofera linifolia*, *Chromolaena odorata*		
OTHER SPECIMENS			

IUCN LISTED SPECIES

Indigofera linifolia – Least Concern

INVASIVE SPECIES

Hyptis suaveolens, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI03-001

ZONE 52L **UTM COORDINATES:** 0208405 E 9063108 S **ELEVATION:** 231m
VEGETATION TYPE: OPEN WOODLAND
% LITTER <5% **% GRAVEL** <15% **%BARE** >10% **% WEEDS** 20%
SOIL TYPE: SANDY LOAM **BASAL FACTOR:** 3.25 m^2/ha
NOTES: adjacent forest, high level weed disturbance.

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*, *Santalum album*, *Schleichera oleosa*	<5%	10-12m
MIDDLE	*Lantana camara*, *Chromolaena odorata*, *Hyptis suaveolens*	<5%	1-2m
LOWER	Grasses with mixed herbs, *Iseilema minutiflorum*, *Indigofera* spp.	40%	
OTHER SPECIMENS	*Senna occidentalis*		

IUCN LISTED SPECIES

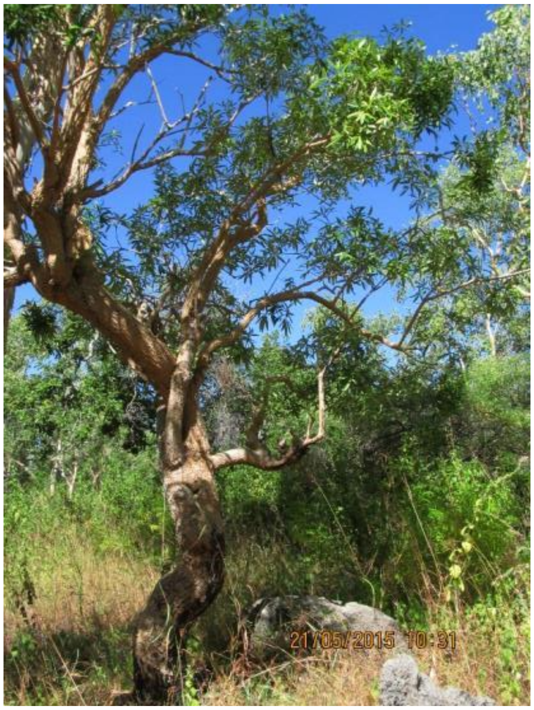
Santalum album – Vulnerable, *Indigofera* spp – *(poss; linifolia)* – Least Concern

INVASIVE SPECIES

Lantana camara, *Hyptis suaveolens*, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI03-002



ZONE 52L **UTM COORDINATES:** 0208341 E 9063186 S **ELEVATION:** 216m
VEGETATION TYPE: Open woodland
% LITTER 20% **% GRAVEL** <5% **%BARE** <5% **% WEEDS** 15%
SOIL TYPE: **BASAL FACTOR:** 5.25 m^2/ha
NOTES: North aspect slopes with limestone outcrops and extensive grass cover

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*, *Alstonia actinophylla*, *Gmelina arborea*, *Schleichera oleosa*	30%	7-15m
MIDDLE	*Eucalyptus alba* juveniles, *Tecoma stans*, *Ziziphus mauritiana*, *Chromolaena odorata*	10%	2-3m
LOWER	Grasses, *Imperata cylindrica*	90%	1-2m
OTHER SPECIMENS	*Dischidia major*, *Dischidia nummularlia* epiphytes		

IUCN LISTED SPECIES

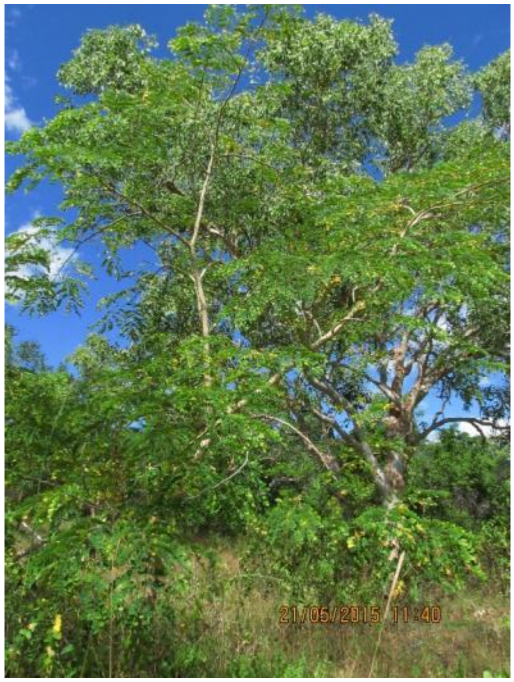
None recorded

INVASIVE SPECIES

Tecoma stans, *Ziziphus mauritiana*, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI03-003



ZONE 52L **UTM COORDINATES:** 0208631 E 9063376 S **ELEVATION:** 203m
VEGETATION TYPE: OPEN FOREST SLOPING TO CLOSED FOREST
% LITTER 15% **% GRAVEL** <5% **%BARE** <5% **% WEEDS** 30%
SOIL TYPE: Limestone **BASAL FACTOR:** 0.56 m^2/ha
NOTES: Limestone outcrops

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Eucalyptus alba*, *Schleichera oleosa*, Senna timoriensis	10%	10-12m
MIDDLE	*Tecoma stans*, *Chromolaena odorata*, *Ziziphus mauritiana*	30%	1.5m
LOWER	*Hyptis suaveolens*, Grewia sp, grasses	90%	1m

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Tecoma stans, *Chromolaena odorata*, *Ziziphus mauritiana*, *Hyptis suaveolens*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI04-001

ZONE 52L **UTM COORDINATES:** 8209239 E 9063534 S **ELEVATION:** 234m
VEGETATION TYPE: CLOSED FOREST
% LITTER >15% **% GRAVEL** <10% **%BARE** <10% **% WEEDS** 20%
SOIL TYPE: Loam **BASAL FACTOR:** 2.75 m^2/ha
NOTES: Gully slope with limestone outcrops

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Schleichera oleosa*, *Tecoma stans*, *Santalum album*, *Cryptocarya foetida*	30%	8m
MIDDLE	*Wrightia pubescens*, *Dichapetalum timorense*, *Vanda insignis*, *Dischidia major*, *Dischidia nummularlia*	30%	2m
LOWER	*Uraria lagopodiodes*, *Breynia cernua*, *Iseilema minutiflorum*, *Lantana camara*, *Chromolaena odorata*, *Hyptis suaveolens*	70%	

IUCN LISTED SPECIES

Santalum album

INVASIVE SPECIES

Lantana camara, *Chromolaena odorata*, *Hyptis suaveolens*, *Tecoma stans*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI04-002

ZONE 52L **UTM COORDINATES:** 0209080 E 9063669 S **ELEVATION:** 204m
VEGETATION TYPE: OPEN WOODLAND
% LITTER >20% **% GRAVEL** <5% **%BARE nil** **% WEEDS** 5%
SOIL TYPE: Loam **BASAL FACTOR:** 6.00 m^2/ha
NOTES: Minimal disturbance from weeds

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Eucalyptus alba*, *Alstonia actinophylla*, *Pometia pinnata*	5%	6-8m
MIDDLE	*E. alba* juveniles	<5%	to 2m
LOWER	*Imperata cylindrica*, *Grewia* sp. *Phyllanthus virgatus*, *Justicia procumbens*, *Iseilema minutiflorum*	90%	1m

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Lantana camara, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: MINE SITE **DATE:** 21-05-15 **SITE No #** MI04-003

ZONE 52L **UTM COORDINATES:** 0208914 E 9063924 S **ELEVATION:** 150m
VEGETATION TYPE: CLOSED FOREST
% LITTER >20% **% GRAVEL** <10% **%BARE** <10% **% WEEDS** 60%
SOIL TYPE: Loam **BASAL FACTOR:** 3.25 m^2/ha
NOTES: Heavily disturbed closed forest with *Chromolaena odorata* and adjacent grassland. Limestone outcrops

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Eucalyptus alba*, *Dalbergia timoriensis*, *Acacia* sp.	40%	8-10m
MIDDLE	*E. alba* juveniles, *Chromolaena odorata*	<10%	1-2m
LOWER	Mixed grass, *Hyptis suaveolens*	40%	

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Chromolaena odorata, *Hyptis suaveolens*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: PLANT SITE **DATE:** 22-05-15 **SITE No #** P001

ZONE 52L **UTM COORDINATES:** 0208103 E 9064628 S **ELEVATION:** 63m
VEGETATION TYPE: OPEN WOODLAND
% LITTER 10% **% GRAVEL** <5% **%BARE** 10% **% WEEDS** 60%
SOIL TYPE: Loam **BASAL FACTOR:** 2.50 m^2/ha
NOTES: Heavily disturbed and modified open woodland with weed understory and limestone outcrops and pebbles

NATIVE VEGETATION

STRATUM	FAMILY GENUS SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Eucalyptus alba*, *Schleichera oleosa*	<5%	8-10m
MIDDLE	*E.alba* juveniles, *Ziziphus mauritiana*, *Chromolaena odorata*, *Canarium vulgare*, *Annona squamosa*,	20%	2-3m
LOWER	*Hyptis suaveolens*, *Jatropha gossypifolia*	40%	0-2m

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Hyptis suaveolens, *Chromolaena odorata*, *Jatropha gossypifolia*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: PLANT SITE **DATE:** 22-05-15 **SITE No #** P002

ZONE 52L **UTM COORDINATES:** 0207981 E 9064378 S **ELEVATION:** 69m
VEGETATION TYPE: CLOSED FOREST
% LITTER 70% **% GRAVEL** <10% **%BARE** 10% **% WEEDS** 15%
SOIL TYPE: Loam **BASAL FACTOR:** 2.25 m^2/ha
NOTES: Closed forest in a minor depression bordered by lantana with isolated limestone outcrops

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Tecoma stans*, *Intsia bijuga*, *Ficus* sp., *Muntingia calabura*, *Ziziphus oenopolia*, *Tamarindus indica*, *Senna timoriensis*, *Streblus asper*,	30%	10-15m
MIDDLE	Juveniles of upper stratum, *Lantana camara*, *Chromolaena odorata*	40%	1-3m
LOWER	Leaf litter, seedlings		

IUCN LISTED SPECIES

Intsia bijuga - Vulnerable

INVASIVE SPECIES

Lantana camara, *Jatropha gossypifolia*, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-05-15 **SITE No #** TP01-001

ZONE 52L **UTM COORDINATES:** 0202864 E 9059430 S **ELEVATION:** 206m
VEGETATION TYPE: CLOSED FOREST
% LITTER 40% **% GRAVEL** 0% **%BARE** 20% **% WEEDS** 10%
SOIL TYPE: LOAM **BASAL FACTOR:** 9.25 m^2/ha
NOTES: Closed forest with middle stratum, high soil moisture content, vines and tall trees.

VEGETATION STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Peltophorum pterocarpum*, *Ziziphus oenopolia*, *Ziziphus timoriensis*	40%	10-12m
MIDDLE	*Peltophorum pterocarpum*, *Ziziphus oenopolia*, *Ziziphus timoriensis* (juveniles), *Schleichera oleosa*, *Hibiscus hirtus*, *Lantana camara*	20%	1-3m
LOWER	*Citrus* sp,		

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Lantana camara

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-05-15 **SITE No #** TP01-002

ZONE 52L **UTM COORDINATES:** 0202801 E 9059179 S **ELEVATION:** 230m
VEGETATION TYPE: CLOSED FOREST
% LITTER <5% **% GRAVEL** 5% **%BARE** 10% **% WEEDS** 15%
SOIL TYPE: CLAY LOAM **BASAL FACTOR:** 1.75 m^2/ha
NOTES: Heavily disturbed site from clearing and grazing with numerous weeds dominating the middle stratum and limestone outcrops

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Peltophorum pterocarpum, Pterocarpus indicus, Eucalyptus alba*	<5%	15m
MIDDLE	*Acacia nilotica, Lantana camara*	10%	1-3m
LOWER	*Thecanthes concreta*		

IUCN LISTED SPECIES

Pterocarpus indicus - Vulnerable

INVASIVE SPECIES

Acacia nilotica, Lantana camara, Chromolaena odorata

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-05-15 **SITE No #** TP01-003

ZONE 52L **UTM COORDINATES:** 0202375 E 9059053 S **ELEVATION:** 225m
VEGETATION TYPE: OPEN WOODLAND – HEAVILY DEGRADED GRASSLAND
% LITTER 0% **% GRAVEL** 20% **%BARE** 20% **% WEEDS** 30%
SOIL TYPE: CLAY LOAM **BASAL FACTOR:** 0.50 m^2/ha
NOTES: Heavily disturbed site from previous clearing.

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	absent	0%	**-**
MIDDLE	*Acacia nilotica*	10%	2m
LOWER	*Thecanthes concreta*, *Indigofera linifolia*, *Iseilma minutiflorum*		

IUCN LISTED SPECIES

Indigofera linifolia – Least Concern

INVASIVE SPECIES

Acacia nilotica

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 22-05-15 **SITE No #** TP01-004

ZONE 52L **UTM COORDINATES:** 0202517 E 9059019 S **ELEVATION:** 249m
VEGETATION TYPE: CLOSED FOREST – HEAVILY DEGRADED
% LITTER <5% **% GRAVEL** <5% **%BARE** 20% **% WEEDS** 85%
SOIL TYPE: CLAY LOAM **BASAL FACTOR:** 0.75 m^2/ha
NOTES: Cleared closed forest that has become extensively infested with weeds

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Peltophorum pterocarpum*	<5%	6m
MIDDLE	*Lantana camara, Chromolaena odorata*	80%	2m
LOWER	*Lantana camara, Chromolaena odorata, Iseilma minutiflorum*		

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Lantana camara, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-5-15 **SITE No #** TP01-005

ZONE 52L **UTM COORDINATES:** 0202426 E 9059249 S **ELEVATION:** 234m
VEGETATION TYPE: CLOSED FOREST
% LITTER 15% **% GRAVEL** 0% **%BARE** 5% **% WEEDS** 75%
SOIL TYPE: LOAM **BASAL FACTOR:** 2.75 m^2/ha
NOTES: Heavily disturbed/degraded closed forest with extensive weeds middle and lower stratum, some limestone outcrops.

VEGETATION

STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Peltophorum pterocarpum, Hibiscus hirtus, Terminalia cattapa*	20%	10-15m
MIDDLE	*Peltophorum pterocarpum* (juvenile), *Chromolaena odorata*, *Lantana camara, Pometia pinnata*	40%	1-3m
LOWER	*Chromolaena odorata*, *Lantana camara*		

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Chromolaena odorata, *Lantana camara*, *Jatropha gossypifolia*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-05-15 **SITE No #** TP02-001

ZONE 52L **UTM COORDINATES:** 0203914 E 9059565 S **ELEVATION:** 259m
VEGETATION TYPE: MODIFIED AGRICULTURAL
% LITTER <10% **% GRAVEL** 0% **%BARE** <5% **% WEEDS** 30%
SOIL TYPE: CLAY LOAM **BASAL FACTOR:** 3.00 m^2/ha
NOTES: This site falls within the oldest established farming are at the Clay Mine and is 100% modified for agriculture.

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Psidium guajava*, *Mangifera indica*, *Musa* sp, *Gliricidia sepum*, *Ceiba pentandra*, *Leucaena leucocephala*, *Cocos nucifera*	5%	3-5m
MIDDLE	*Corypha utan*, *Chromolaena odorata*,		
LOWER	*Oryza* sp, *Senna occidentalis*		
OTHER SPECIMENS			

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Chromolaena odorata,

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 23-05-15 **SITE No #** TP03-001

ZONE 52L **UTM COORDINATES:** 0202730 E 9058244 S **ELEVATION:** 306m
VEGETATION TYPE: OPEN WOODLAND (DEGRADED)
% LITTER <10% **% GRAVEL** 5% **%BARE** 40% **% WEEDS** 25%
SOIL TYPE: CLAY **BASAL FACTOR:** 1.00 m^2/ha
NOTES: Exposed hill top, previously cleared woodland

VEGETATION			
STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Acacia leucophloea*, *Peltophorum pterocarpum*	<5%	8-12m
MIDDLE	*Acacia nilotica*, *Lantana camara*	10%	2m
LOWER	*Thecanthes concreta*, *Indigofera linifolia*, *Iseilma minutiflorum*		

IUCN LISTED SPECIES

Indigofera linifolia – Least Concern

INVASIVE SPECIES

Acacia nilotica, *Lantana camara*

SURVEY SITE NAME: CLAY MINE **DATE:** 23-05-15 **SITE No #** TP03-002

ZONE 52L **UTM COORDINATES:** 0202813 E 9058201 S **ELEVATION:** 315m
VEGETATION TYPE: CLOSED FOREST - BAMBOO
% LITTER <10% **% GRAVEL** 0% **%BARE** 5% **% WEEDS** 70%
SOIL TYPE: CLAY LOAM **BASAL FACTOR:** 2.50 m^2/ha
NOTES: Steep sloping bamboo forest to test pit No. 3 with adjacent creek.

VEGETATION

STRATUM	SPECIES	COVERAGE %	HEIGHT RANGE (m)
UPPER	*Dendrocalamus* sp, *Acacia leucophloea*, *Peltophorum pterocarpum*, *Pterocarpus indicus*, *Tectona grandis*, *Sesbania grandiflora*	20%	10-15m
MIDDLE	*Senna surattensis*, *Chromolaena odorata*, *Acacia nilotica*	<5%	2-3m
LOWER	*Gliricidia sepum*		

IUCN LISTED SPECIES

Pterocarpus indicus

INVASIVE SPECIES

Chromolaena odorata, *Acacia nilotica*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: CLAY MINE **DATE:** 25-05-15 **SITE No #** TP04-001

ZONE 52L **UTM COORDINATES:** 0203759 E 9058277 S **ELEVATION:** 310m
VEGETATION TYPE: CLOSED FOREST - BAMBOO
% LITTER 80% **% GRAVEL** 0% **%BARE** <10% **% WEEDS** 35%
SOIL TYPE: LOAM CLAY **BASAL FACTOR:** 3.75 m^2/ha
NOTES: Closed bamboo forest with limited middle stratum, extensive leaf litter and weeds in understory.

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Dendrocalamus* sp, *Tamarindus indica*, *Ceiba pentandra*	30%	8-10m
MIDDLE	*Chromolaena odorata*	<5%	1m
LOWER	*Desmodium gangeticum*, *Canavalia papuana*, *Ageratina riparia*, *Brucea javanica*	20%	

IUCN LISTED SPECIES

None recorded

INVASIVE SPECIES

Chromolaena odorata

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: JETTY **DATE:** 22-05-15 **SITE No #** J001

ZONE 52L **UTM COORDINATES:** 207740 E 9065527 S **ELEVATION:** 20m
VEGETATION TYPE: CLOSED FOREST - PALMS
% LITTER 50% **% GRAVEL** 0% **%BARE** 0% **% WEEDS** 50%
SOIL TYPE: SANDY **BASAL FACTOR:** 5.50 m^2/ha
NOTES: Tall palm forest with plantation species and dominant weed middle stratum

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Borassus flabelifer*, *Corypha utan, Artocarpus integer, Tamarindus indica*	30%	20-30m
MIDDLE	*Lantana camara*, *Chromolaena odorata*	70%	2m
LOWER	absent		

IUCN LISTED SPECIES
None recorded

INVASIVE SPECIES
Lantana camara, *Chromolaena odorata*

TL CEMENT - VEGETATION FIELD SURVEY

SURVEY SITE NAME: JETTY **DATE:** 22-05-15 **SITE No #** J002

ZONE 52L **UTM COORDINATES:** 0207628 E 9065449 S **ELEVATION:** 22m
VEGETATION TYPE: CLOSED FOREST - PALMS
% LITTER 90% **% GRAVEL** 0% **%BARE** 0% **% WEEDS** 10%
SOIL TYPE: SANDY **BASAL FACTOR:** 5.25 m^2/ha
NOTES: Heavily modified plantation environment/degraded Beach forest with absent lower stratum, dominant breadfruit trees.

VEGETATION			
STRATUM	**SPECIES**	**COVERAGE %**	**HEIGHT RANGE (m)**
UPPER	*Artocarpus atilis, Persea americana, Cocos nucifera, Borassus flabelifer*	30%	25-30m
MIDDLE	*Lantana camara, Chromolaena odorata*	10%	2m
LOWER	absent		

IUCN LISTED SPECIES
None recorded

INVASIVE SPECIES
Lantana camara, Chromolaena odorata

Appendix 2. Complete plant species list recorded during field surveys, family, lifeform, local name, status (IUCN & Interim list of protected species) and systematic quadrat records.

Plant Species	Family	Form	Local name	Common name	Introduced /native	IUCN status	Interim list of protected species	Quadrat location
Acacia leucophloea syn *Vachellia leucophloea*	Fabaceae	Tree	Sia buto		Native?			TP03-001-1
Acacia nilotica syn *Vachellia nilotica*	Fabaceae	Tree			Introduced/weed			MI01-002
Acacia sp	Fabaceae	Small tree	Ai bercama					MI04-003-2
Ageratina riparia	Asteraceae (Eupatoriae)	Herb		Mist flower	Introduced/weed			TP04-001-13
Alstonia actinophylla	Apocynaceae	Tree			N			
Annona squamosa	Annonaceae	Tree	Ai ata					P001-7
Artocarpus altilis	Moraceae	Tree						
Artocarpus integer	Moraceae	Tree	Ai lemi	Chempedak	Native			J001 T3; J001-1
Borassus flabellifer	Arecaceae	Tree	Tali tahan					J001-T1
Breynia cernua	Phyllanthaceae	Small tree			Native			MI04-001-12
Brucea javanica	Simaroubaceae	Small tree						TP04-001-14
Canarium vulgare	Burseraceae	Tree	Kai tudo				✓	P001-6
Canavalia papuana	Fabaceae	Vine						TP04-001-12
Chromolaena odorata	Asteraceae (Eupatoriae)	Shrub		Siam weed	Introduced/weed		Alien	
Citrus sp. possibly gracilis ?	Rutaceae	Small tree	Kai wetu manu		Native?			TP01-001-11
Cocos nucifera	Arecaceae	Tree	Nu'u	coconut				
Corypha utan	Arecaceae	Tree	Akadiru					J001-T2
Cryptocarya sp (foetida?)	Lauraceae	Tree	Ai sten mean					MI04-001-2
Dalbergia timoriensis	Fabaceae	Tree	Tali putih					MI04-003
Dendrocalamus sp	Poaceae	Grass		Bamboo				TP04-001-1
Desmodium gangeticum	Fabaceae	Herb						TP04-001-11
Dichapetalum timorense	Dichapetalaceae	Tree						MI04-001-7
Dischidia major syn. rafflesiana	Asclepiadaceae	Epiphyte	Gamu	ant plants	Native			MI03-002-T3-1
Dischidia nummularlia	Asclepiadaceae	Epiphyte		ant plants	Native			MI04-001-9
Eucalyptus alba	Mytraceae	Tree	Bubu		Native			
Ficus sp	Moraceae	Tree	Kwai woo boco				✓	P002-1
Gliricidia sepum	Fabaceae	Tree	Dum loi	Gamal, Kehiri				TP03-002-11
Gmelina arborea	Lamiaceae	Tree			Native			MI03-002-T3
Grewia sp (oxyphylla?)	Malvaceae	Shrub						MI03-003-13
Hibiscus hirtus	Malvaceae	Tree			Native			TP01-001-10
Hyptis suaveolens	Lamiaceae	Herb		Horehound	Introduced/weed			
Imperata cylindrica	Poaceae	Grass						MI04-

								002-11
Indigofera linifolia	Fabaceae	Herb	Mau lame	Indigo		Least Concern		MI02-001; TP03-001-11
Indigofera sp	Fabaceae	Herb		Indigo				MI03-001
Intsia bijuga	Fabaceae	Tree	ai besi	Borneo Teak		Vulnerable	✓	P002-3
Iseilema minutiflorum	Poaceae	Grass	duut					
Jatropha gossypifolia	Euphorbiaceae	Herb		bellyache bush	Introduced/weed		Alien	
Justicia procumbens	Acanthaceae	Herb						MI04-002-13
Lantana camara (red variety)	Verbenaceae	Shrub			Introduced/weed		Alien	MI01-001
Miliusa sp	Annonaceae	Tree	Lesi a bou					TP01-001-8
Muntingia calabura	Eleocarpaceae	Tree	Ai futuk					P002-4
Neoalsomitra podoagrica	Cucurbitaceae	Herb			poss Native		✓	
Pandanus sp	Pandanaceae	Tree						
Peltophorum pterocarpum	Caesalpiniaceae	Tree	Kai kui heiu		Native			
Persea americana	Lauraceae	Tree						
Phyllanthus virgatus	Euphorbiaceae	Herb						MI04-002-12
Pithecellobium dulce	Fabaceae	Climber	Ai tarak					MI01-002-11
Pometia pinnata	Sapindaceae	Tree	Ai lele vaca		Native		✓	J001-T3; TP01-005-6
Pterocarpus indicus	Fabaceae	Tree	Kai naar	rosewood		Vulnerable	✓	TP01-002-TP03-002
Santalum album	Santalaceae	Tree	Ai kameli	sandalwood	Native	Vulnerable	✓	MI03-001-MI04-001
Schleichera oleosa	Sapindaceae	Tree	Ai dak	ceylon oak				MI01-002
Senna occidentalis	Caesalpiniaceae	Herb		sicklepod	Introduced/weed			
Senna siamea	Caesalpiniaceae	Tree						MI03-003 T1; MI03-003-7
Senna surattensis	Caesalpiniaceae	Tree	Kai saiuro					TP03-002-6
Senna timoriensis	Caesalpiniaceae	Tree						
Sesbania grandiflora	Fabaceae	Tree	Kai modok klela					TP03-002-3
Streblus asper	Moraceae	Tree			Native			P002-6
Syzigium nervosum	Mytraceae	Tree			Native			MI04-003-3
Tamarindus indica	Fabaceae	Tree						
Tecoma stans	Bignoniaceae	Shrub	Ai funan kinur	Yellow bells	Introduced/weed			MI04-001-T2
Tectona grandis	Verbenaceae	Tree	Kai bu teca	Teak				TP03-002-2
Terminalia catappa	Combretaceae	Tree		Indian, sea almond				
Thecanthes concreta	Thymelaeaceae	Herb			Native			TP03-001-12
Timonius timon	Rubiaceae	Small tree			Native			

Uraria lagopoides	Fabaceae	Herb						MI04-001
Vanda isignis	Orchidaceae	Epiphyte			Native			
Wrightia pubescens	Apocynaceae	Tree	Ai dak					MI04-001-1
Ziziphus mauritiana	Rhamnaceae	Tree		Chinee apple	Introduced/weed		Alien	
Ziziphus oenopolia	Rhamnaceae	Tree	Kai kuri; Kai ou bou					P002-5; P002-7; TP01-001-03
Ziziphus timoriensis	Rhamnaceae	Tree	Ai mutin; Kai rau di					MI04-001-6; POO2-5; TP01-001-5-5; TP01-001-6

Appendix 3. Likelihood of IUCN threatened plants and fauna species to occur at sites

IUCN Status: DD= Data deficient (A taxon with inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status); NT= Near threatened ("may be considered threatened with extinction in the near future, although it does not currently qualify for the threatened status"); VU= Vulnerable ("likely to become endangered unless the circumstances threatening its survival and reproduction improve"); EN= Endangered (facing a very high risk of extinction in the wild); CR= Critically endangered (facing an extremely high risk of extinction in the wild).

Common name	IUCN	Forest specialised	Threats	Jetty	Plant	Mine	Clay mine
Plants/Trees							
Sandalwood *Santalum album*	VU	F	Habitat loss, fires, agriculture, extraction	Unlikely	Likely	**Recorded**	Likely
Borneo Teak *Intsia bijuga*	VU	F	Habitat loss/selective logging	Possible	Possible	Possible	**Recorded**
Rosewood *Pterocarpus indicus*	VU	F	Habitat loss, agriculture, selective logging	Possible	Possible	Possible	**Recorded**
Reptiles							
Roti Island Snake-necked Turtle *Chelodina maccordi*	CR		Lake Iralalaro catchment only; Hunting, habitat disturbance	Absent	Absent	Absent	Absent
Green Turtle *Chelonia mydas*	CR		Hunting, beach disturbance/conversion	Possible	Absent	Absent	Absent
Hawksbill Turtle *Eretmochelys imbricata*	CR		Hunting, beach disturbance/conversion	Possible	Absent	Absent	Absent
Leatherback Turtle *Dermochelys coriacea*	CR		Hunting, beach disturbance/conversion	Possible	Absent	Absent	Absent
Loggerhead Turtle *Caretta caretta*	EN		Hunting, beach disturbance/conversion	Possible	Absent	Absent	Absent
Olive Ridley Turtle *Lepidochelys olivacea*	EN		Hunting, beach disturbance/conversion	Possible	Absent	Absent	Absent
Mammals							
Thin Shrew *Crocidura tenuis*	VU	?	Habitat loss, degradation, restricted range	Unlikely	Possible	Possible	Possible
Western Naked-backed bat *Dobsonia peronii*	VU	F	Habitat loss, extraction, restricted range	Possible	Possible	Possible	Possible
Timor leaf-nosed bat *Hipposideros cruminiferous*	DD	F	?	Possible	Possible	Possible	Possible
Sumban Leaf-nosed Bat Hipposideros sumbae	NT	F	?	Possible	Possible	Possible	Possible

Canut's Horseshoe Bat *Rhinolophus canuti*	NT	F	?cave disturbance	**Recorded**	Likely	**Recorded**	**Recorded**
Kai Horseshoe Bat *Rhinolophus celebensis*	DD	?	?cave disturbance	**Recorded**	Likely	Likely	**Recorded**
Indonesian Tomb Bat *Taphozous achates*	DD	F	?cave disturbance	Possible	Possible	Possible	Possible
Timor Rat *Rattus timorensis*	DD	F	Montane species only	Absent	Absent	Absent	Absent
Birds							
Christmas Island Frigatebird *Fregata andrewsi*	CR		Vagrant coastal seabird	Unlikely	Absent	Absent	Absent
Malaysian Plover *Charadrius peronii*	NT		Resident beach dweller; Loss beach habitat	Likely	Absent	Absent	Absent
Black-tailed Godwit *Limosa limosa*	NT		Coastal conversion/habitat loss	Possible	Absent	Absent	Absent
Asian Dowitcher *Limnodromus semipalmatus*	NT		Coastal conversion/habitat loss	Unlikely	Absent	Absent	Absent
Beach Thick-knee *Esacus neglectus*	NT		Loss beach habitat	Likely	Absent	Absent	Absent
Timor Green Pigeon *Treron psittaceus*	EN	F	Habitat loss, hunting, agriculture	Possible	Possible	Possible	Likely
Pink-headed Imperial Pigeon *Ducula rosacea*	NT	F	Hunting, Forest loss	Likely	Likely	Likely	**Recorded**
Timor Imperial Pigeon *Ducula cineracea*	EN	F	Montane (>400 m), Habitat loss, hunting, agriculture	Absent	Absent	Absent	Possible
Slaty Cuckoo-dove *Turacoena modesta*	NT	F		Likely	Likely	Likely	Likely
Wetar Ground-dove *Gallicolumba hoedtii*	EN	F	Highly restricted; Habitat loss, hunting, agriculture	Unlikely	Unlikely	Unlikely	Unlikely
Iris Lorikeet *Psitteuteles iris*	NT	F	Forest conversion	Likely	Likely	Likely	Likely
Yellow-crested Cockatoo *Cacatua sulphurea*	CR	F	Populations destroyed by trade; Habitat loss, agriculture	Unlikely	Unlikely	Unlikely	Unlikely
Olive-shouldered Parrot *Aprosmictus jonquillaceus*	NT	F	Habitat loss, hunting, agriculture	Likely	Likely	**Recorded**	**Recorded**
Cinnamon-banded Kingfisher *Todiramphus australasia*	NT	F	Habitat loss, hunting, agriculture	Likely	Likely	**Recorded**	**Recorded**
White-bellied Bush-chat *Saxicola gutturalis*	NT	F	Loss of tropical dry forest, savanna	Possible	**Recorded**	**Recorded**	**Recorded**
Chestnut-backed Thrush *Geokichla dohertyi*	NT	F	Mostly montane; Trade (Indonesia)	Unlikely	Unlikely	Unlikely	Unlikely
Orange-banded Thrush *Geokichla peronii*	NT	F	Trade (Indonesia)	Likely	Likely	**Recorded**	**Recorded**
Black-banded Flycatcher *Ficedula timorensis*	NT	F	Tropical forest species'; Forest habitat loss	Unlikely	Unlikely	Unlikely	Likely
Spot-breasted Dark-eye *Heleia muelleri*	NT	F	Forest habitat loss	Possible	Possible	Likely	Likely
Timor Sparrow *Padda fuscata*	NT		Trade (Indonesia)	Likely	**Recorded**	**Recorded**	**Recorded**

Appendix 4. Fauna species list by study site.

Status: E= endemic; rr= globally restricted-range; F= forest specialized. IUCN [status]: ne= not yet evaluated; lc= least concern ["evaluated but not qualified for any other category. As such they do not qualify as threatened, near-threatened"); DD= Data deficient (A taxon with inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status); NT= Near threatened ("may be considered threatened with extinction in the near future, although it does not currently qualify for the threatened status"); VU= Vulnerable ("likely to become endangered unless the circumstances threatening its survival and reproduction improve"). Interim List of protected species: see www.laohamutuk.org/Agri/EnvLaw/div/SpeciesLists.pdf. Species listed as present in square brackets [] were not directly recorded, but were indicated as present in site by local assistants.

English name	Scientific name	Status	IUCN	Interim list of protected species	Jetty	Plant	Mine	Clay
Amphibians								
Black-spined Toad	*Duttaphrynus melanostictus*	*Tramp/Introduced*	lc	X-Alien			X	X
Rice Paddy Frog	*Fejervarya* sp 1 [c.f. Kaiser *et al*. 2011]	Native	lc					X
Lizards								
Gekkonidae								
Tokay Gecko	*Gekko gecko*	*Tramp/Introduced*	lc	X-Trade	X	X	X	X
House Gecko	*Hemidactylus frenatus*	*Tramp/Introduced*	lc		X	X	X	X
Varanidae								
Timor Monitor	*Varanus timorensis*	Native	lc					X
Scincidae								
Skink sp.	*Carlia sp 'lowland'*	Native	ne		X			
Skink sp.	*Carlia sp 'Baucau'*	Native	ne			X	X	X
Leschenault's snake-eyed skink	*Cryptoblepharus schlegelianus*	Native	lc					X
Snakes								
Timor Inornate Bronzeback	*Dendrelaphis inornatus*	Native	lc		X			
White-lipped Island Viper	*Trimeresurus insularis*	Native	lc				X	
Mammals								
Phalangeridae								
Common Spotted Cuscus	*Phalanger orientalis*	*Introduced*	lc				[X]	[X]
Pteropodidae								
Indonesian Short-nosed Fruit Bat	*Cynopterus titthaecheilus*	Native	lc		X			
Microchiroptera								
20 cFM	*n.a*	Native			x			X
25 sFM	*n.a*	Native			x			
25 cFM	*n.a*	Native					X	X

English name	Scientific name	Status	IUCN	Interim list of protected species	Jetty	Plant	Mine	Clay
35 cFM	*n.a*	Native			X			X
45 st.cFM	*n.a*	Native			X		X	X
54 st.cFM	*n.a*	Native			X		X	X
63 st.cFM *Miniopteris australis*	*Miniopteris australis*	Native		X	X		X	X
55 mCF *Hipposideros diadema*	*Hipposideros diadema*	Native		X	X			X
72 ICF *Rhinolophis canuti*	*Rhinolophis canuti*	Native	VU	X	X		X	X
86 ICF *Rhinolophis celebensis*	*Rhinolophis celebensis*	Native	DD	X	X			X
Cercopithecidae								
Long-tailed Macaque	*Macaca fascicularis*	Native	lc			[X]	[X]	[X]
Viverridae								
Common palm civet	*Paradoxurus hermaphroditus*	*Introduced*	lc			[X]	[X]	[X]
Suidae								
Sulawesi wild boar/Feral pig	*Sus celebensis/scrofa*	*Introduced*	lc				[X]	[X]
Cervidae								
Timor/Rusa deer	*Cervus timorensis*	*Introduced*	lc				[X]	X
Bovidae								
Banteng (Bali cattle)	*Bos javanicus*	*Domesticated*	lc				X	X
Water buffalo	*Bubalis bubalis*	*Domesticated*	lc				X	X
Domestic goat	*Capra hircus*	*Domesticated*	lc		X		X	X
Domestic sheep	*Ovis aries*	*Domesticated*	lc			X	X	X
Horse	*Equus ferus caballas*	*Domesticated*	lc			X	X	X
Birds								
Spotted Kestrel	*Falco moluccensis*		lc	X			X	
Brown Quail	*Coturnix ypsilophora*		lc					X
Red Junglefowl	*Gallus gallus*		lc				X	X
Spotted Dove	*Spilopelia chinensis*		lc		X		X	X
Pacific Emerald Dove	*Chalcophaps longirostris*		lc		X		X	X
Barred Dove	*Geopelia maugeus*		lc			X	X	X
Banded Fruit Dove	*Ptilinopus cinctus*	F	lc	X			X	X
Rose-crowned Fruit Dove	*Ptilinopus regina*	F	lc	X			X	X
Pink-headed Imperial Pigeon	*Ducula rosacea*	rr,F	NT	X				X
Marigold Lorikeet	*Trichoglossus capistratus*	rr, F	lc	X				X
Olive-shouldered Parrot	*Aprosmictus jonquillaceus*	rr,F	NT	X			X	X
Little Bronze Cuckoo	*Chrysococcyx minutillus*		lc				X	X
Lesser Coucal	*Centropus bengalensis*		lc				X	
Streaked Boobook	*Ninox fusca*	E,rr,F	lc	X			X	X
Glossy Swiftlet	*Collocalia esculenta*		lc	X	X	X	X	X
Collared Kingfisher	*Todiramphus chloris*		lc				X	X
Cinnamon-banded Kingfisher	*Todiramphus australasia*	rr,F	NT	X		X	X	X
Rainbow Bee-eater	*Merops ornatus*	migrant	lc				X	X
Paddyfield Pipit	*Anthus rufulus*		lc				X	X

English name	Scientific name	Status	IUCN	Interim list of protected species	Jetty	Plant	Mine	Clay
Wallacean Cuckooshrike	*Coracina personata*	F	lc				X	X
White-shouldered Triller	*Lalage sueurii*		lc				X	X
Wallacean Drongo	*Dicrurus densus*	F	lc	X				X
Timor Oriole	*Oriolus melanotis*	rr,F	lc	X			X	X
Timor Figbird	*Sphecotheres viridis*	E,rr,F	lc	X			X	X
Large-billed Crow	*Corvus macrorhynchos*		lc		X			
Orange-sided Thrush	*Geokichla peronii*	rr,F	NT	X			X	X
Pied Bush Chat	*Saxicola caprata*		lc				X	X
White-bellied Bush Chat	*Saxicola gutturalis*	E,rr,F	NT	X			X	X
Plain Gerygone	*Gerygone inornata*	rr	lc	X		X	X	X
Timor Stubtail	*Urosphena subulata*	rr,F	lc	X				X
Buff-banded Thicketbird	*Buettikoferella bivittata*	E,rr,F	lc	X				X
Little Pied Flycatcher	*Ficedula westermanni*	F	lc			X		X
Timor Blue Flycatcher	*Cyornis hyacinthinus*	rr,F	lc	X				X
Spectacled Monarch	*Symposiachrus trivirgatus*	F	lc					X
Broad-billed Flycatcher	*Myiagra ruficollis*		lc					X
Northern Fantail	*Rhipidura rufiventris*	F	lc		X	X	X	X
Arafura Fantail	*Rhipidura dryas*	F	lc					X
Fawn-breasted Whistler	*Pachycephala orpheus*	rr,F	lc	X			X	X
Yellow-throated Whistler	*Pachycephala macrorhyncha*	rr,F	lc	X				X
White-breasted Woodswallow	*Artamus leucorynchus*		lc				X	X
Long-tailed Shrike	*Lanius schach*		lc				X	
Timor Friarbird	*Philemon inornatus*	E,rr,F	lc	X	X	X	X	X
Helmeted Friarbird	*Philemon buceroides*	F	lc	X		X	X	X
Streak-breasted Honeyeater	*Meliphaga reticulata*	E,rr	lc	X	X	X	X	X
Indonesian Honeyeater	*Lichmera limbata*		lc		X	X	X	X
Black-breasted Myzomela	*Myzomela vulnerata*	E,rr	lc	X				X
Flame-breasted Sunbird	*Cinnyris solaris*	rr	lc	X				X
Blue-cheeked Flowerpecker	*Dicaeum maugei*	rr	lc			X	X	X
Ashy-bellied White-eye	*Zosterops citrinella*	F	lc			X		X
Red Avadavat	*Amandava amandava*		lc				X	X
Zebra Finch	*Taeniopygia guttata*		lc			X	X	X
Tricolored Parrotfinch	*Erythrura tricolor*	rr,F	lc	X				X
Scaly-breasted Munia	*Lonchura punctulata*		lc				X	X
Five-colored Munia	*Lonchura quinticolor*		lc				X	X
Pale-headed Munia	*Lonchura pallida*		lc				X	X
Timor Sparrow	*Lonchura fuscata*	E,rr	NT	X		X	X	X

Appendix 5. Presence of fauna species at 24 point count fauna survey sites.

Scientific name	English name	Jetty 01	Jetty02	Plant01	Plant02	Plant03	Mine01	Mine02	Mine03	Mine04	Mine05	Mine06	Mine07	Mine08	Mine09	Mine10	Clay01	Clay02	Clay03	Clay04	Clay05	Clay06	Clay07	Clay08	Clay09
Amphibians																									
Bufo/Duttaphrynus melanostictus	Black-spined Toad																X								
Fejervarya sp 1 [c.f. Kaiser *et al.* 2011]	Rice Paddy Frog																								
Lizards																									
Gekkonidae																									
Gekko gecko	Tokay Gecko	X			X										X	X	X		X		X		X		X
Hemidactylus frenatus	House Gecko	X		X									X				X	X							
Varanidae																									
Varanus timorensis	Timor Monitor																								
Scincidae																									
Carlia sp 'lowland'	Skink sp.					X								X	X	X									
Carlia sp 2 'Baucau'	Skink sp.	X											X		X										
Cryptoblepharus schlegelianus	Leschenault's snake-eyed skink																								
Snakes																									
Dendrelaphis inornatus timorensis	Timor Inornate Bronzeback																								
Trimeresurus insularis	White-lipped Island Viper																								
Mammals																									
Phalangeridae																									
Phalanger orientalis	Common Spotted Cuscus																								

Pteropodidae																									
Cynopterus titthaecheilus	Indonesian Short-nosed Fruit Bat																								
Cercopithecidae																									
Macaca fascicularis	Long-tailed Macaque																								
Viverridae																									
Paradoxurus hermaphroditus	Common palm civet																								
Suidae																									
Sus celebensis	Sulawesi wild boar/warty pig																								
Cervidae																									
Cervus timorensis	Timor/Rusa deer										X														
Bovidae																									
Bos javanicus	Banteng (Bali cattle)																								
Bubalis bubalis	Water buffalo																								
Capra hircus	Domestic goat	X	X																						
Ovis aries	Domestic sheep			X																					
Equus ferus caballas	Horse				X											X									
Birds																									
Spotted Kestrel	*Falco moluccensis*																								
Brown Quail	*Coturnix ypsilophora*																								
Red Junglefowl	*Gallus gallus*												X					X		X		X	X		
Spotted Dove	*Spilopelia chinensis*	X						X																	
Pacific Emerald Dove	*Chalcophaps longirostris*																						X		
Barred Dove	*Geopelia maugeus*			X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X
Banded Fruit Dove	*Ptilinopus cinctus*																X			X			X		
Rose-crowned Fruit Dove	*Ptilinopus regina*								X		X					X		X	X	X	X				
Pink-headed Imperial Pigeon	*Ducula rosacea*																		X						
Marigold Lorikeet	*Trichoglossus capistratus*																					X			
Olive-shouldered Parrot	*Aprosmictus jonquillaceus*												X	X						X	X				

Little Bronze Cuckoo	*Chrysococcyx minutillus*																	X		X				X	
Lesser Coucal	*Centropus bengalensis*								X																
Streaked Boobook	*Ninox fusca*																								
Glossy Swiftlet	*Collocalia esculenta*					X		X	X	X					X	X				X	X	X			
Collared Kingfisher	*Todiramphus chloris*							X																X	
Cinnamon-banded Kingfisher	*Todiramphus australasia*			X															X		X		X		
Rainbow Bee-eater	*Merops ornatus*							X		X				X	X		X	X	X	X		X			X
Paddyfield Pipit	*Anthus rufulus*												X								X				
Wallacean Cuckooshrike	*Coracina personata*												X		X		X								
White-shouldered Triller	*Lalage sueurii*						X				X		X					X				X			X
Wallacean Drongo	*Dicrurus densus*																X			X				X	
Timor Oriole	*Oriolus melanotis*						X			X									X	X			X	X	X
Timor Figbird	*Sphecotheres viridis*						X		X					X		X	X	X	X	X		X	X		
Large-billed Crow	*Corvus macrorhynchos*																								
Orange-sided Thrush	*Geokichla peronii*																X		X						
Pied Bush Chat	*Saxicola caprata*							X					X	X											X
White-bellied Bush Chat	*Saxicola gutturalis*						X	X	X		X		X	X		X	X	X	X	X	X	X	X		
Plain Gerygone	*Gerygone inornata*				X		X		X		X		X	X	X	X	X	X	X	X	X	X	X		
Timor Stubtail	*Urosphena subulata*																X		X					X	
Buff-banded Thicketbird	*Buettikoferella bivittata*																X	X	X				X		
Little Pied Flycatcher	*Ficedula westermanni*			X	X													X							
Timor Blue Flycatcher	*Cyornis hyacinthinus*																	X							
Spectacled Monarch	*Symposiachrus trivirgatus*																		X				X	X	
Broad-billed Flycatcher	*Myiagra ruficollis*																X				X				
Northern Fantail	*Rhipidura rufiventris*				X		X	X		X		X				X	X	X	X	X	X				
Arafura Fantail	*Rhipidura dryas*																				X				
Fawn-breasted Whistler	*Pachycephala orpheus*						X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	
Yellow-throated Whistler	*Pachycephala macrorhyncha*																		X						
White-breasted Woodswallow	*Artamus leucorynchus*						X										X								X

Black-faced Woodswallow	*Artamus cinereus*																								
Long-tailed Shrike	*Lanius schach*												X	X											
Timor Friarbird	*Philemon inornatus*			X			X	X	X		X			X	X		X	X	X				X	X	X
Helmeted Friarbird	*Philemon buceroides*				X		X	X	X										X			X	X		
Streak-breasted Honeyeater	*Meliphaga reticulata*		X	X			X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	
Indonesian Honeyeater	*Lichmera limbata*						X		X							X									
Black-breasted Myzomela	*Myzomela vulnerata*													X			X							X	
Flame-breasted Sunbird	*Cinnyris solaris*																X	X					X	X	
Blue-cheeked Flowerpecker	*Dicaeum maugei*			X		X	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X
Ashy-bellied White-eye	*Zosterops citrinella*			X													X	X	X	X	X	X			
Red Avadavat	*Amandava amandava*							X																	X
Zebra Finch	*Taeniopygia guttata*			X				X						X	X	X	X	X	X	X	X	X			X
Tricolored Parrotfinch	*Erythrura tricolor*																	X					X		
Scaly-breasted Munia	*Lonchura punctulata*										X														
Five-colored Munia	*Lonchura quinticolor*													X					X				X		
Pale-headed Munia	*Lonchura pallida*							X	X	X															X
Timor Sparrow	*Lonchura fuscata*									X			X		X										

Appendix 6. Fauna habitat characteristics for each of 24 point count fauna survey sites.

Fauna Habitat Assessment:

Site Name: Mine 1

Date: **21/5/2015**

UTM Coordinates: 52 209264 Easting, 906 3205 Northing

Elevation (m): 261 m

Habitat value: Moderate

Vegetation Type: Closed Tropical Forest (secondary)

Canopy Cover: 60%

Canopy Height: 10 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 0

Weeds (0-5): 1

Total: 1

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 5

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

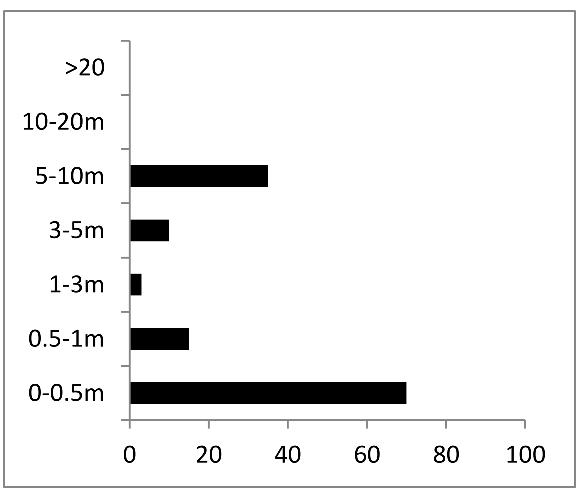
Leaf litter (%): 70

Grass (%): 0

Palm cover (%): 0

Log number: 2

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 2

Date: **21/5/2015**

UTM Coordinates: 52 209457 Easting, 906 3192 Northing

Elevation (m): 270 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 7 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 2

Weeds (0-5): 3

Total: 5 (High)

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 5

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 10

Rock Outcrop (%): 20

Ground cover:

Bare ground (%): 0

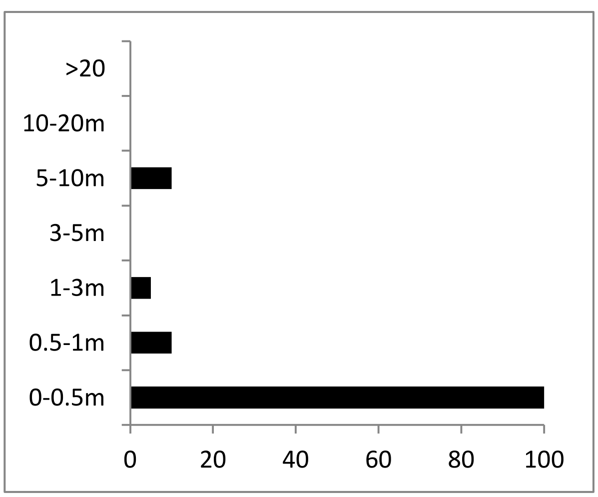
Leaf litter (%): 30

Grass (%): 50

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 3

Date: **21/5/2015**

UTM Coordinates: 52 209151 Easting, 906 3156 Northing

Elevation (m): 270 m

Habitat value: Moderate

Vegetation Type: *Schleichera oleosa* woodland

Canopy Cover: 20%

Canopy Height: 8 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 0

Weeds (0-5): 3

Total: 3 (Moderate)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

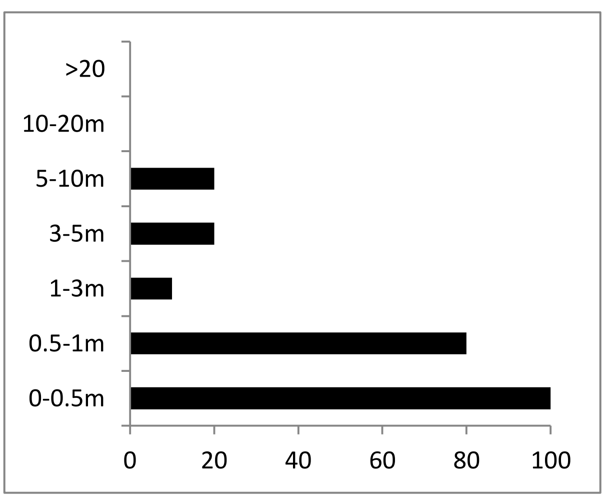
Leaf litter (%): 20

Grass (%): 10

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 4

Date: **21/5/2015**

UTM Coordinates: 52 208890 Easting, 906 3040 Northing

Elevation (m): 244 m

Habitat value: Moderate

Vegetation Type: *Schleichera oleosa* woodland (old garden)

Canopy Cover: 15%

Canopy Height: 8 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 2

Cow/horse/Buffalo (0-5): 2

Weeds (0-5): 3

Total: 7 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

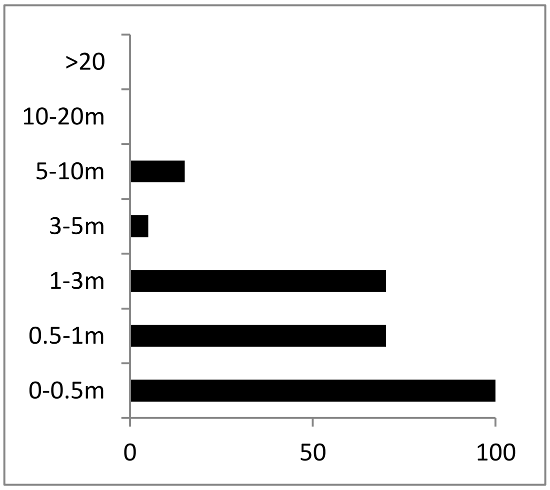
Leaf litter (%): 30

Grass (%): 10

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 5

Date: **21/5/2015**

UTM Coordinates: 52 208599 Easting, 906 2910 Northing

Elevation (m): 247 m

Habitat value: Low

Vegetation Type: *Schleichera oleosa* woodland (old garden)

Canopy Cover: 40%

Canopy Height: 9 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 2

Cow/horse/Buffalo (0-5): 0

Weeds (0-5): 3

Total: 5 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 20

Big rocks 60-200 cm (%): 50

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

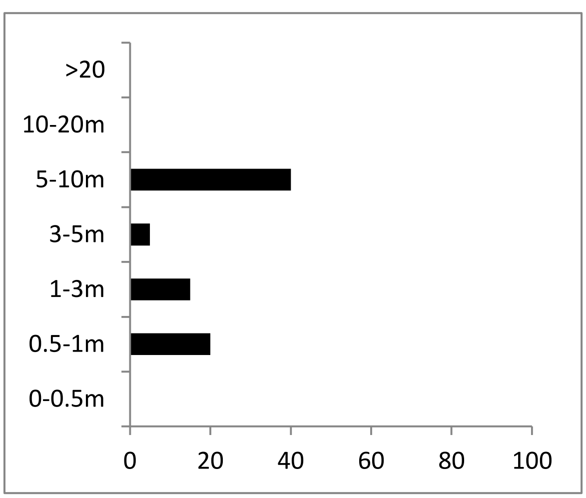
Leaf litter (%): 50

Grass (%): 10

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 6

Date: **21/5/2015**

UTM Coordinates: 52 208599 Easting, 906 2910 Northing

Elevation (m): 230 m

Habitat value: Low

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 14%

Canopy Height: 5 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 0

Weeds (0-5): 3

Total: 3 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 2

Rocks 20-60cm (%): 5

Big rocks 60-200 cm (%): 5

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 10

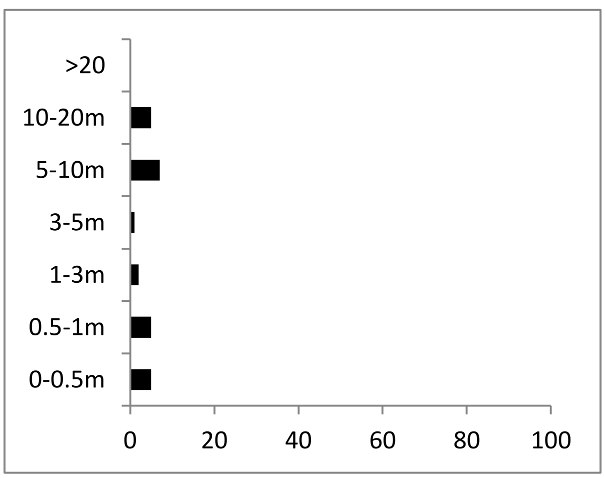
Leaf litter (%): 2

Grass (%): 5

Palm cover (%): 0

Log number: 1

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 7 [northwest test pit]

Date: **22/5/2015**

UTM Coordinates: 52 208422 Easting, 906 4205 Northing

Elevation (m): 96 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 12 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 1

Weeds (0-5): 3

Total: 4 (Moderate)

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 5

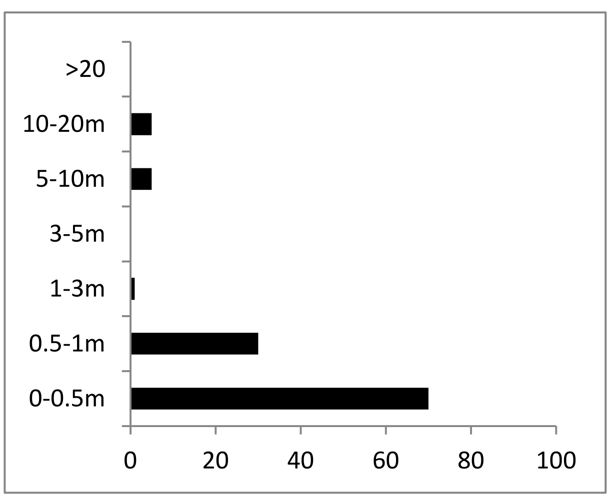
Leaf litter (%): 15

Grass (%): 5

Palm cover (%): 0

Log number: 2

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 8

Date: 22/5/2015

UTM Coordinates: 52 208422 Easting, 906 4205 Northing

Elevation (m): 96 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 12 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 0

Weeds (0-5): 1

Total: 1 (Low)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 25

Rocks 20-60cm (%): 20

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

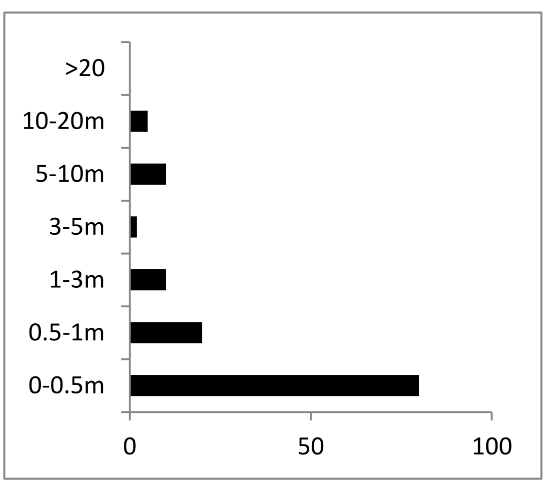
Leaf litter (%): 20

Grass (%): 50

Palm cover (%): 0

Log number: 3

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 9

Date: **22/5/2015**

UTM Coordinates: 52 208222 Easting, 906 3983 Northing

Elevation (m): 108 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 12 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 0

Weeds (0-5): 2

Total: 2 (Low)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

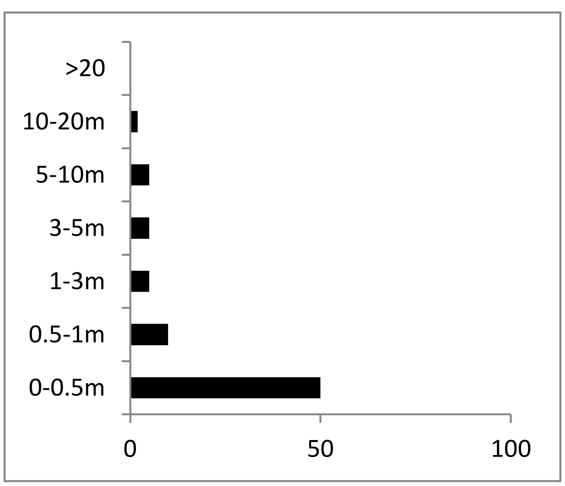
Leaf litter (%): 5

Grass (%): 15

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Mine 10

Date: **22/5/2015**

UTM Coordinates: 52 207900 Easting, 906 3892 Northing

Elevation (m): 104 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 12 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 2

Weeds (0-5): 4

Total: 6 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 20

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 5

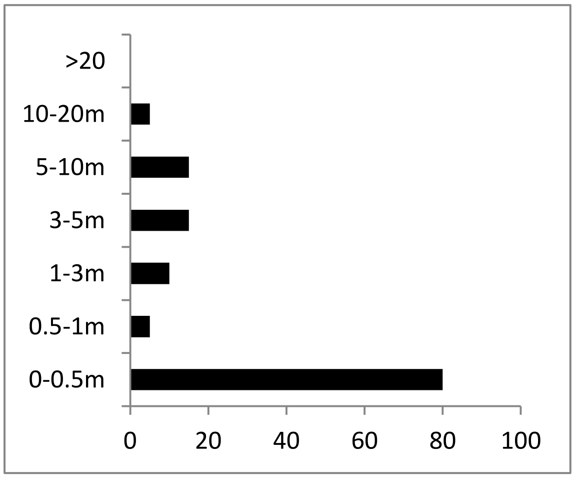
Leaf litter (%): 5

Grass (%): 0

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Plant 1

Date: 22/5/2015

UTM Coordinates: 52 207857 Easting, 906 4224 Northing

Elevation (m): 65 m

Habitat value: Moderate

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 10%

Canopy Height: 11 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 1

Weeds (0-5): 2

Total: 3 (Moderate)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 30

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 40

Ground cover:

Bare ground (%): 0

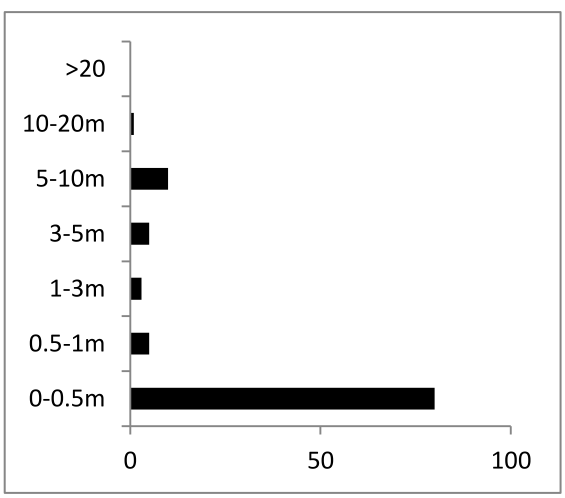
Leaf litter (%): 5

Grass (%): 30

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Plant 2

Date: 22/5/2015

UTM Coordinates: 52 207861 Easting, 906 4481 Northing

Elevation (m): 49 m

Habitat value: Low

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 4%

Canopy Height: 11 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 3

Weeds (0-5): 3

Total: 6(High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 10

Rock Outcrop (%): 50

Ground cover:

Bare ground (%): 0

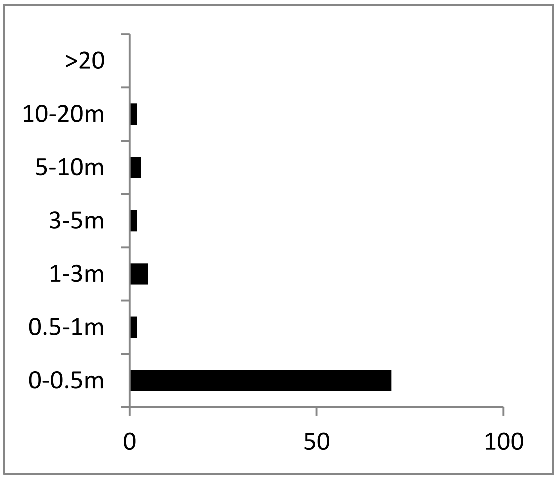
Leaf litter (%): 10

Grass (%): 50

Palm cover (%): 0

Log number: 6

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Plant 3

Date: 22/5/2015

UTM Coordinates: 52 207861 Easting, 906 4481 Northing

Elevation (m): 49 m

Habitat value: Low

Vegetation Type: *Eucalyptus alba* woodland

Canopy Cover: 4%

Canopy Height: 11 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 3

Weeds (0-5): 3

Total: 6(High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 10

Rock Outcrop (%): 50

Ground cover:

Bare ground (%): 0

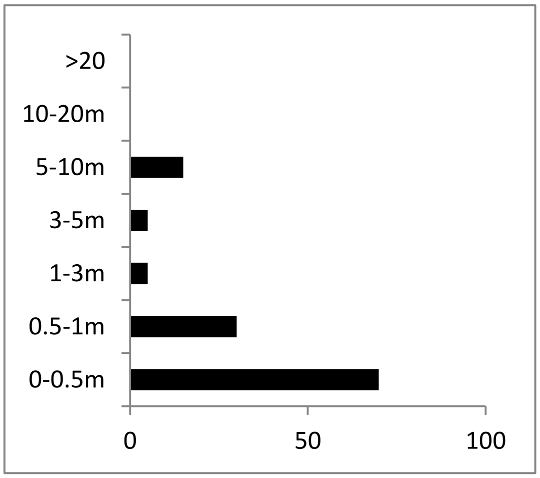
Leaf litter (%): 10

Grass (%): 50

Palm cover (%): 0

Log number: 6

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Jetty Option 1

Date: 22/5/2015

UTM Coordinates: 52 207584 Easting, 906 5439 Northing

Elevation (m): 1 m

Habitat value: Moderate

Vegetation Type: Beach forest (degraded)

Canopy Cover: 70%

Canopy Height: 19 m

Disturbance:

Fire Impact (0-5): 0

Agriculture (0-5): 1

Cow/horse/Buffalo (0-5): 3

Weeds (0-5): 1

Total: 5 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 0

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 50

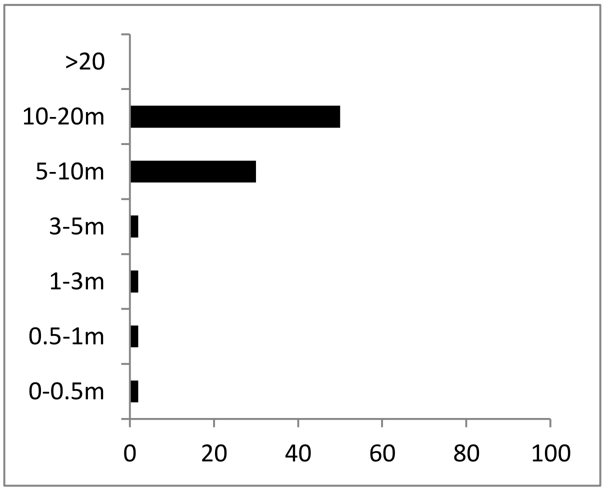
Leaf litter (%): 50

Grass (%): 0

Palm cover (%): 70

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Jetty Option 2

Date: 22/5/2015

UTM Coordinates: 52 207670 Easting, 906 5593 Northing

Elevation (m): 1 m

Habitat value: Moderate

Vegetation Type: Beach forest (degraded)

Canopy Cover: 30%

Canopy Height: 18 m

Disturbance:

Fire Impact (0-5): 3

Agriculture (0-5): 0

Cow/horse/Buffalo (0-5): 3

Weeds (0-5): 4

Total: 10 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 0

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 30

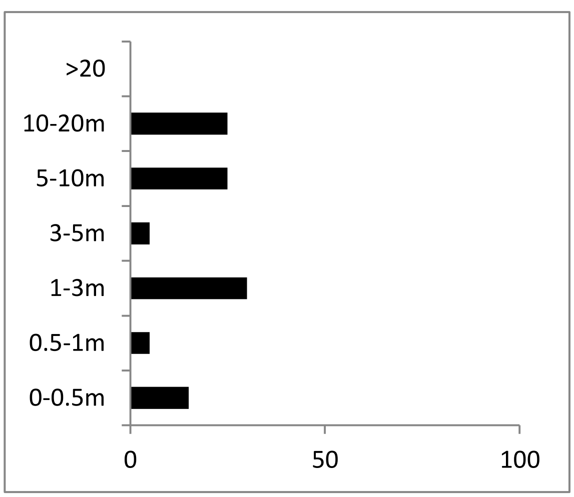
Leaf litter (%): 50

Grass (%): 0

Palm cover (%): 30

Log number: 5

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 1

Date: **23/5/2015**

UTM Coordinates: 52 203757 Easting, 905 8280 Northing

Elevation (m): 295 m

Habitat value: High

Vegetation Type: Bamboo thicket

Canopy Cover: 60%

Canopy Height: 15 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 0

Weeds (0-5): 1

Total: 1

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 0

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

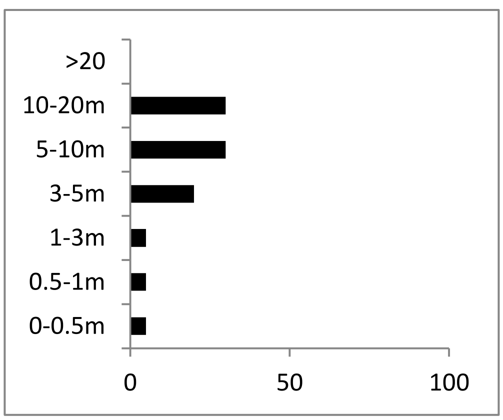
Leaf litter (%): 70

Grass (%): 70

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 2

Date: **23/5/2015**

UTM Coordinates: 52 202764 Easting, 905 8264 Northing

Elevation (m): 306 m

Habitat value: Moderate

Vegetation Type: Bamboo thicket

Canopy Cover: 40%

Canopy Height: 19 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 1

Weeds (0-5): 2

Total: 3 (Low)

Rock cover:

Stones 2-6cm (%): 1

Rocks 6-20cm (%): 1

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 1

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

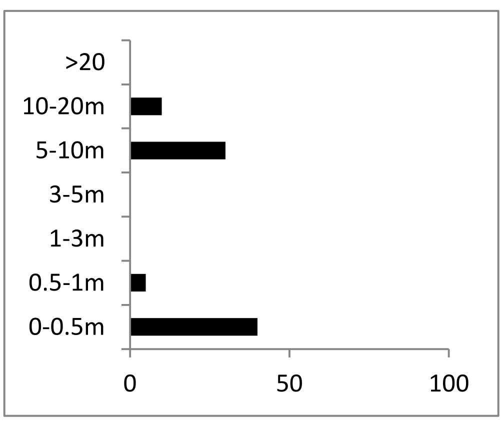
Leaf litter (%): 20

Grass (%): 40

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 3

Date: **24/5/2015**

UTM Coordinates: 52 203133 Easting, 905 9784 Northing

Elevation (m): 146 m

Habitat value: Low

Vegetation Type: Bamboo thicket

Canopy Cover: 15%

Canopy Height: 18 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 1

Weeds (0-5): 3

Total: 4 (Moderate)

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 5

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

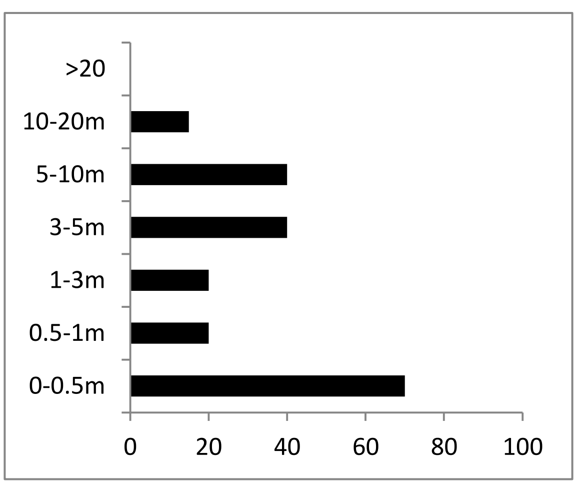
Leaf litter (%): 10

Grass (%): 20

Palm cover (%): 0

Log number: 1

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 4

Date: **24/5/2015**

UTM Coordinates: 52 202929 Easting, 905 9647 Northing

Elevation (m): 156 m

Habitat value: Low

Vegetation Type: Woodland (Acacia/grazing land)

Canopy Cover: 7%

Canopy Height: 8 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 3

Weeds (0-5): 2

Total: 5 (High)

Rock cover:

Stones 2-6cm (%): 5

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 3

Big rocks 60-200 cm (%): 2

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 5

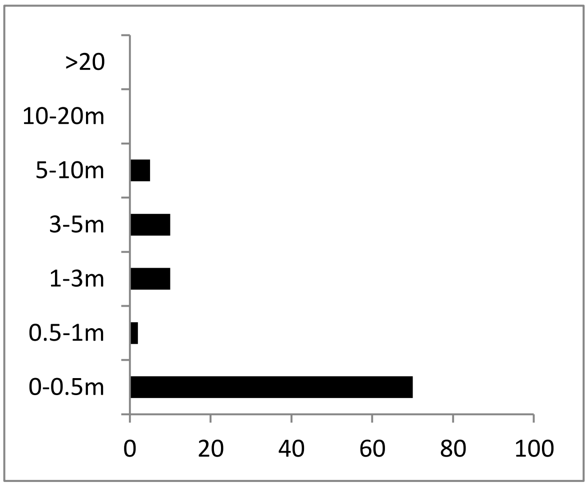
Leaf litter (%): 1

Grass (%): 80

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 5

Date: **24/5/2015**

UTM Coordinates: 52 202810 Easting, 905 9442 Northing

Elevation (m): 189 m

Habitat value: Low

Vegetation Type: Woodland (between closed tropical forest)

Canopy Cover: 10%

Canopy Height: 14 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 1

Weeds (0-5): 1

Total: 2 (Low)

Rock cover:

Stones 2-6cm (%): 10

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 5

Big rocks 60-200 cm (%): 5

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 5

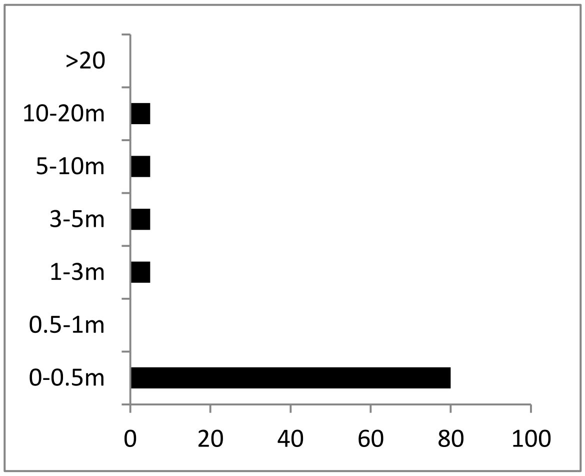
Leaf litter (%): 1

Grass (%): 70

Palm cover (%): 0

Log number: 1

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 6

Date: **24/5/2015**

UTM Coordinates: 52 202777 Easting, 905 9276 Northing

Elevation (m): 212 m

Habitat value: Low

Vegetation Type: Woodland (between closed tropical forest)

Canopy Cover: 5%

Canopy Height: 11 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 3

Weeds (0-5): 2

Total: 5 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 30

Rocks 20-60cm (%): 20

Big rocks 60-200 cm (%): 5

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

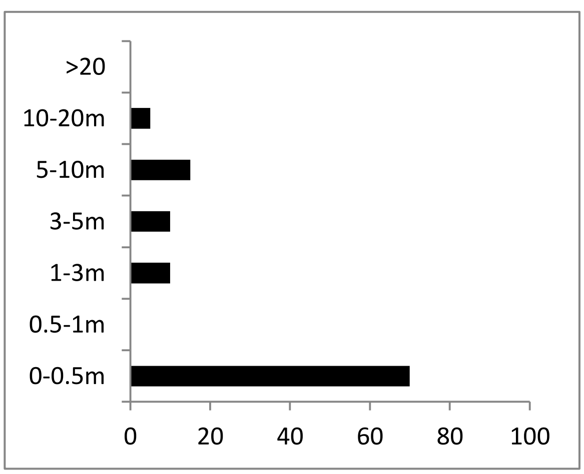
Leaf litter (%): 0

Grass (%): 80

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 7

Date: **24/5/2015**

UTM Coordinates: 52 202557 Easting, 905 9310 Northing

Elevation (m): 217 m

Habitat value: Moderate

Vegetation Type: Closed Tropical Forest (secondary)

Canopy Cover: 30%

Canopy Height: 13 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 1

Weeds (0-5): 3

Total: 4 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 30

Rocks 20-60cm (%): 20

Big rocks 60-200 cm (%): 5

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

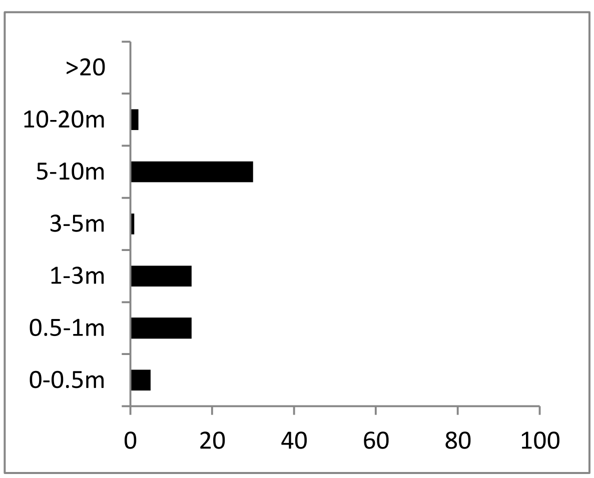
Leaf litter (%): 0

Grass (%): 80

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 8

Date: **25/5/2015**

UTM Coordinates: 52 204241 Easting, 905 9789 Northing

Elevation (m): 208 m

Habitat value: Moderate

Vegetation Type: Closed Tropical Forest (riparian/bamboo)

Canopy Cover: 35%

Canopy Height: 22 m

Disturbance:

Fire Impact (0-5): 0

Cow/horse/Buffalo(0-5): 3

Weeds (0-5): 3

Total: 6 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 10

Rocks 20-60cm (%): 10

Big rocks 60-200 cm (%): 30

Rock Outcrop (%): 30

Ground cover:

Bare ground (%): 0

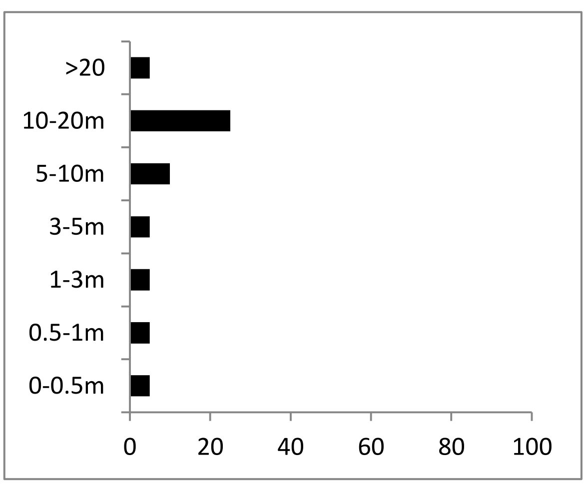
Leaf litter (%): 20

Grass (%): 25

Palm cover (%): 0

Log number: 2

Vegetation Profile, % cover in different height classes:



Fauna Habitat Assessment:

Site Name: Clay 9

Date: **25/5/2015**

UTM Coordinates: 52 203940 Easting, 905 9540 Northing

Elevation (m): 255 m

Habitat value: Low

Vegetation Type: Agricultural land/ricefields

Canopy Cover: 2%

Canopy Height: 7 m

Disturbance:

Fire Impact (0-5): 0

Agriculture(0-5): 5

Cow/horse/Buffalo(0-5): 3

Weeds (0-5): 2

Total: 10 (High)

Rock cover:

Stones 2-6cm (%): 0

Rocks 6-20cm (%): 0

Rocks 20-60cm (%): 0

Big rocks 60-200 cm (%): 0

Rock Outcrop (%): 0

Ground cover:

Bare ground (%): 0

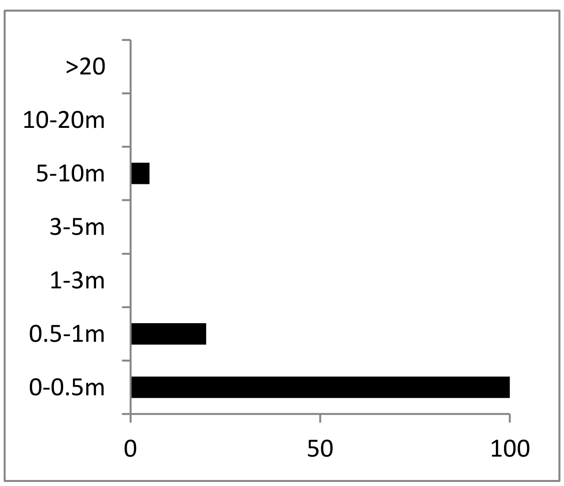
Leaf litter (%): 0

Grass (%): 100

Palm cover (%): 0

Log number: 0

Vegetation Profile, % cover in different height classes:



Appendix 7. Summary of coordinates at 24 fauna point count survey sites.

Site	Easting	Northing	Elevation(m)	Habitat type	Habitat quality
Jetty1	52 207584	906 5439	2	Beach forest	Moderate
Jetty2	52 207670	906 5593	1	Beach forest	Moderate
Plant1	52 207857	906 4224	65	*Eucalyptus alba* woodland	Low
Plant2	52 207861	906 4481	49	*Eucalyptus alba* woodland	Low
Plant3	52 207987	906 4647	50	*Eucalyptus alba* woodland	Low
Mine1	52 209264	906 3205	261	Closed forest	Moderate
Mine2	52 209457	906 3192	270	*Eucalyptus alba* woodland	Moderate
Mine3	52 209151	906 3156	270	Schleichera woodland	Moderate
Mine4	52 208890	906 3040	244	Schleichera woodland	Moderate
Mine5	52 208599	906 2910	247	Schleichera woodland	Low
Mine6	52 208599	906 2910	230	*Eucalyptus alba* woodland	Low
Mine7	52 208422	906 4205	96	*Eucalyptus alba* woodland	Low
Mine8	52 208518	906 4007	114	*Eucalyptus alba* woodland	Moderate
Mine9	52 208222	906 3983	108	*Eucalyptus alba* woodland	Moderate
Mine10	52 207900	906 3892	104	*Eucalyptus alba* woodland	Moderate
Clay1	52 203757	905 8280	295	Closed forest-bamboo	High
Clay2	52 202764	905 8264	306	Closed forest-bamboo	Moderate
Clay3	52 203133	905 9784	146	Bamboo thicket	Low
Clay4	52 202929	905 9647	156	Woodland	Low
Clay5	52 202810	905 9442	189	Woodland	Low
Clay6	52 202777	905 9276	212	Woodland	Low
Clay7	52 202557	905 9310	217	Closed forest	Moderate
Clay8	52 204241	905 9789	208	Bamboo thicket	Moderate
Clay9	52 203940	905 9540	255	Agricultural	Low

Appendix 8. Bat acoustic recorder survey sites and effort.

***Recordings failed at sites 5-7 failed due to technical issues. See also Appendix 9.**

Bat Acoustic Site	Easting	Northing	Elevation (m)	Habitat	Set out date	Pick up date	No. nights
Site 1, Baucau Jetty			2	Beach forest degraded	21-May	26-May	5
Site 2, Baucau Mine I-1	0209373	9063501	280	*Eucalyptus alba* woodland	21-May	26-May	5
Site 3, Baucau Clay (bamboo1)	0203157	9059737	154	Tropical forest (secondary bamboo)	23-May	27-May	4
Site 4, Baucau Clay (bamboo2)	0203194	9059893	169	Tropical forest (secondary bamboo)	23-May	27-May	4
*Site 5, Baucau Mine Site I-1	0203822	9059580	260	*Eucalyptus alba* woodland	25-Jun	27-Jun	2
*Site 6, Baucau Mine Site I-1	0203962	9059347	280	*Eucalyptus alba* woodland	25-Jun	27-Jun	2
*Site 7, Baucau Clay (hut)	0209622	9064324	229	Tropical forest (secondary)	25-Jun	27-Jun	2
Site 8, Baucau Clay (forest)	0209320	9063166	279	Tropical forest (secondary)	25-Jun	27-Jun	2

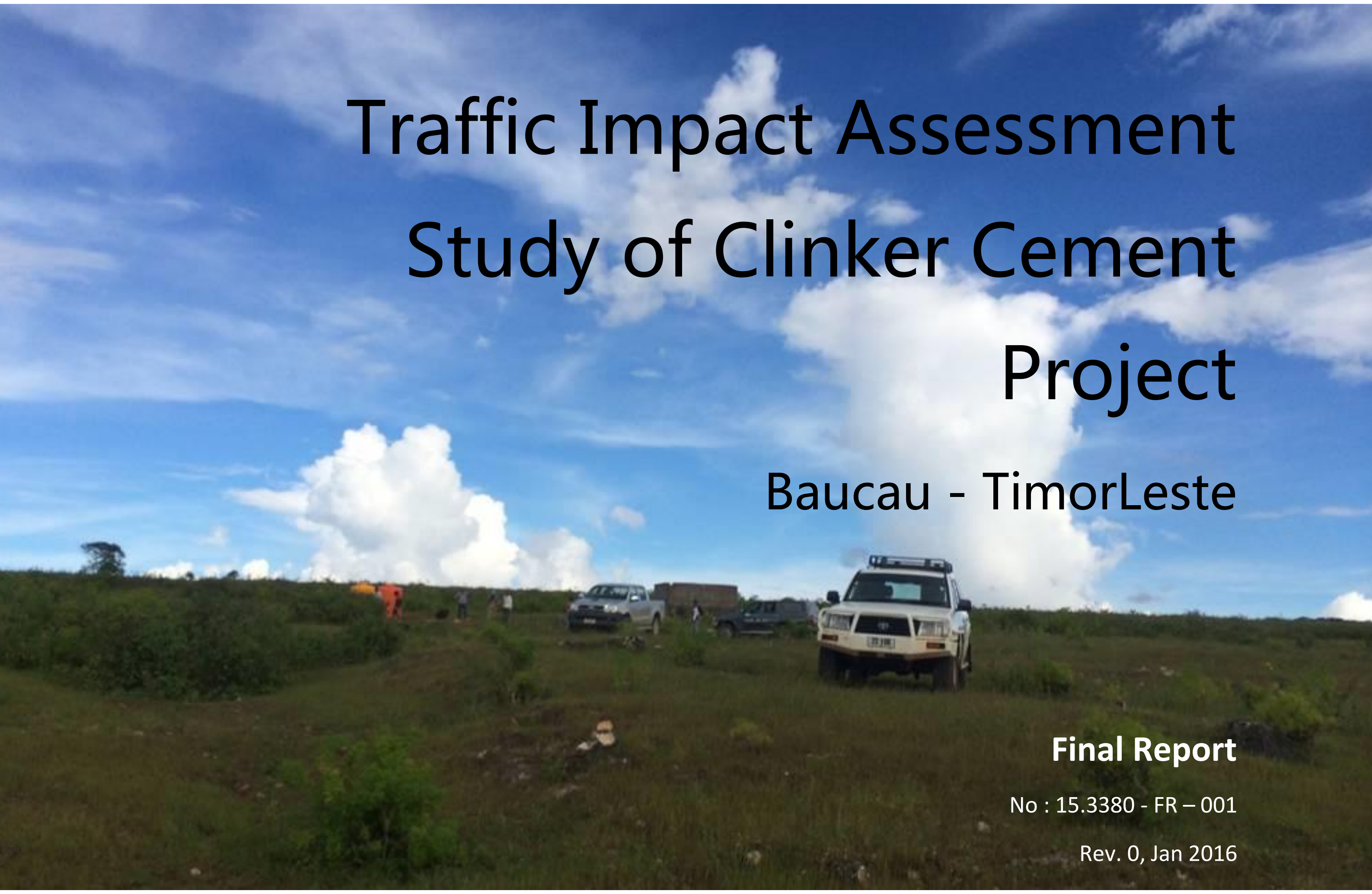
Appendix 9. Report: Armstrong & Konishi (2015), Bat call identification

Appendix 6 Traffic Impact Asessment Study

Cement

Your Dream, We will Build!

TL CEMENT Lda.



Traffic Impact Assessment Study of Clinker Cement Project

Baucau - TimorLeste

Final Report

No : 15.3380 - FR – 001

Rev. 0, Jan 2016

Prepared by:

PT. **BITA** BINA SEMESTA

CONTENTS

GLOSSARY

Annual Average Daily Traffic	The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year.
Capacity	The maximum sustainable flow rate at which vehicles or persons reasonably can be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions; usually expressed as vehicles per hour, passenger cars per hour, or persons per hour.
Centroid Connectors	Links that connect centroid nodes with the model network. These can represent local streets not included in the model network. Centroid Connectors provide the linkage between the trips associated with the TAZ land uses and the roadway segments (or links).
Centroids	They represent the center of activity for a transportation analysis zone (TAZ). This is not the geometric center of the zone.
Demand	The number of users desiring service on the highway system usually expressed as vehicles per hour or passenger cars per hour.
Demand to capacity ratio	The ratio of demand flow rate to capacity for a traffic facility.
External Station	A location where a roadway crosses the outside boundary of a travel demand model or zone cumulative analysis.
Flow rate	The equivalent hourly rate at which vehicles, bicycles, or persons pass a point on a lane, roadway, or other traffic way; computed as the number of vehicles, bicycles, or persons passing the point, divided by the time interval (usually less than 1 h) in which they pass; expressed as vehicles, bicycles, or persons per hour.
Geometric condition	The spatial characteristics of a facility, including approach grade, the number and width of lanes, lane use, and parking lanes.
Lateral clearance	(1) The total left- and right-side clearance from the outside edge of travel lanes to fixed obstructions on a multilane highway; (2) the right-side clearance distance from the rightmost travel lane to fixed obstructions on a freeway.
Level of service	A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience
Link	A segment of highway ending at a major intersection on an urban street or at a ramp merge or diverge point on a freeway. Links have a node at each end
Internal trip	a trip with both its origin and its destination located inside of the study area. If either trip ends is outside the study area, it is an external trip. If both trip ends are outside the study area, it is a through trip
External trip	a trip with either its origin or its destination located outside of the study area. The external trip end is assigned to an external station
Through trip	a trip has both trip ends outside the study area
Off-peak flow traffic	A time period during any given day when the traffic volume is normally the least
Peak-flow traffic	A time period during any given day when the traffic volume is normally

	the heaviest. Peak-flow traffic may last up to two hours in some locations and is normally for the a.m. commute to work and the p.m. commute home from work
Peak-hour factor	The hourly volume during the maximum-volume hour of the day divided by the peak 15-min flow rate within the peak hour; a measure of traffic demand fluctuation within the peak hour
Pcuph	Passenger car unit per hour
Nodes	(1) link endpoints, typically intersections or points representing changes in link attributes (2) Indicates the intersections of links
Network	A graphical and/or mathematical representation of a region's transportation infrastructure and services, comprising links and nodes and their corresponding characteristics. Also refers to the actual networks of highways, transit, and other modes
Shoulder	A portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, emergency use, and lateral support of the subbase, base, and surface courses
Spacing	The distance, in meters, b etween two successive vehicles in a traffic lane, measured from the same common feature of the vehicles (e.g., rear axle, front axle, or front bumper)
Speed	A rate of motion expressed as distance per unit of time
Space mean speed	(1) The harmonic mean of speeds over a length of roadway; (2) an average speed based on the average travel time of vehicles to traverse a segment of roadway; in kilometers per hour
Spot speed	The instantaneous speed of a vehicle at a specified location
Time mean speed	The arithmetic average of individual vehicle speeds passing a point on a roadway or lane, in kilometers per hour
Traffic control device (TCD)	Signs, signals, markings, and devices placed on, over, or adjacent to a street or highway by an authority of a public body having jurisdiction to regulate, warn, or guide traffic.
Traffic volume	Amount of traffic that travels any given roadway during any given time period.
T-Intersection	An intersection where two roads meet (whether or not at right angles) and one of the roads ends
Undersaturation	A traffic condition in which the arrival flow rate is lower than the capacity or the service flow rate at a point or uniform segment of a lane or roadway
Unsignalized intersection	An intersection not controlled by traffic signals
Volume	The number of persons or vehicles passing a point on a lane, roadway, or other traffic-way during some time interval, often 1 h, expressed in vehicles, bicycles, or persons per hour
Volume-to-Capacity Ratio (v/c)	The ratio of the traffic flow rate to the capacity of the road
Zone	The basic geographical unit of analysis for conventional travel forecasting. All locations in a study area are contained in one and only one analysis zone, the number and size of which depend on the scale and scope of the modelling effort. Zones should be as homogenous as possible with respect to the associated travel behaviour

EXECUTIVE SUMMARY

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker. The traffic impact assessment study has been conducted to predict the impact to the traffic during the construction and operation phase of this cement manufacturing project, as well as setting up the mitigation measures for negative impacts.

Traffic counting has been conducted in six locations for six hours of each location. The location was chosen to describe baseline traffic condition around project area and around city as well. The location in the city was chosen to give description of traffic condition as well as comparing with its hinterland. The traffic counting was conducted in six hour. Six hour counting is divided into 3 periods of 2 hours (morning peak, mid-day peak, and afternoon peak).

The road network is classified into two functional classes, i.e. arterial and collector roads. Road width varies from 4 to 5 meters, resulting a road capacity of 900 pcuph and 1,227 pcuph respectively. Based on the traffic calculation, the volume capacity ratio is between 0.2 - 0.7. It can be concluded that road capacity is still sufficient to accomodate current traffic demand.

During construction phase, there will be impact on traffic flows from various activities, as follows:

- There will be 1,000 persons per day from Baucau work in both clay deposit and Clinker Plant. There will be an additional traffic flow to and from clay deposit and Clinker Plant of 18 pcuph and 102 pcuph respectively.
- Daily mobillisation of heavy vehicle transporting construction materials to clay deposit (4 trucks) and Clinker Plant (7 trucks). Accordingly, there will be additional traffic flow due to transportation of construction materials, i.e. 26 pcuph.

Based on the prevailing standard, road networks performance during construction phase is still in good condition.

During operation phase, there will be impact on traffic flows from various activities, as follows:

- Clay (0.41 mio tonnes/year) will be transported from quarry to Plant using a dump truck with a capacity of 25 tonnes. Accordingly, it could generate approx. 4 truck trips per hour (330 days, 12-hours per day), so there will be additional traffic flow of 10 pcuph.
- Finished product (cement) will be delivered from Plant (Baucau) to local market, i.e. Dili. Up to 0.5 million tonnes per annum of finished product will be transported using trucks to Dili. If using 25-ton trucks to transport, it could generate approx. 5 truck trips per hour (330 days, 12-hours per day), so there will be additional traffic flow of 12 pcuph.
- There will be 700 persons per day work during operation phase. It is assumed that all the worker stay in Baucau city, so they will commute from the city to clinker plant and from the city to clay deposit. There will be additional traffic from the city to clay deposit of 13 pcuph and from the city to Clinker Plant of 71 pcuph respectively.

Based on the prevailing standard, road networks performance during operation phase is still in good condition. Hence, the Government of the Democratic Republic of Timor-Leste plans to undertake the National Road No. 1 Upgrading Project to upgrade the 118 km road from capital city Dili to Baucau. The project involves the widening of the current 3.2 - 4.5 m road to 6.0 m width asphaltic concrete

pavement. By implementing the above project, it is believed that the road network will be in better performance as more vehicles could be accommodated.

To manage the impact of traffic both in the construction and the operation phases, managing traffic is essential to providing a safe construction and operation activities. Traffic can include cars, utilities, delivery trucks, excavators, etc. The safe construction and operation activities can be achieved by careful planning and by controlling vehicle operations.

The traffic management plan should be regularly monitored and reviewed to ensure whether it is effective and to take into account any changes during construction and operation activities. All workers should be familiar with the traffic management plan and receive sufficient information, instruction, training, and supervision.

1 INTRODUCTION

1.1 Brief Project Description

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker.

Clinker refers to small lumps (3.0-25.0 mm diameter), produced by heating limestone and other materials such as clay and sand in a cement kiln. Clinker, if stored in dry conditions, can be kept for several months without appreciable loss of quality. Because of this, it can easily be handled by ordinary mineral handling equipment; clinker is traded internationally in large quantities. Clinker is then ground to a fine powder, along with gypsum and other substances to produce useable cement.

The proposed project will provide cement for both domestic use and international sale. A feasibility study is currently being undertaken to demonstrate the commercial viability of the project.

The proposed project represents a significant investment of approximately $350 million and the largest industrial project undertaken in Timor-Leste to date. It is anticipated to create 1000 jobs at the peak of the construction. It will then continue to have 700 permanent employees during operation. The project aims to develop local capacity and will develop a training center.

The spin off benefit would be indirect employment to local community members, through the multiplier effect due to downstream socio-economic benefits and consequent improvement in the living conditions of local population in the project area.

A. <u>Cement Clinker Plant</u>

The plant includes clinkerisation and cement grinding facilities with a rated capacity of 5,000 tons per day (tpd) of clinker and 100 tons per hour (tph) of cement. The plant also includes a waste heat recovery (WHR) power plant.

Up to 60% of 0.53 Mtpa of cement will be sold in the local markets and balance 40% will be shipped to Australia in 8,000 Deadweight-Ton (DWT) ships either in bulk or in. Balance clinker of 1.15 Mtpa will be shipped in vessels of 40,000 DWT ships to Australia.

The project involves developing a green field plant including, but not limited, to the engineering, design, manufacturing and supply of new equipment for cement plant, a waste heat recovery based power plant, a captive thermal power plant of approx. 30 MW and Port (Double wharf jetties) about 1.5-2 Km from the plant site.

B. <u>Thermal Power Plant bottom and fly ash utilization</u>

The waste from the thermal power plant will be fly ash and bottom ash. The total ash will be utilised in the cement grinding for producing PPC based on the coal data and ash in the coal the fly/bottom ash generation will be approximately 50 t/day i.e approx. 16500 t/annum. This will produce around 66000 t/a of PPC based on 25% ash in PPC. All ash from the thermal power plant will be transported pneumatically to the cement grinding section.

C. <u>Mines and Raw Materials</u>

The raw and fuel material requirements for the proposed plant are to be met from different sources as given in Table below.

Table 1 Raw Materials

No.	Material	Source	Source Locality	Remarks
1.	Limestone	Local	Suco Tirilolo, Bahu, Caibada, Triloca, Bucoli, Baucau Municipality	Primary raw material. Transported from mine site to crusher by trucks.
2.	Clay	Local	Suco Wailacama, Baucau administrative post in Baucau municipality	A corrective material. Transported from quarry to plant by road.
3.	Iron Ore	Import	Australia	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.
4.	Gypsum	Import	Australia or other	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and pipe conveyor.
5.	Coal	Import	Australia/ Indonesia	Fuel source and corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.

D. Limestone Deposit

The limestone deposit is accessible from Baucau by a tar road. The mine is located about 1 km from the main road and Bucoli village. The mining area is located around 0.5 km from the coastline where a jetty is proposed to be constructed. The limestone concession area (I-1) which shall meet the initial limestone requirement of the plant covers an area of 576 ha. The deposit area is generally undulating and hilly. As observation result, the limestone bearing area is covered by thick or scattered trees, thorny bushes and tall grass.

E. Clay Deposit

Clay is found to occur close to the plant site in Suco Wailacama in Baucau administrative post, less than 10 km west of the plant site. Clay shall be used as corrective to compensate for silica and alumina deficiency in the raw mix. Clay is proposed to be transported to the plant site by trucks.

F. Jetty

A dedicated jetty is proposed at a distance of 2 km from the plant site. Inbound material, (e.g., coal, gypsum, iron ore) and outbound clinker shall be transported between the plant and the jetty by a 0.5 km long conveyor belt + 1.5 km Pipe Conveyor (fully enclosed). The maximum load during unloading is estimated as 1000 tons per hour and during loading is estimated as 1000 tons per hour.

G. Utilities

a. Power

Power will be supplied by captive thermal power plant of approximately 30 mega-watts (MW) capacity and Waste Heat Recovery power plant.

Power for initial phase of plant operation when cement grinding is commissioned will be from grid power. Tapping from the nearby grid line of 20 KV will be tapped and step down to 11 KV at the plant substation. Generator sets will be utilized for construction power.

Emergency power requirement for initial commissioning of cement grinding is not required. For full plant 1.5 MW genset will be required. Thermal power plant shall include black start power requirement separately.

b. Water Supply

The water requirement for the cement project shall be met from groundwater by drilling bore wells. A makeup water supply of approximately 3,150 m^3/day is required for operations including requirement of mines, colony and green belt which may be possible to obtain this from one or two boreholes.

An underground aquifer is reported to occur below the mining blocks. As there is no industry in the area, the exploitation of water resources during the operation is not expected to adversely affect the water availability in the area for other competing users.

A detailed hydrogeological study is proposed to be carried out to assess the availability of groundwater in the area. Water shall be required for:

- Process Water Circuit;
- Cooling water (required for machine cooling);
- Make-up water shall be provided while re-circulating water shall be in a close loop;
- Water required for township;
- Water for on-site facilities;
- Construction and operations (dust suppression).

c. Waste Water

The cement plant is being designed as a Zero Discharge facility and there shall be no discharge of waste water outside the plant premises. All the process waste water shall be treated in Water Treatment Plant and reused for plantation purposes. The waste water generated from domestic activities shall also be treated and reused for dust suppression, green belt development to the extent possible.

d. Solid Waste

Domestic solid waste generated from plant and jetty area shall be segregated and will be sent to waste disposal site as allocated by the local administrative authorities.

1.2 Location of Study

The proposed cement plant and marine jetty are located in Suco Tirilolo, Aldeia Osso-ua, in the Baucau administrative post of Baucau municipality, Timor-Leste. The location is about 120 km east of Dili and approximately 16 km west of Baucau.

The Proponent has been granted a Prospecting License for limestone over three blocks, including, Block I-1 (Bucoli North Area-1), covering areas of 576 Ha. The prospecting blocks are spread over Sucos Tirilolo, Bahu, Caibada, Triloca, Bucoli, and Wailili in administrative posts of Baucau, Vemasse and Venilele in Baucau municipality.

Sources of clay are located at Suco Wailacama within 10 km from proposed plant site. Corrective iron ore and additive gypsum are proposed to be procured from Australia. Coal will be used as a fuel for the kiln and power supply at the cement plant and is proposed to be procured from either Indonesia or Australia. The location of plant, mines (Block I-1) and jetty are shown in figure below.

Source : *https://commons.wikimedia.org/wiki/File:Sucos_Baucau.png*
https://www.mof.gov.tl/about-the-ministry/statistics-indicators/sensus-fo-fila-fali/download-suco-reports/baucau-suco-reports/

Figure 1 Location of TL Cement Development Project

1.3 Scope of Works

According to scope of works from WorleyParsons, the traffic impact assessment study will assess the following task:

- Identifying the transportation planning and transportation network (road and public transportation) existing of Baucau around the studied area.
- Predict and calculate the generation and attraction of the developed area.
- Conduct survey traffic count in road and intersections in surrounding area.
- Conduct corridor and travel time survey to identify the existing road and intersections condition.
- Analyse the traffic circulation of external traffic at the road network and intersections in surrounding area.
- Managing the interface at the road network and intersections in surrounding area.
- Analyse option of entry/exit gate configuration, report on options and propose modification as needed.
- Planning of proposed street furniture for alternatives.
- Recommend and investigate appropriate mitigation measures associated with the development.

2 METHODOLOGY

2.1 Data Collection

Transport study consisted of spot speed at link, geometric of link and intersection, and traffic volume studies, both at link (between two intersections) and at the intersection. Traffic volume study was conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help to identify critical flow time periods, and determine the existing conditions. Traffic counting was conducted during the peak flow period with 15-minute intervals and using manual method.

Manual counts were typically used to gather data for determination of vehicle classification, turning movements, and direction of travel. These manual counts were recorded using tally sheets. The data was recorded with a tick mark on a pre-prepared field form. A watch or stopwatch was necessary to measure the desired count interval.

Intersection counts were used for timing traffic signals, designing channelization, planning turn prohibitions, computing capacity, analyzing high crash intersections, and evaluating congestion. A single observer was placed at each approach for very light traffic conditions otherwise two observers were placed.

Speed is an important transportation consideration because it relates to safety, time, comfort, convenience, and economics. In these transport studies, spot speed data was collected. Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions.

Spot speed data was gathered using stopwatch method over a relatively short period of time to get a sample size of at least 30. The spot speed study length was determined for 50 meters as average speed of the traffic stream below 30 km/h. These speed data were used to determine vehicle speed percentiles, which were useful in making many speed-related decisions and the existing road performance**. Figure 2** illustrates a typical layout for conducting a spot speed study using a stopwatch.

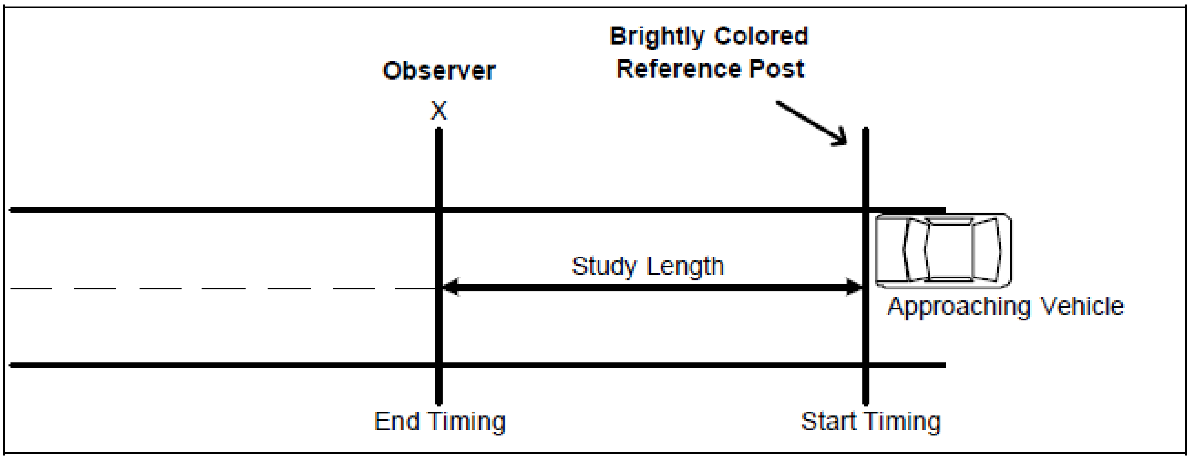


Figure 2 Stopwatch Spot Speed Study Layout

2.2 Intersection Control

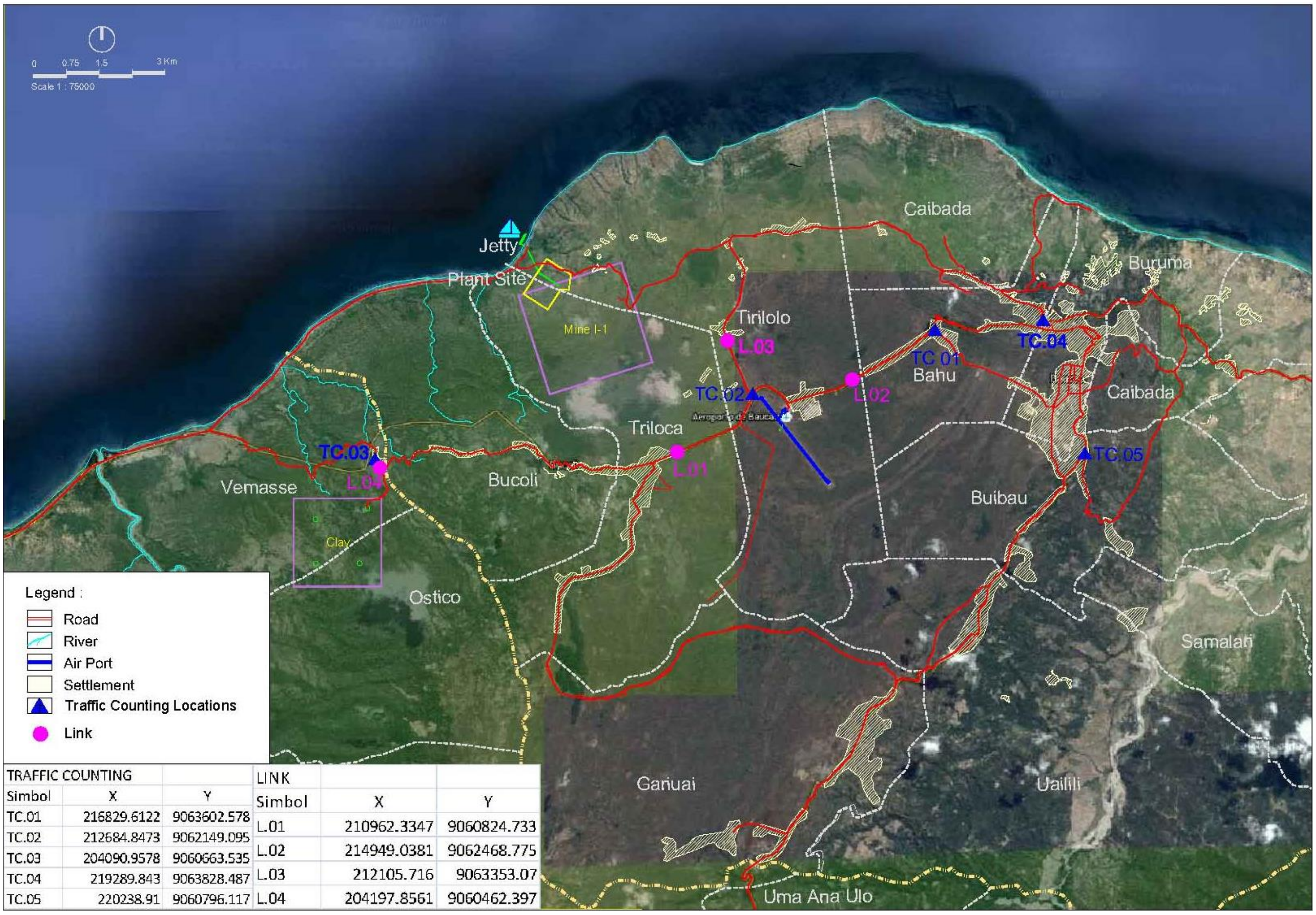
An intersection is the area where two or more streets join or cross at-grade. The intersection includes the areas needed for all modes of travel: pedestrian, bicycle, motor vehicle, and truck. Thus, the intersection includes not only the pavement area, but typically the adjacent sidewalks and pedestrian curb cut ramps. Intersections are a key feature of street design in four res pects:

- **Focus of activity -** The land near intersections often contains a concentration of travel destinations.
- **Conflicting movements -** Pedestrian crossings and motor vehicle and bicycle turning and crossing movements are typically concentrated at intersections.
- **Traffic control -** At intersections, movement of users is assigned by traffic control devices such as yield signs, stop signs, and traffic signals. Traffic control often results in delay to users traveling along the intersecting roadways, but helps to organize traffic and decrease the potential for conflict.
- **Capacity -** In many cases, traffic control at intersections limits the capacity of the intersecting roadways, defined as the number of users that can be accommodated within a given time period.

2.3 Traffic Counting

Traffic counting has been conducted in six locations for six hours of each location, these locations can be seen on **Figure 3**. The location was chosen to describe baseline traffic condition around project area and around city as well. The location in the city was chosen to give description of traffic condition as well as comparing with its hinterland.

The traffic counting were conducted in six hour. Six hour counting is divided into 3 period of 2 hours (morning peak, mid-day peak, and afternoon peak).



TRAFFIC COUNTING		
Simbol	X	Y
TC.01	216829.6122	9063602.578
TC.02	212684.8473	9062149.095
TC.03	204090.9578	9060663.535
TC.04	219289.843	9063828.487
TC.05	220238.91	9060796.117

LINK		
Simbol	X	Y
L.01	210962.3347	9060824.733
L.02	214949.0381	9062468.775
L.03	212105.716	9063353.07
L.04	204197.8561	9060462.397

Figure 3 Traffic Counting Location Survey

2.4 Data Analysis

2.4.1 Modeling Approach

Figure 4 shows the main structure of modeling approach used in this research. Traffic related indicators such as link flows, speeds and times, hence in network-wide level could be reproduced from the traffic assignment model.

First of all, inputs data related to trip matrix as the demand side and road network database as the supply side of transport system in the base year case have to be provided, as well as the trip matrices and network databases for alternative scenarios that were tested. Estimation method to obtain trip matrices was adapted, such as maximum entropy matrix estimation (ME2). Assignment process was conducted using SATURN (Van Vlient, 1994) with input data that had been adapted to the characteristic of road network and traffic in Timor-Leste.

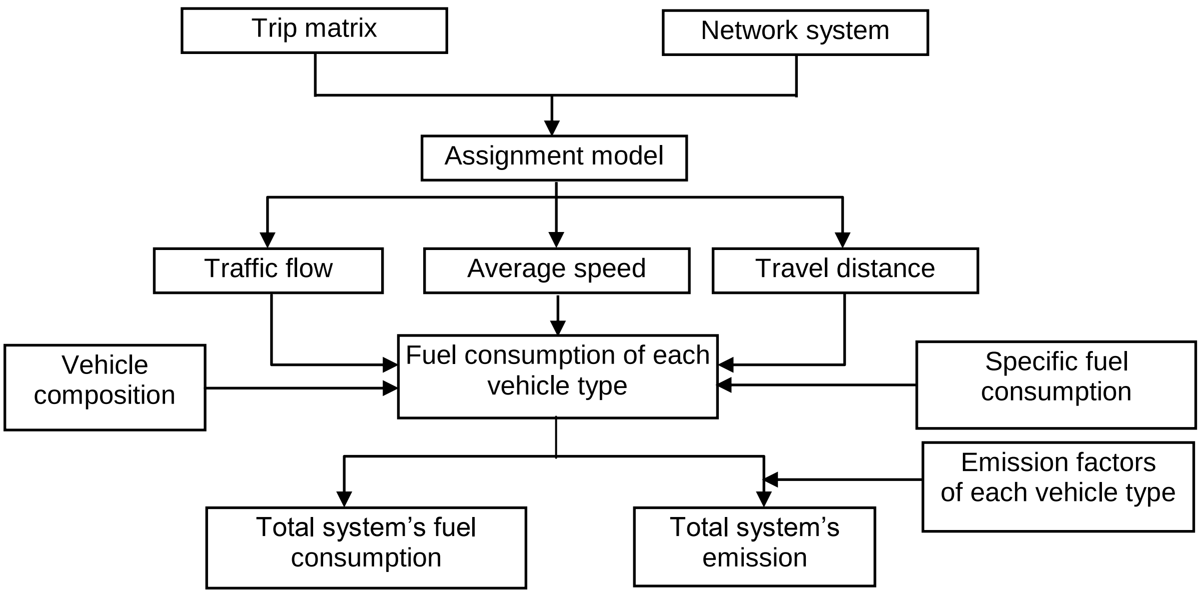


Figure 4 Main Structure of Modeling Approach

2.4.2 Zoning Design

Traffic was modeled to represent study area (Baucau subdistrict) using zoning system (based on suco) and road network, with link represent road segment and node represent intersection, as shown in **Figure 5**.

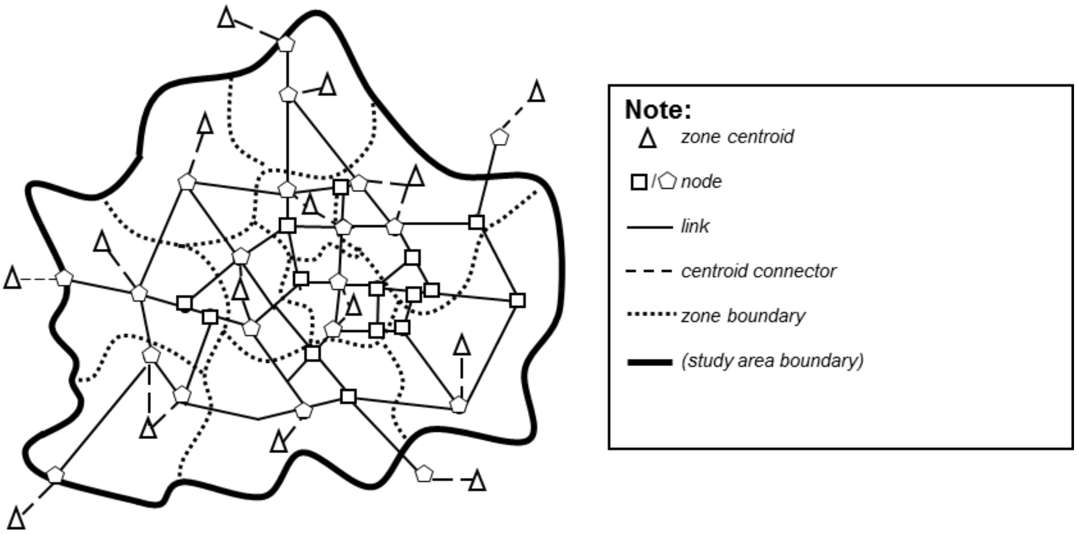


Figure 5 Road Network System Representation

In this study, every zone represented by 1 (one) centroid which was connected to the road network through centroid connector. **Table 2** shows zone number (code) and zone name. Internal zone is a zone which is located inside the road network (study area). External zone is a zone which is located outside the road network (study area).

Table 2 Zoning

No	Zone Number	Zone Name	Zone Type
1	903	Samalari	Internal
2	904	Seical	Internal
3	905	Buibau	Internal
4	906	Caibada	Internal
5	907	Buruma	Internal
6	908	Bahu	Internal
7	909	Tirilolo	Internal
8	910	Tricola	Internal
9	911	Vemasse	Internal
10	912	West Zone	External
11	913	South Zone	External
12	914	East Zone	External

Source: https://www.mof.gov.tl/about-the-ministry/statistics-indicators/sensus-fo-fila-fali/download-suco-reports/baucau-suco-reports/

2.4.3 Road Network System

Road network data model consists of primary arterial, primary collector, secondary arterial and secondary collector roads surrounding the study location or within Baucau Subdistrict. Based on zoning system, the road network is shown as **Figure 6** below.

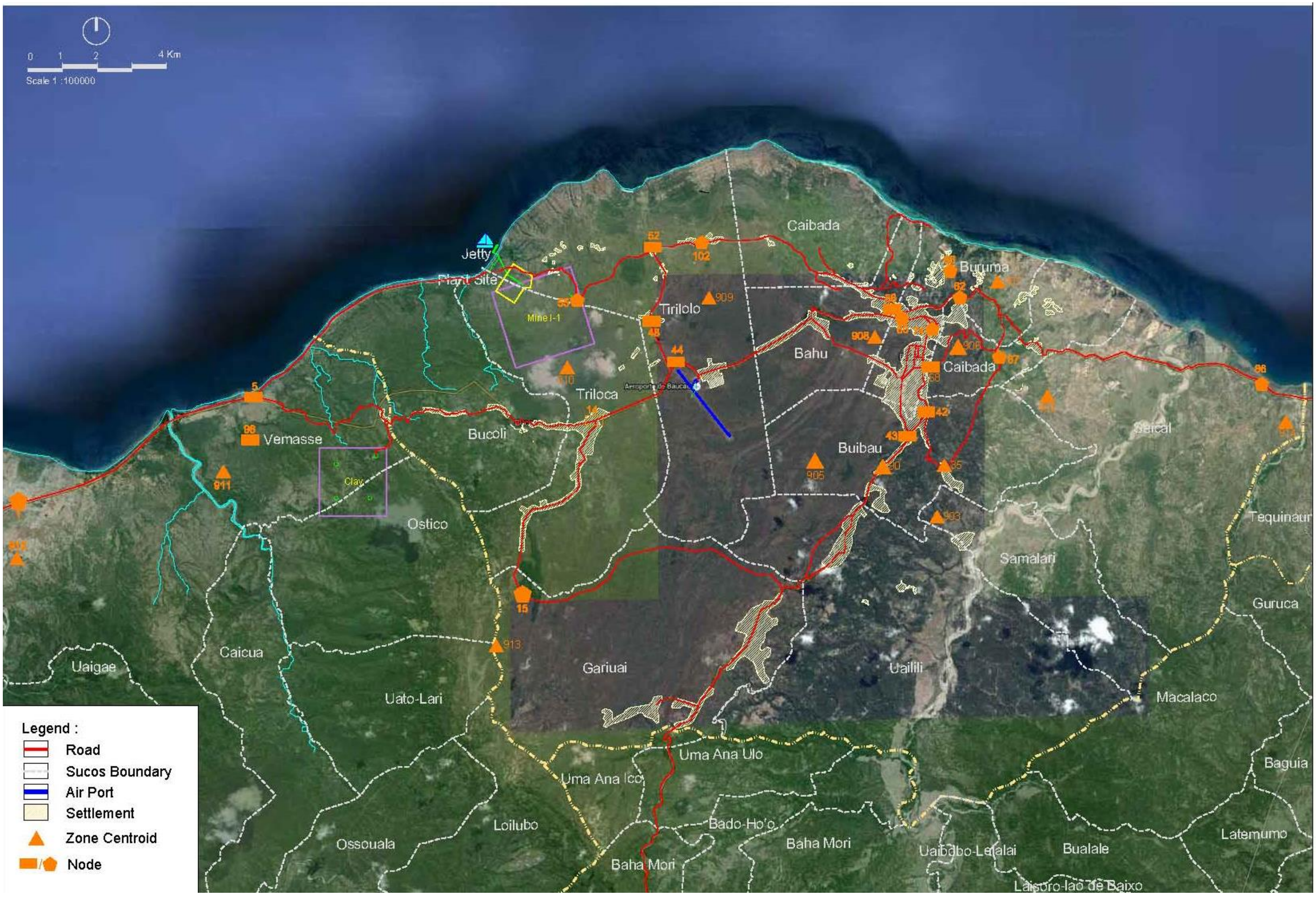


Figure 6 Existing Road Network System

Then, this road network is converted into model format and the configuration of road network of study location is shown in **Figure 7**.

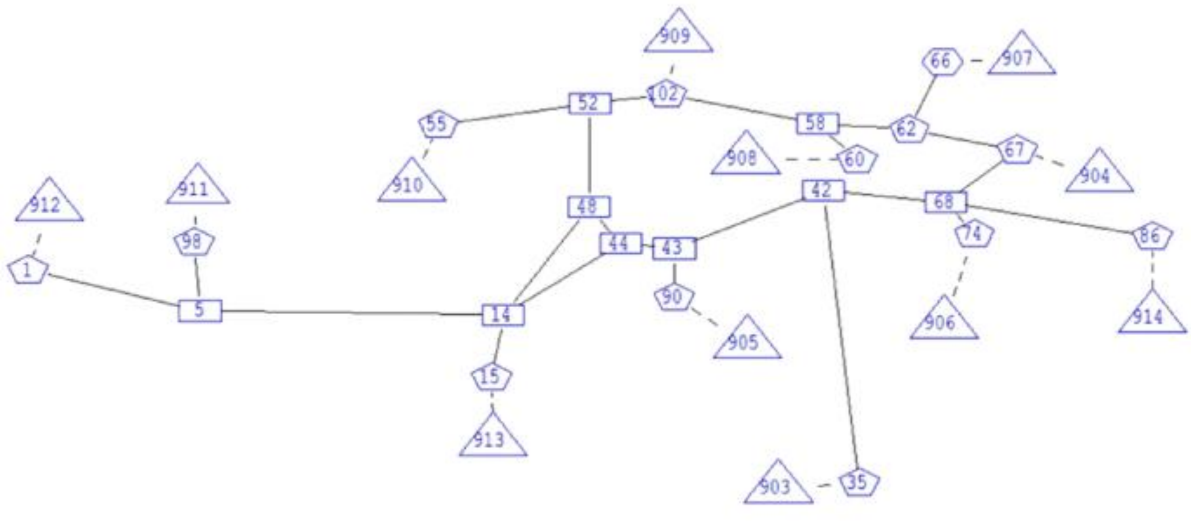


Figure 7 Model Format of Road Network System

2.4.4 Validation Model

R^2 of 0.7578 indicate that Origin–Destination matrix (trip matrix) prediction using ME2 can be representing more than 75.8% of traffic in the Baucau subdistrict. Trip matrix prediction model is fairly accurate to present trip demand pattern in the study area, so it can be used to predict future trip matrix.

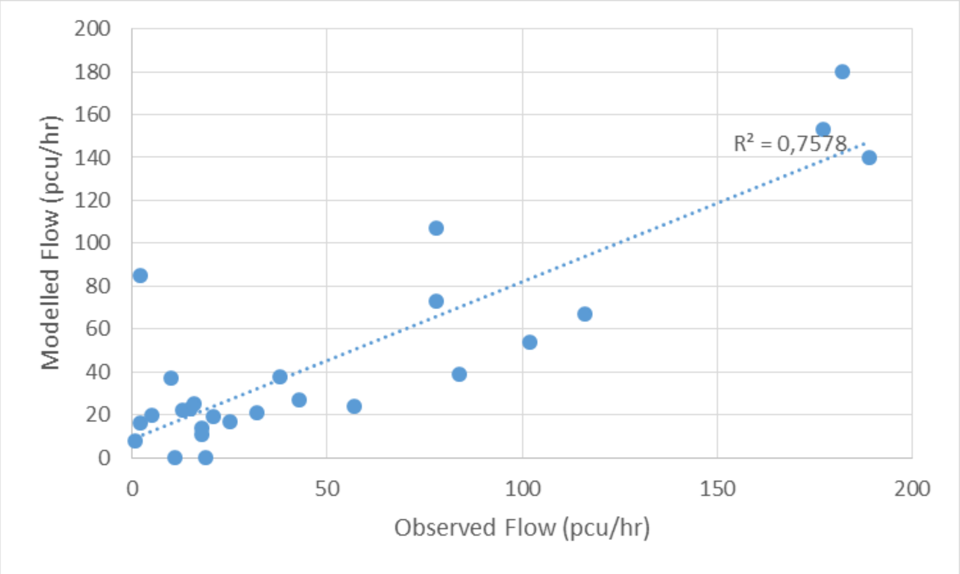


Figure 8 Validation Model

Table 3 Observed vs Model Speed (kph)

No	Segment	Speed (km/h)	
		Model	Observed
1	L1 (Triloca)	31.5	41
2	L2 (Tirilolo)	31,5	46
3	L3 (Lialailesu)	28,5	19
4	L4 (Wailacama)	69	NA

Table 4 Observed vs Model Flow (pcuph)

No	Name		Flow (pcuph)	
			Count	Model
1	TC 01	Dili-Baucau Kota Baru	78	63
2		Baucau Kota Baru-Dili	116	107
3		Baucau Kota Baru-Baucau Kota Lama	18	18
4		Baucau Kota Lama-Baucau Kota Baru	18	18
5		Baucau Kota Lama-Dili	25	23
6		Dili-Baucau Kota Lama	32	25
7	TC02	Baucau-Caisido	19	0
8		Dili-Caisido	15	13
9		Caisido-Dili	21	13

No	Name		Flow (pcuph)	
			Count	Model
10		Caisido-Baucau	11	0
11		Dili-Baucau	84	81
12		Baucau-Dili	177	170
13	TC 03	Dili-Baucau	78	77
14	TC 03	Baucau-Dili	102	97
15	TC 04	Dili-Losp	182	50
16	TC 04	Dili-Caibada	57	57
17	TC 04	Dili-Flamboyan	43	43
18	TC 04	Calibada-Losp	1	10
19	TC 04	Calibada-Dili	38	38
20	TC 04	Calibada-Flamboyan	2	22
21	TC 04	Losp-Dili	189	189
22	TC 04	Losp-Flamboyan	2	24
23	TC 04	Losp-Calibada	5	18
24	TC 04	Flamboyan-Dili	16	16
25	TC 04	Flamboyan-Losp	10	62
26	TC 04	Flamboyan-Calibada	13	52

3 TRAFFIC DATA

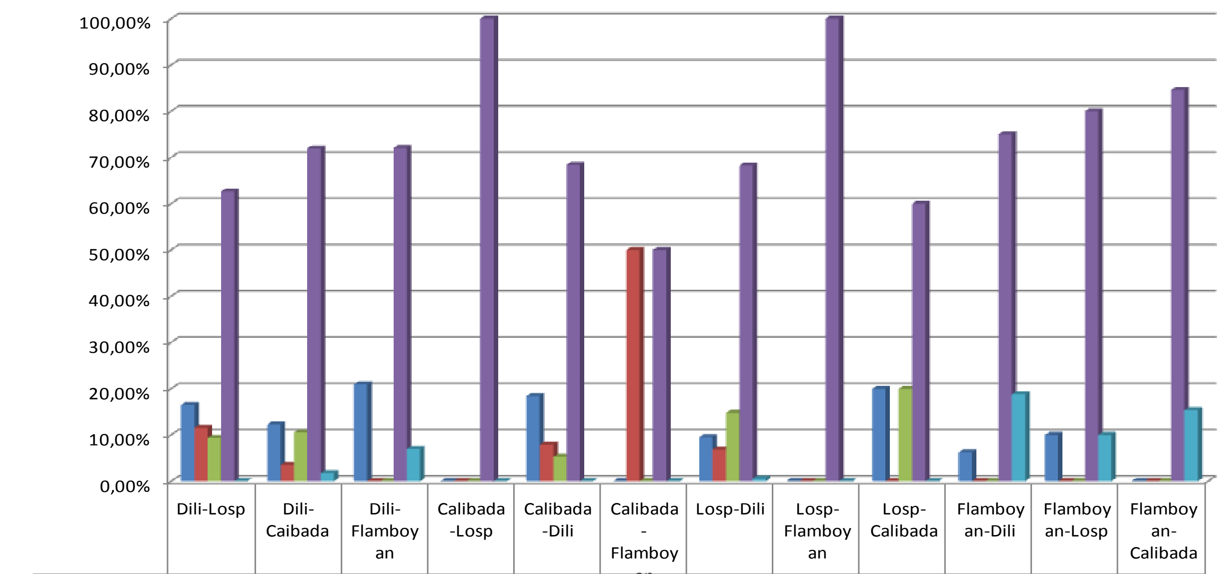
3.1 Road Network Traffic Condition

3.1.1 Traffic Counting Data

Data has been compiled and the result is shown in **Table 5** and **Figure 9**. It can be seen that the highest percentage of flow is motor cycle. Unmotorised vehicle is included in traffic flow calculation, but for further analysis using Indonesia Highway Capacity Manual (IHCM) it is excluded. It is assumed as side friction.

Table 5 Traffic Flow (pcuph)

Time	Dili-Baucau Kota Baru	Baucau Kota Baru-Baucau Kota Lama	Baucau Kota Baru-Dili	Baucau Kota Lama-Baucau Kota Baru	Baucau Kota Lama-Dili
7:00 - 7:15	32	68	0	0	32
7:15 - 7:30	44	32	12	12	8
7:30 - 7:45	64	44	0	0	28
7:45 - 8:00	60	64	8	8	32
8:00 - 8:15	60	64	20	20	28
8:15 - 8:30	44	44	16	16	24
8:30 - 8:45	20	48	4	4	12
8:45 - 9:00	76	72	8	8	28
Maksimum	76	72	20	20	32
12:00 - 12:15	40	56	8	8	12
12:15 - 12:30	36	56	0	0	4
12:30 - 12:45	60	48	16	16	8
12:45 - 13:00	20	48	16	16	16
13:00 - 13:15	20	72	8	8	4
13:15 - 13:30	20	52	8	8	28
13:30 - 13:45	56	72	4	4	16
13:45 - 14:00	60	60	12	12	12
Maksimum	60	56	16	16	16
16:00 - 16:15	32	24	4	4	32
16:15 - 16:30	44	32	8	8	32
16:30 - 16:45	80	48	8	8	16
16:45 - 17:00	8	48	0	0	16
17:00 - 17:15	40	12	16	16	20
17:15 - 17:30	60	32	4	4	24
17:30 - 17:45	76	24	28	28	24
17:45 - 18:00	56	28	4	4	12
Maksimum	80	48	28	28	32



	Dili-Losp	Dili-Caibada	Dili-Flamboyan	Calibada-Losp	Calibada-Dili	Calibada-Flamboyan	Losp-Dili	Losp-Flamboyan	Losp-Calibada	Flamboyan-Dili	Flamboyan-Losp	Flamboyan-Calibada
Car	16,48%	12,28%	20,93%	0,00%	18,42%	0,00%	9,52%	0,00%	20,00%	6,25%	10,00%	0,00%
Bus	11,54%	3,51%	0,00%	0,00%	7,89%	50,00%	6,88%	0,00%	0,00%	0,00%	0,00%	0,00%
Truck	9,34%	10,53%	0,00%	0,00%	5,26%	0,00%	14,81%	0,00%	20,00%	0,00%	0,00%	0,00%
Motorcycle	62,64%	71,93%	72,09%	100,00%	68,42%	50,00%	68,25%	100,00%	60,00%	75,00%	80,00%	84,62%
Unmotorised	0,00%	1,75%	6,98%	0,00%	0,00%	0,00%	0,53%	0,00%	0,00%	18,75%	10,00%	15,38%

Figure 9 Traffic Flow as Percentage by Vehicle Types

3.1.2 Speed Data

Spot speed was conducted in 4 locations **L1, L2, L3, and TC03** (see **Figure 3**). Approximately 20 speed data has been collected for each location and then space mean speed is calculated. The example of data and calculation of location L1 is shown in **Table 6**.

Table 6 Spot Speed Data

Vehicle No.	Travel Time (second)	Vehicle No.	Travel Time (second)
1	8.43	11	6.57
2	6.66	12	5.95
3	8.04	13	6.39
4	8.75	14	6.11
5	6.51	15	7.88
6	7.45	16	6.77
7	7.81	17	6.18
8	6.68	18	7.25
9	7.86	19	6.49
10	7.41	20	6.93

Location	L1
Segment length (m)	80
Average Travel Time (sec)	7.106
Space mean speed (km/h)	40.53

3.1.3 Road Network Condition

Traffic impact caused by new activities will be experienced by a road network surrounding Clinker Plant and Clay Deposit (see red line in **Figure 21**). Existing condition of all road in the network are lack of road furniture, i.e. road lighting, road marking, road sign, and road barrier. Road furniture was only found closed to the bridge, consist of bridge warning sign (unclear) cover with plantation, directional sign, maximum axle load sign, horizontal curve sign, and road barrier (only one side), see **Figure 10**.

Figure 11 shows existing road condition which has 5 meter wide, unpaved shoulder and some shoulder are covered by plantation, and no side ditch. Because road width is relatively narrow, it is difficult if two vehicles pass through at the same time. Generally, arterial road are paved by asphalt, but collector road are remained unpaved. Some points at the segment of roads were found damaged or potholes, either small or big. **Figure 11** shows road geometric are in substandard design, it is indicated by:

- Small radii curvatures
- Short lateral clearance
- High gradient (steep -upgrade and -downgrade)

All the intersections in the road network are uncontrolled intersection, no road marking, no road sign (see **Figure 12**).

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Figure 10 Road Furnitures in Existing Road

Figure 11 Road Network Condition

Figure 12 Uncontrolled Intersection at the Study Area

3.1.4 Coastal Road

Coastal road is located western part of Clinker Plant. A large portion of the coastal road is unpaved and only suitable for 4x4 (see **Figure 13**). The coastal road passing estuary is unpassable at high-tide. But, a few portion of the coastal road (eastern part) is already paved and in good condition. The intersection between Dili-Baucau road and coastal road is a T-junction and it is located in Caravela.

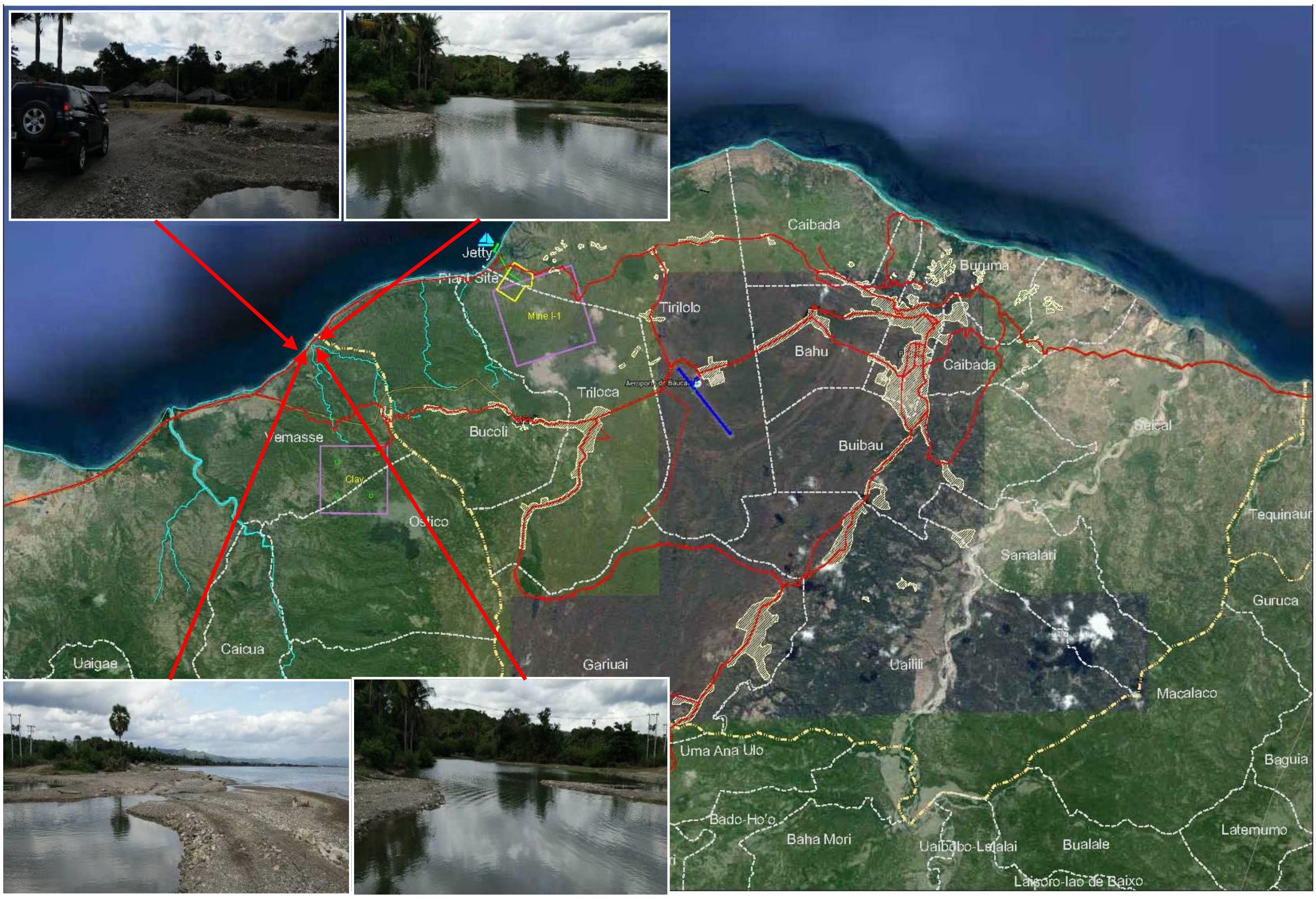


Figure 13 Coastal Road Passing the Estuary

3.2 Road Network Traffic Performance

3.2.1 Trip Attraction and Generation Model

Trip Attraction and Generation Model year 2015 is developed from traffic counting data and then using ME2 method trip attraction and trip generation for each zone centroid will be found and is represented as Origin Destination Matrix (O-D matrix). Trip Attraction and trip Generation is summation of row and column of O-D matrix and it is figured out as barchart as seen in **Figure 14.**

It was shown from the figure that each zone centroid attracts a number of vehicles (green bar) and generate a number of vehicles (purple bar). Zone centroids in Baucau city attract and generate more vehicle than zone centroid in rural areas (non-developed areas). Zone centroid 905 (Buibau), 913 (South zone), and 914 (East zone) are attract more trip than generate, whereas others are attracting fewer trips than generate trip.

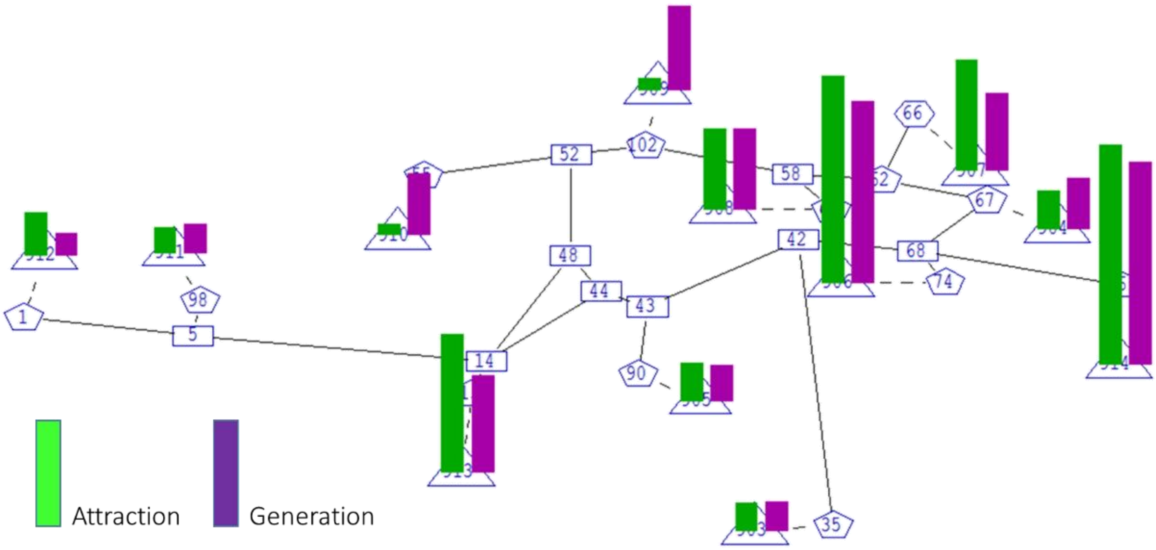


Figure 14 Trip Attraction and Generation

3.2.2 Trip Distribution Model

Trip distribution model is developed to distribute trip generation and trip attraction from and to each zone based on accessibility level for each zone-pair. Trip distribution matrix can be represented as desire line, which is the trip value between zone and the thickness of the line representing the relative value. Trip distribution (in pcuph), which is representing as desire line, of study area year 2015 can be seen in **Figure 15.**

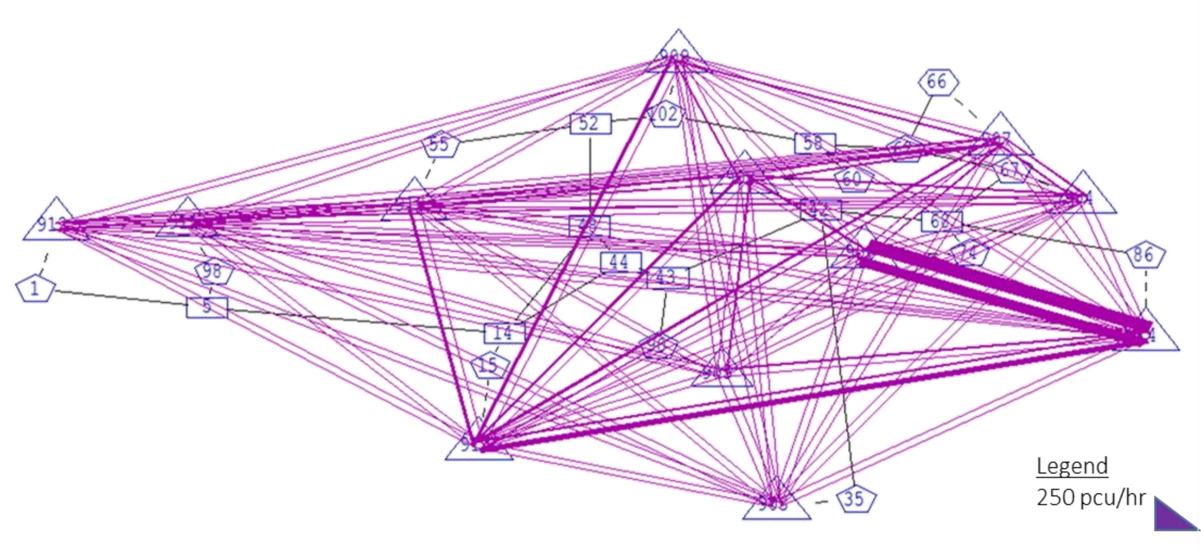


Figure 15 Desire Line

3.2.3 Trip Assignment Model

The main purpose of trip assignment is to identify which routes will be used by road user from origin to destination and to know the number of trip using each link in the road network. Factors influencing trip assignment are characteristic of study area, alternate routes, road user behavior, and traffic jam.

In this study all-or-nothing method is chosen as assignment model and the result of traffic assignment in the road network can be seen in **Figure 16**.

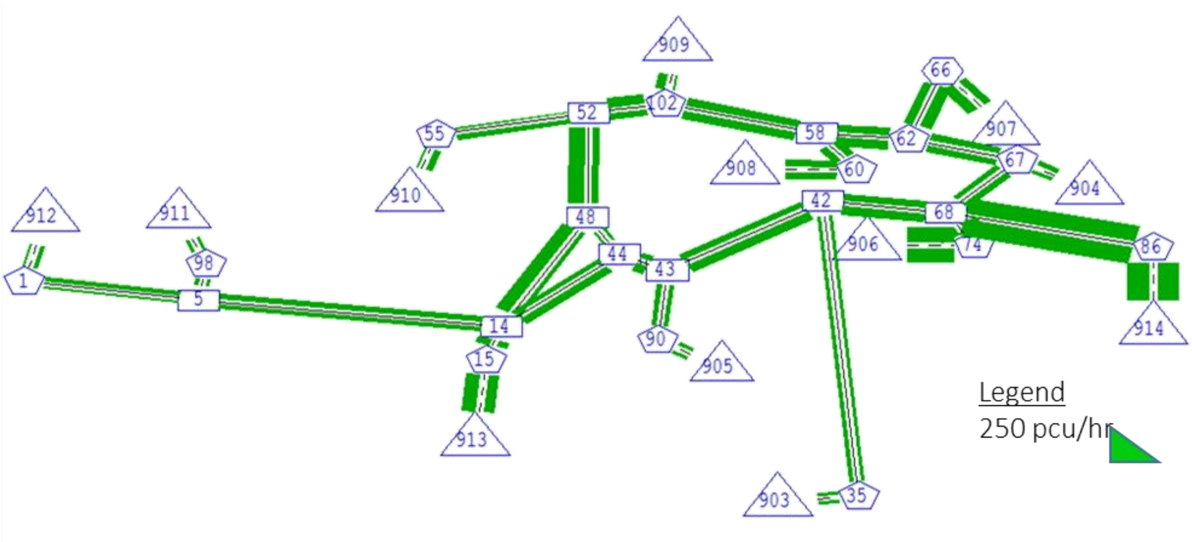


Figure 16 Trip Assignment

Trip assignment can also be presented in tabular. It was shown that the highest trip on link is occurred in link between zone 86 (external zone) and zone 68 (Caibada) which is 245 pcuph. The second highest trip distribution is occurred in link between zone 68 to zone 86, which is 225 pcuph. This resulting total trip on this road is 470 pcuph.

Table 7 Existing Link Flow Condition

Origin	Destination	Flow (pcuph)	Origin	Destination	Flow (pcuph)	Origin	Destination	Flow (pcuph)
1	5	47	44	14	102	60	58	90
5	1	24	44	43	76	62	66	87
5	14	73	44	48	19	62	67	88
5	98	32	48	14	39	62	58	124
5	1	24	48	44	23	66	62	124
14	44	53	48	52	172	67	68	62
14	48	153	48	14	39	67	62	77
14	5	54	52	48	62	68	42	128
14	15	107	52	55	67	68	67	66
15	14	153	52	102	135	68	74	203
35	42	31	52	55	67	68	86	225
42	35	32	52	102	135	74	68	231
42	43	121	55	52	11	86	68	245
42	68	84	58	60	89	90	43	42
43	42	78	58	62	98	98	5	28
43	44	121	58	102	122	102	52	81
43	90	40	58	62	98	102	58	95

3.2.4 Traffic Performance

The road network is classified into two functional classes, i.e. arterial and collector roads. Road width varies from 4 to 5 meters, resulting a road capacity of 900 pcuph and 1,227 pcuph respectively.

Volume capacity ratio between 0.5 - 0.7 only occurred on link between node 86 and node 68 and node 74 to node 68 (see **Figure 17**) and volume capacity ratio between 0.2 – 0.5 occured only on several link as shown as red line in **Figure 18**. It can be concluded that traffic demand for existing condition is still far below road capacity. The rest of the links are experienced volume capacity ratio less than 0.2.

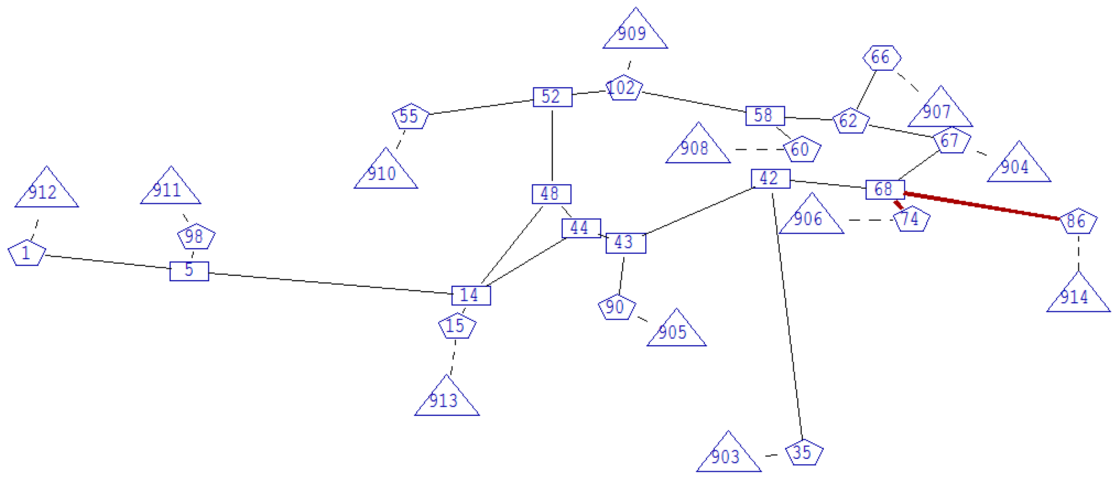


Figure 17 Volume Capacity Ratio 0.5 - 0.7

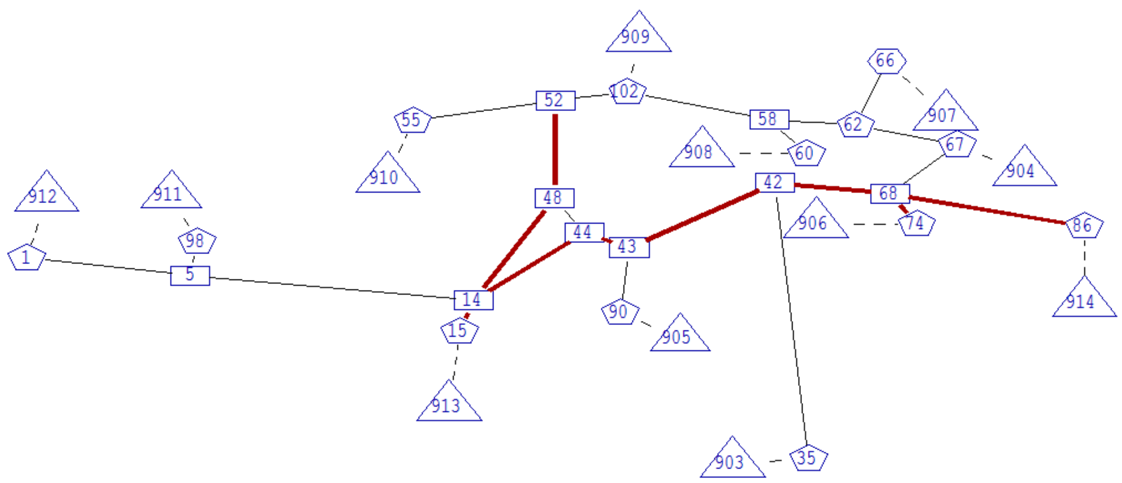
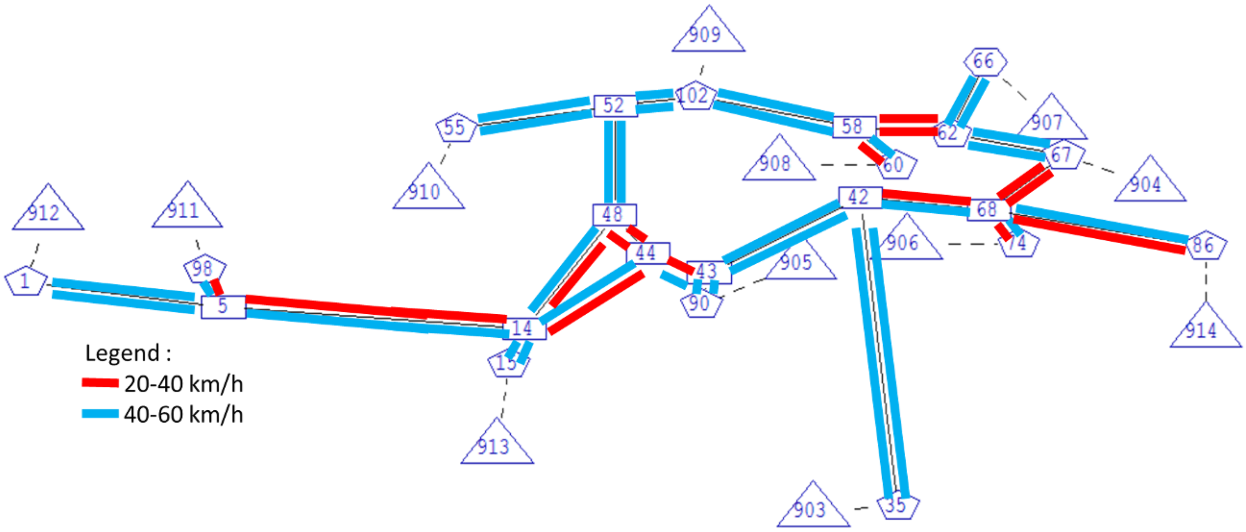


Figure 18 Volume Capacity Ratio between 0.2 – 0.5

The blue line in **Figure 19** shows the road with time mean speed at the existing condition. There is a link road that experience time mean speed less than 20 kmph, but the link is short and occur around node 68. The rest of the roads in the studied road network experience time mean speed between 40-60 kmph. It can be concluded that overall time mean speed around project area are still in a good condition.



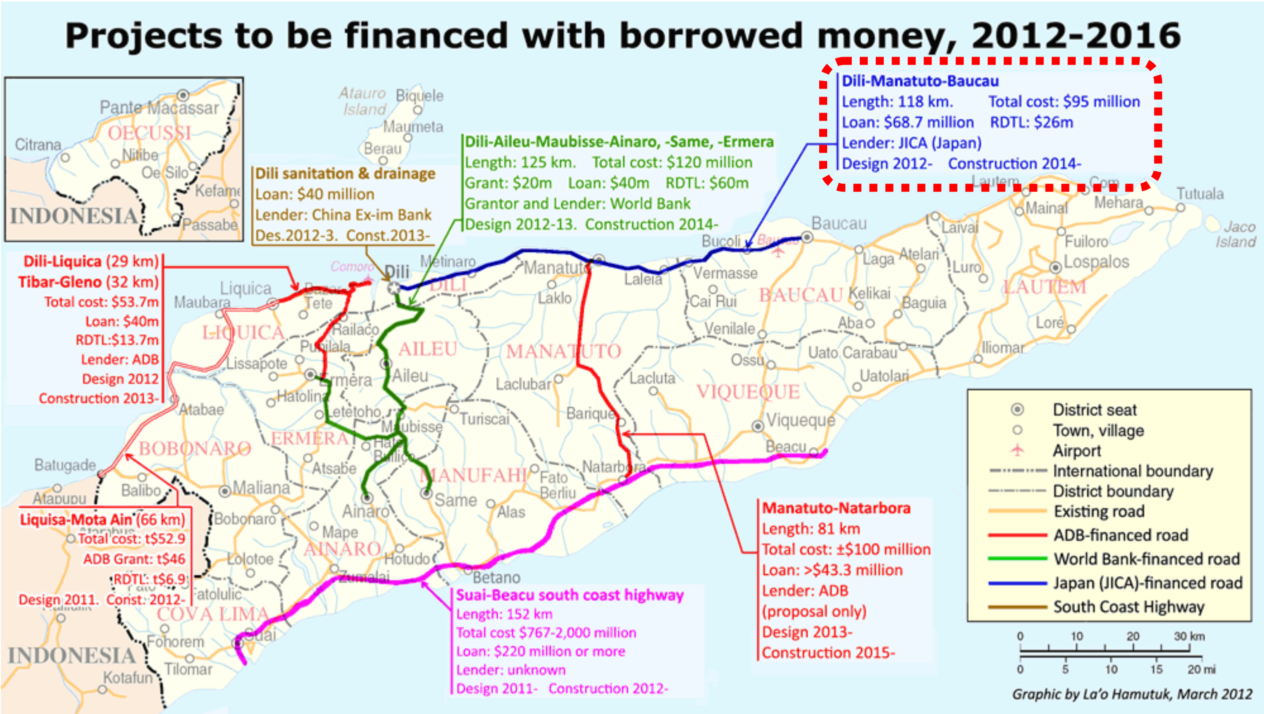
Note : speed from node 5 to 14 is shown in blue colour, whereas from node 14 to node 5 speed is noted as red colour

Figure 19 Speed at the existing condition

3.3 Regional Transport Development Plan

During survey implementation, BITA had met with the officers of MPoW (Ministry of Public of Work) and JICA representative on June 1, 2015. The meeting discussed the government plan for road improvement between Dili – Baucau. During discussion with the authorized officers, BITA did not obtained the report document as this report was being discussed by relevant agencies. BITA just got the brief information on the length and width of the proposed road which will be improved.

The Government of the Democratic Republic of Timor-Leste (hereinafter referred to as GOTL) has received a Loan from Japan International Cooperation Agency (JICA) toward the cost of the National Road No. 1 Upgrading Project. This Project is to make the National Road No.1 passable in safe throughout a year in any weather situation by upgrading the 118 km road from capital city Dili to the second largest city, Baucau. The project involves the widening of the current 3.2 - 4.5 m road to 6.0 m width asphaltic concrete pavement. Improvement includes drainage and slope protection works, construction of 7 new bridges and rehabilitation of existing bridges.



Source : http://www.laohamutuk.org

Figure 20 Road Projects in TimorLeste

4 IMPACT ASSESSMENT

4.1 Construction Phase

It is predicted that there will be an additional traffic flow due to the following activities:

- Mobilisation of heavy vehicle and materials from Dili to clay deposit and clinker plant areas.
- Mobilisation of construction workers.

To analyze the magnitude of impacts, the assumption has been developed based on professional judgement and analogical approach.

During construction phase of Clinker Plant, it is assumed that there will be 1,000 persons per day from Baucau work in both clay deposit (zone 915) and Clinker Plant (zone 916). Medium bus with a capacity of 20 passengers will be provided to serve workers. It causes additional daily traffic flow on an existing road network during construction. In consequence, there will be an additional traffic flow to and from clay deposit and Clinker Plant of 18 pcuph and 102 pcuph respectively (see **Table 8**).

Additional traffic flow also comes from daily mobillisation of heavy vehicle transporting construction materials to clay deposit (4 trucks) and Clinker Plant (7 trucks). Accordingly, there will be additional traffic flow due to transportation of construction materials, i.e. 26 pcuph.

Table 8 Additional Traffic Flow

Origin - Destination	Vehicle Type	pcu value	Additional Traffic Flow (pcuph)	
			Construction Phase	Operation Phase
Clay Deposit and Clinker plant	MHV	2.4	26	10
Baucau city - Clinker plant (85%)	MB	2.4	102	71
Baucau city - clay deposit (15%)	MB	2.4	18	13
Baucau – Dili (Finished Product)	MHV	2.4		12

Source: IHCM (1997)

Assumption: Rolling terrain and Total traffic flow = 650 vph

Volume capacity ratio and time mean speed for construction phase can be seen in **Figure 21 to 23**. It was shown that traffic performance during construction will be worse compare with an existing condition (do nothing). It can be seen in **Figure 21** that volume capacity ratio greater than 0.5 is occurred on several links (node 48 – 52 – 55). **Figure 23** shows only three short links experience speed less than 20 km/h (node 5 – 103; node 44 – 48; node 52 - 102).

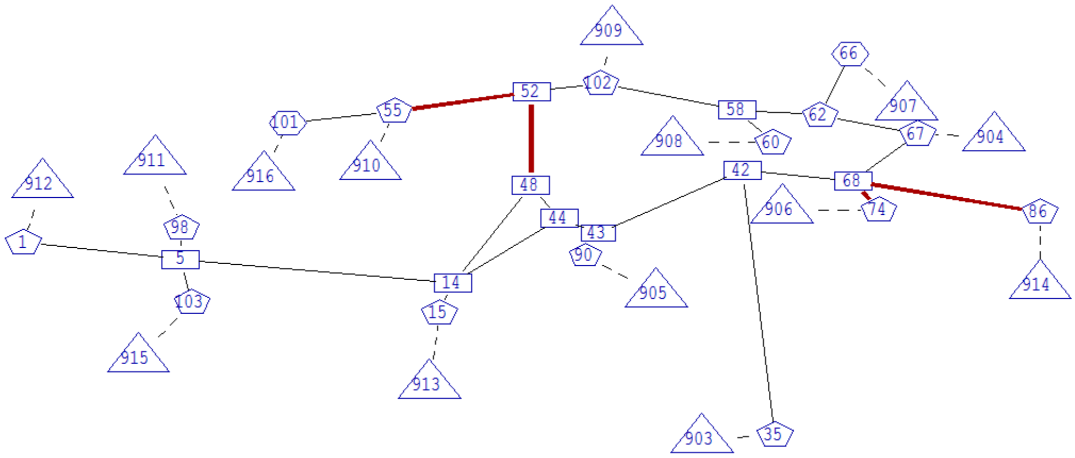


Figure 21 Volume Capacity Ratio between 0.5 – 0.7

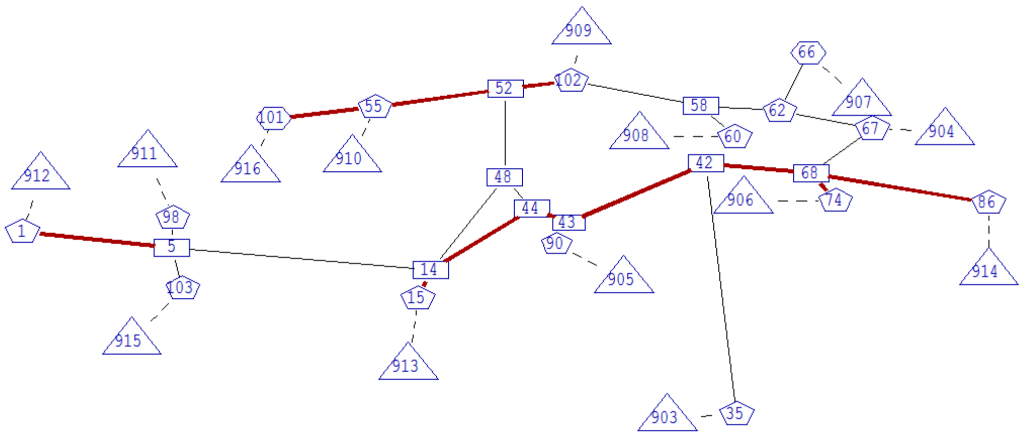
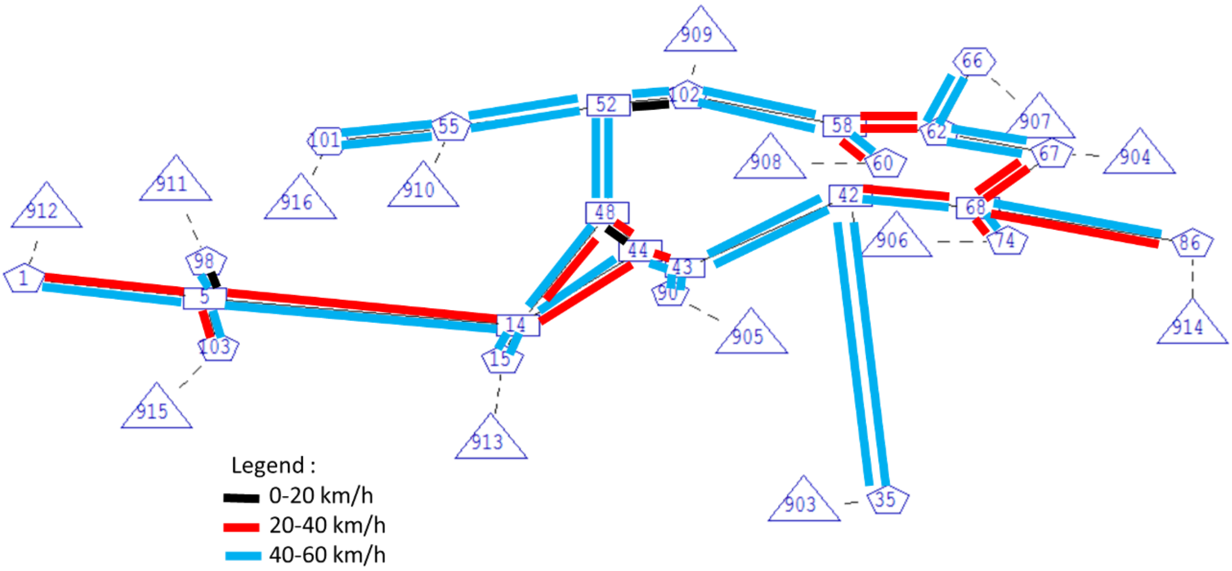


Figure 22 Volume Capacity Ratio between 0.2 – 0.5



Note : speed from node 5 to 14 is shown in blue colour, whereas from node 14 to node 5 speed is noted as red colour.

Figure 23 Speed less than 20 km/h

A v/c ratio over 1.0 indicates the road or intersection is over-capacity; a v/c ratio under 1.0 indicates there is still room to accommodate additional vehicles. IHCM (Indonesian Highway Capacity Manual) recommend v/c ratio during peak hours for design year not exceed 0.75. According to this standard, road networks performance during construction phase is in good condition.

4.2 Operation Phase

During operation phase there will be a generated traffic caused by transportation activities in clay deposit and Clinker Plant, and this will caused traffic impact on road network.

A. Transportation of Clay Material to Clinker Plant

It is assumed that clay (0.41 mio tonnes/year) will be transported from quarry to Plant using a dump truck with a capacity of 25 tonnes. Accordingly, it could generate approx. 4 truck trips per hour (330 days, 12-hours per day), so there will be additional traffic flow of 10 pcuph.

Clay transportation is planned to use three alternative routes (see **Figure 24**):

1) From clay deposit turn right, then using an existing road,
2) From clay deposit turn left until T-junction, then continue to use a coastal road, and
3) Built a new road direct from clay deposit to the coastal road, and then continue to clinker plant.

Figure 24 Alternative Routes

Alternative 1: Existing Road Network

Figure 25 shows links which has volume capacity ratio between 0.2 - 0.5 are links between node 101 – 55 – 52 – 102 and node 14 – 44 – 43 - 42 – 68 – 86. **Figure 26** shows only one link (node 44 – 48) experienced speed less than 20 km/h.

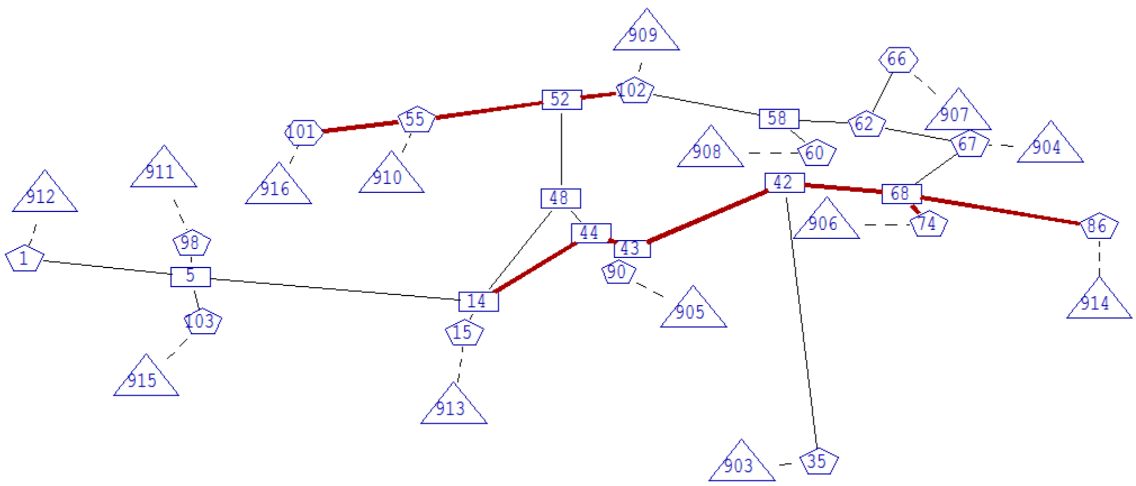
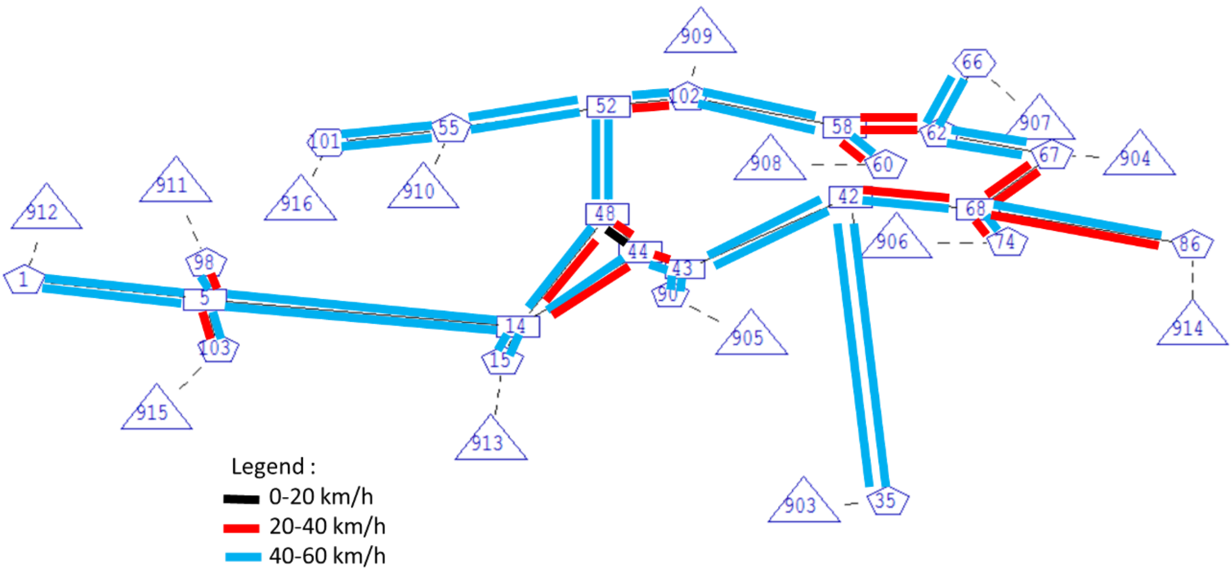


Figure 25 Volume Capacity Ratio between 0.2 – 0.5



Note : speed from node 14 to 44 is shown in red colour, whereas from node 44 to node 14 speed is noted as blue colour.

Figure 26 Speed using Existing Road

Alternative 2: Using Coastal Road

Figure below shows only several links (node 5 – 104; node 14 – 48 – 52 – 102; node 14 - 44 – 43 – 42 – 68 – 86; and node 68 – 74) has volume capacity ratio between 0.2 - 0.5 and the rest experienced volume capacity ratio less than 0.2. None of the link has speed lees than 20 km/h.

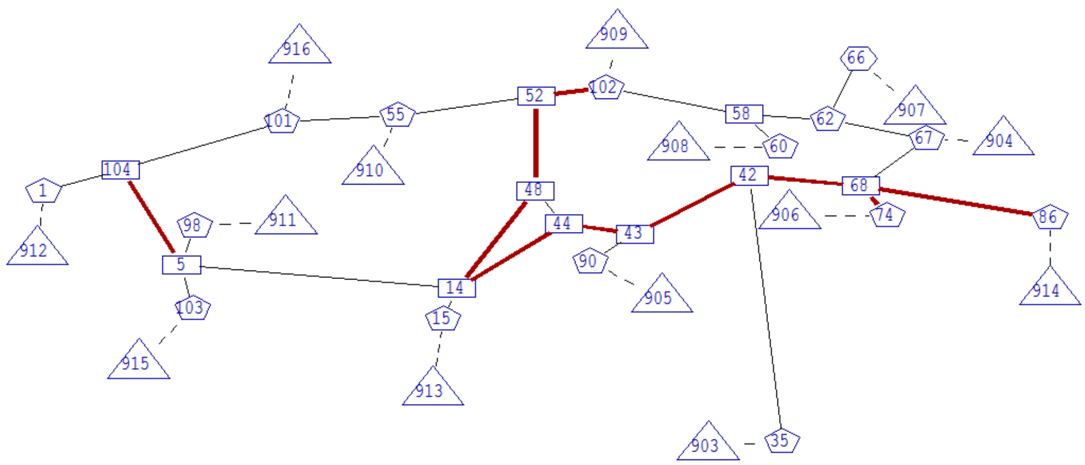
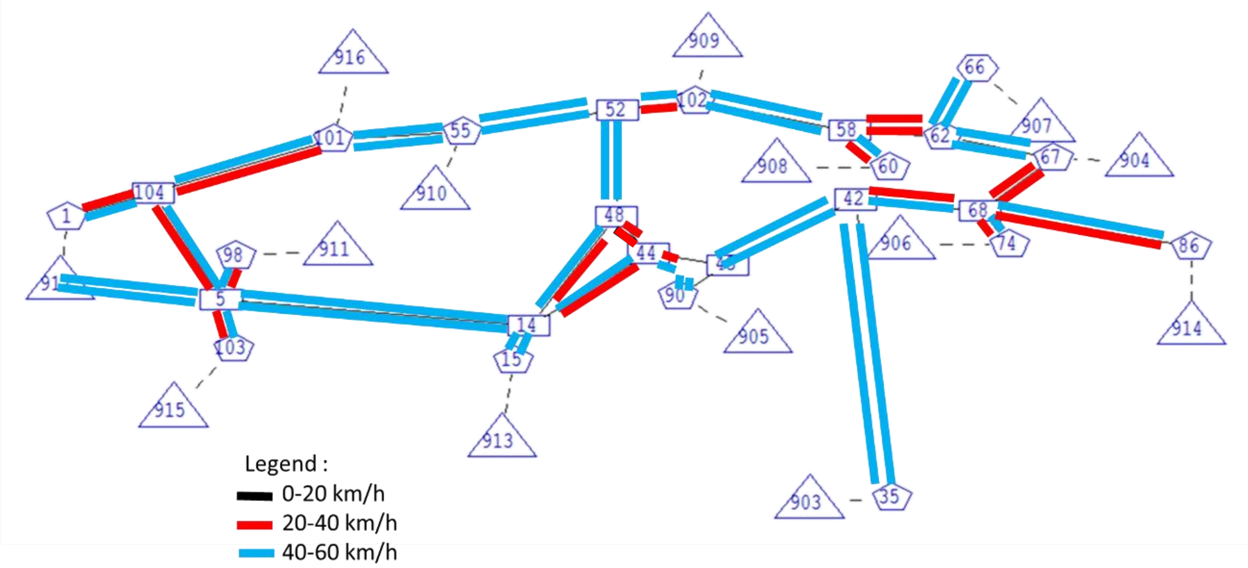


Figure 27 Volume Capacity Ratio between 0.2 – 0.5



Note : speed from node 14 to 44 is shown in red colour, whereas from node 44 to node 14 speed is noted as blue colour.

Figure 28 Speed using Coastal Road

Alternative 3: New Road

Links from node 1 – 5 – 104, node 14 – 48 – 52, node 14 – 44 – 43 – 42 – 68 – 86, and node 68 – 74 have volume capacity ratio between 0.2 - 0.5 (see Figure 27). None of the link has speed lees than 20 km/h.

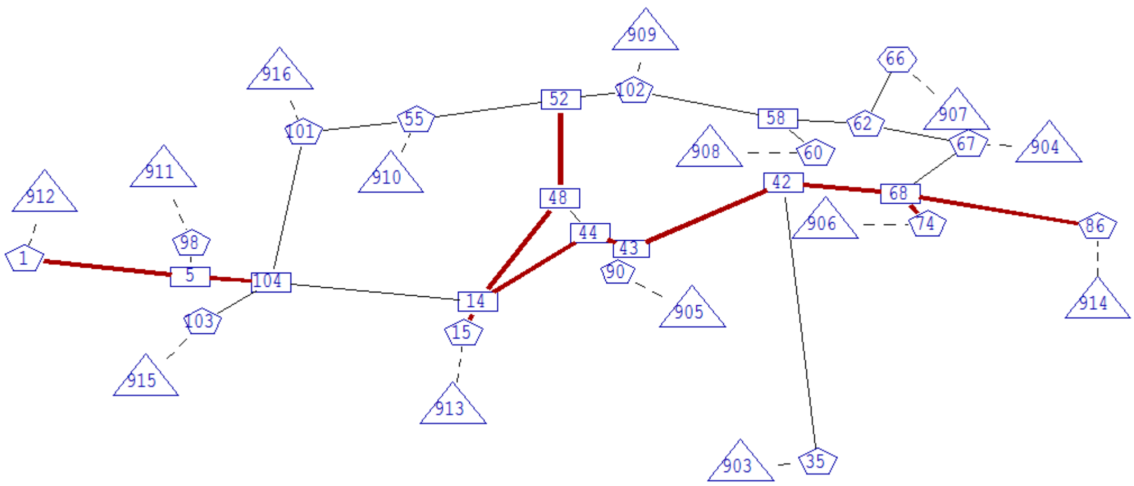
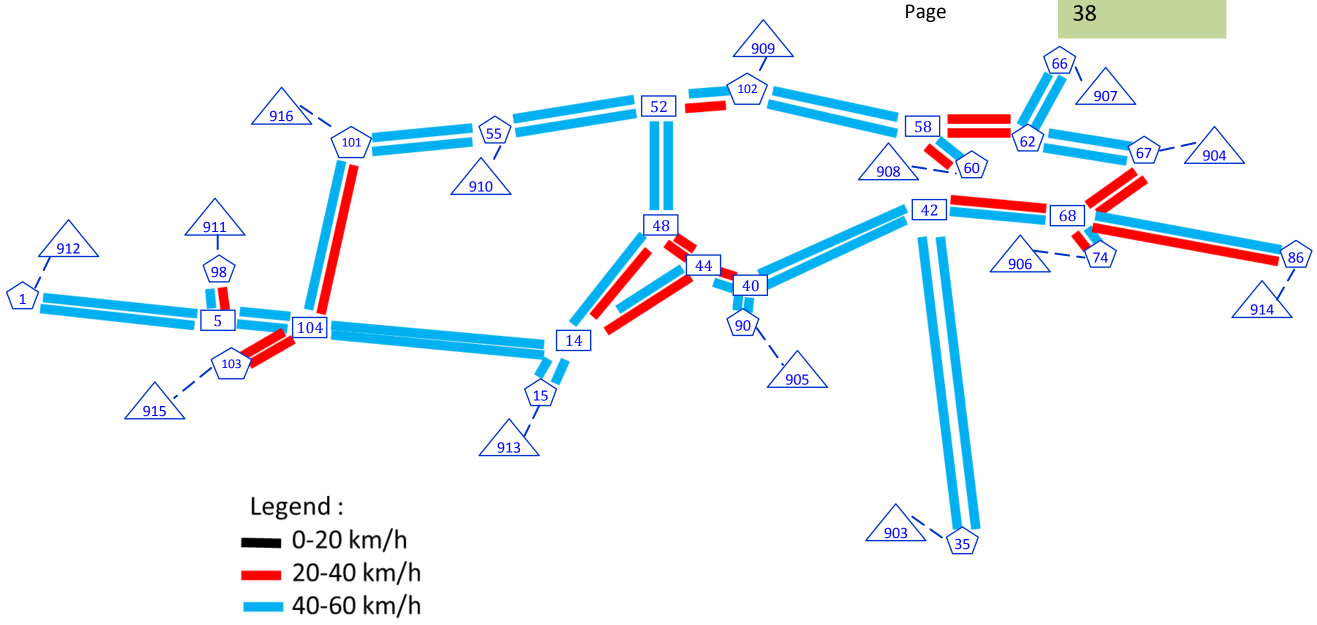


Figure 29 Volume Capacity Ratio between 0.2 – 0.5



Note : speed from node 14 to 44 is shown in red colour, whereas from node 44 to node 14 speed is noted as blue colour.

Figure 30 Speed using a New Road

A v/c ratio over 1.0 indicates the road or intersection is over-capacity; a v/c ratio under 1.0 indicates there is still room to accommodate additional vehicles. IHCM recommend v/c ratio during peak hours for design year not exceed 0.75. According to this standard, road networks performance during clay transportation is in good condition.

B. Transportation of Finished Product

During operation phase, the finished product will be delivered from Plant (Baucau) to local market, i.e. Dili. Up to 0.5 million tonnes per annum of finished product will be transported using trucks to Dili. If using 25-ton trucks to transport, it could generate approx. 5 truck trips per hour (330 days, 12-hours per day), so there will be additional traffic flow of 12 pcuph.

C. Transportation of Workers

There will be 700 persons per day work during operation phase. It is assumed that all the worker stay in Baucau city, so they will commute from the city to clinker plant and from the city to clay deposit. All workers will be transported by medium bus with a capacity of 20 passengers. It is assumed that 85 % of worker work in Clinker Plant and the other 15 % work in clay deposit, so there will be additional traffic from the city to clay deposit of 13 pcuph and from the city to Clinker Plant of 71 pcuph.

During operation phase, all road networks within the study area are in a good traffic performance. Most road link experience low volume capacity ratio and average mean speed higher than 20 km/h.

D. Road Development Plan

The Government of the Democratic Republic of Timor-Leste (hereinafter referred to as GOTL) has received a Loan from Japan International Cooperation Agency (JICA) toward the cost of the National Road No. 1 Upgrading Project. This Project is to make the National Road No.1 passable in safe throughout a year in any weather situation by upgrading the 118 km road from capital city Dili to the second largest city, Baucau. The project involves the widening of the current 3.2 - 4.5 m road to 6.0 m width asphaltic concrete pavement.

By implementing the above project, it is believed that the road network will be in good performance as more vehicles could be accommodated. Assuming that the volume value remains the same, then the volume capacity ratio (v/c) value could be less than 0.75 as the value of the capacity (c) will be increasing due to road widening. Therefore, the road networks will provide better service.

4.3 Intersection Performance

Intersection is most critical one in the network and it should be designed with a proper type of control. Intersection which is indicated having heavy traffic will be analysed further.

During construction phase and operation phase for alternative 1 and 2, there will be two intersections should be taken into account, i.e Intersection A and B, and for alternative 3 of operation phase there will be additional intersection, i.e. C (see **Figure 24**). Those three intersections are controlled by unsignalised intersection without priority rules, traffic sign, and traffic marking. Using Indonesian Capacity Manual (IHCM), traffic performance can be calculated and the results are presented in **Table 9**. Maximum traffic flow (909 pcuph) occurred in B intersection during construction phase, this is due to mobilization of construction heavy vehicle. All vehicles experience low delay, where the maximum delay (9.16 sec/pcu) is occurred in A intersection for alternative 1 of operation phase.

The road to Plant location, the road from Baucau, and the road from Dili are converging in intersection B. So the traffic performance can be seen in **Table 9**. Whereas, the intersection between existing road and coastal road in Caravela is similar to intersection A in term of traffic flow by movement.

Table 9 Intersection Delay

	Flow (pcuphr)			Delay (sec/pcu)		
	A	B	C	A	B	C
Existing Condition	129	367	NA	6.04	6.39	NA
Construction Phase	767	909	NA	7.32	7.59	NA
Operation Phase Alt 1 : Existing Road	487	781	NA	9.16	7.20	NA
Operation Phase Alt 2 : Coastal Road	382	328	NA	7.13	5.56	NA
Operation Phase Alt 3 : New Road	290	300	553	5.00	6.48	5.85

Traffic performance on Intersection can also measured by travel time. During construction phase, travel time is 32 minutes. While during operation, alternative 3 has the lowest travel time, i.e. 15 minutes.

Table 10 Travel Time from Clay Deposit to Cliker Plant

	Travel Times (minutes)	Speed (km/hr)	Distance (km)
Construction Phase	32	42.21	23
Operation Phase Alt 1 : Existing Road	31	43.58	23
Operation Phase	21	35.25	13

	Travel Times (minutes)	Speed (km/hr)	Distance (km)
Alt 2 : Coastal Road			
Operation Phase Alt 3 : New Road	15	37.99	9

5 IMPACT MITIGATION

To reduce the impact of traffic both in the construction and the operation phases, managing traffic is essential to providing a safe construction and operation activities. Traffic can include cars, utilities, delivery trucks, excavators, etc. The safe construction and operation activities can be achieved by careful planning and by controlling vehicle operations.

The traffic management plan should be regularly monitored and reviewed to ensure it is effective and to take into account any changes during construction and operation activities. All workers should be familiar with the traffic management plan and receive sufficient information, instruction, training, and supervision. The followings are impact mitigation plan during construction and operation activities:

5.1 Mitigation at Workplace

A. Minimising Vehicle Movements

Good planning can help to minimise vehicle movement around a workplace. To limit the number of vehicles at a workplace:

- Provide vehicle parking for workers and visitors away from the work area;
- Control entry to the work area;
- Plan storage areas so that delivery vehicles do not have to cross the site.

B. Vehicles Reversing

The need for vehicles to reverse should be avoided where possible as reversing is a major cause of fatal accidents. One-way systems can reduce the risk, especially in storage areas. A turning circle could be installed so that vehicles can turn without reversing. Where it is necessary for vehicles to reverse:

- Use reversing sensors and mirrors and warning devices such as reversing alarms;
- Ensure drivers have another person to direct them before reversing if they cannot see clearly behind. The driver should maintain visual contact with the person directing them and signallers should wear high visibility clothing;
- Ensure workers and other people are familiar with reversing areas and reversing areas are clearly marked.

C. Traffic Signs

Prominently display clear warning signs in relevant, well lit areas to remind persons of the traffic management hazards and requirements. Excavations area should be clearly signed.

Traffic routes should be clearly sign posted to indicate restricted parking, visitor parking, headroom, speed limits, vehicle movement, key site areas and other route hazards. Standard road signs should be used where possible and speed limits should be implemented and enforced.

5.2 Mitigation along the Route

5.2.1 Construction Phase

A. Minimising Road Damage

The construction activities will potentially damage the local/public roads surrounding the project area due to operation of the heavy vehicles which has high axle load. Therefore, in order to ensure that roads will support the construction activities, be responsible for their own damage, and maintain positive relationships with the local community. The overlaying of existing roads need to be undertaken minimum once a year, in particular roads which are used for heavy vehicle mobilization.

B. Traffic Signs

Standard road signs should be used where possible and speed limits should be implemented and enforced. Warning signs and sight mirrors shall be installed at appropriate places on the roads.

C. Road Widening

During construction, heavy vehicle movement occurred only twice, i.e. mobilisation and demobilisation. It is therefore the road widening will not be required; eventhough the road width within the study area is relatively narrow to support the heavy vehicle movements.

D. Heavy Vehicle and Trucks

- The transport and movement of equipment (trucks) should be limited to working hours only.
- Heavy equipment should be transported during early morning with appropriate pilotage.
- The use of flagmen should be employed to regulate trucks entering and exiting the access roads to the highway or at the junction (if necessary).

5.2.2 Operation Phase

A. Minimising Road Damage

The overlaying of existing roads between clay deposit and clinker plant need to be undertaken as a routine maintenance. The overlaying of roads should be undertaken in accordance with the road design.

B. Traffic Signs

Standard road signs should be used where possible and speed limits should be implemented and enforced. Warning signs and sight mirrors shall be installed at appropriate places on the roads.

Intersection between existing arterial road and acces road to clay deposit become a busy junction and vehicle queue might be developed. Instalation of traffic signal is recommended to minimize delay and queue length.

The gate to the properties (clay, limestone, and plant site) will be designed in accordance with traffic load resulting from project activities.

C. Road Widening

Based on observation, the road width within the study area is relatively narrow to support the heavy vehicle movements. In order to provide better performance for traffic, road widening should be undertaken. For arterial road with quite high percentage of heavy vehicle minimum road width of 6.5 meters are recommended.

D. Heavy Vehicle and Trucks

- The transport and movement of equipment (trucks) should be limited to working hours only.
- The use of flagmen should be employed to regulate trucks entering and exiting the access roads to the highway or at the junction (if necessary).

6 CONCLUSION

1). The existing traffic flows on the studied road network are still far below road capacity. It can be seen that the value of volume capacity ratio mostly are below 0.5. Based on observation, there are no significant generated traffic flow occured on the roads in the study area, although the road width is narrow. The road widths are between 4 to 5 meters. For arterial road with quite high percentage of heavy vehicle minimum road width of 6.5 meters are recommended.

2). Traffic performance during construction phase are still in a good condition, As heavy vehicle with high axle load move along an existing road, road pavement will failure. Heavy vehicle has high axle load, which can be damaged road pavement. To minimize the impact of heavy vehicle to road pavement, it is proposed to overlay an existing road in the studied road network which is used to mobilize heavy vehicle from Dili.

3). Intersection between existing arterial road and acces road to clay deposit (Intersection A) become a busy junction and vehicle queue might be developed. Installation of traffic signal is recommended to minimize delay and queue length. Traffic signal installation causes no significant impact on the major roadway in the country.

4). During operation phase, all alternative routes are in a good traffic performance. Most road link experience low volume capacity ratio and average mean speed higher than 20 kmph. Nevertheless, the road width is relatively narrow, to provide better performance for traffic, road widening should be undertaken.

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7 REFFERENCE

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2). Institute of Transportation Engineer (2011) **Manual of Transportation Engineering Studies**, Prentice hall Inc., New Jersey, 2nd edition.

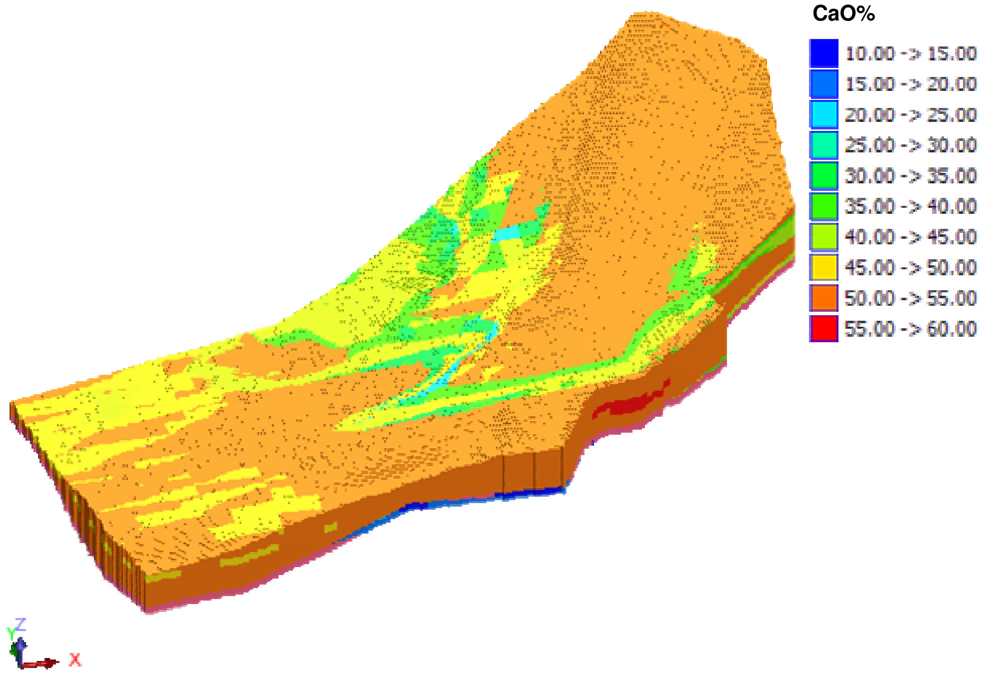
3). Indonesian Public Work (1997): **Indonesian Highway Capacity Manual**, Jakarta, Indonesia

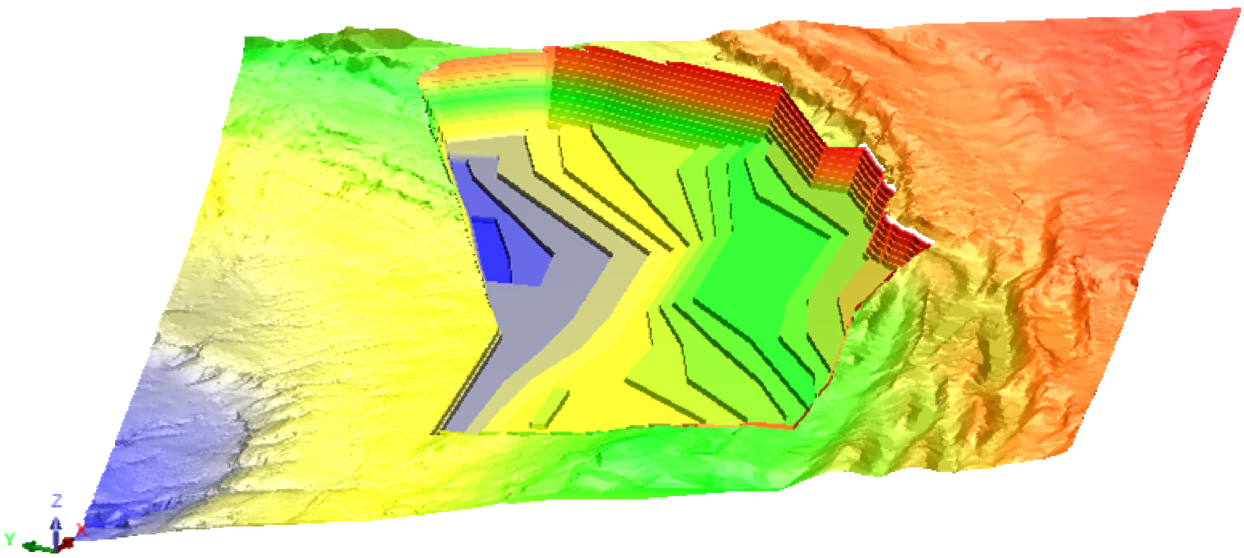
4). U.S Department of Transportation (2009): **Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways**, Federal Highway Administration.

Appendix 7 Mine Closure Plan

TL CEMENT LDA

Mine Closure Plan for Bucoli Limestone Deposit - Block I-1, Baucau district, Timor-Leste





September 2015

HOLTEC CONSULTING PRIVATE LIMITED

CONFIDENTIAL

ACKNOWLEDGEMENT

WE EXPRESS OUR SINCERE GRATITUDE TO THE OFFICIALS OF TL CEMENT LDA FORTHEIR IMMENSE COOPERATION EXTENDED DURING OUR SITE STUDIES AND DISCUSSIONS BUT FOR WHICH THIS REPORT COULD NOT HAVE BEEN PREPARED SUCCESSFULLY.

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AMD	Acid Mine Drainage
AMSL	Above Mean Sea Level
CO	Carbon Monoxide
dB	Decibel
dBA	Weighted Decibels
Drg.	Drawing
E	East
EHS	Environment, Health and Safety
EIS	Environmental Impact Statement
EPC	Engineering Procurement and Construction
EMP	Environmental Management Plan
Fig.	Figure
GIIP	Good International Industrial Practice
Ha/Hect.	Hectare
HEMM	Heavy Earth Moving Machinery
HOLTEC	Holtec Consulting Private Limited
Hp	Horse power
Hr	hour
IFC	International Finance Corporation
KL	Kilo litre
Km	Kilometer
KV	Kilo volt
L_{Aeq}	A-weighted equivalent Sound Level
M	Meter
m/s	Meter per second
m^3	Cubic meter
m^3/s	Cubic meter per second
MCP	Mine Closure Plan
mg/l	Milligram per litre
Mio	Million tonne
mm	Millimeter
Na_2O	Sodium Oxide
NE	North East
NNW	North North West

NO_2	Nitrogen dioxide
Nos.	Numbers
NPV	Net present value
^{o}	Degree
OBS	Overburden Soil
^oC	Degree centigrade
$PM_{10}/PM_{2.5}$	Particulate Pollution
pm	Post meridian
PPE	Personnel Protective Equipment
RQP	Recognized Qualified Person
S	South
SiO_2	Sodium dioxide
SO_2	Sulphur dioxide
Sq km	Square Kilometer
SSE	South South East
SW	South West
TLC	TL Cement LDA
TSP	Total Suspended Particles
$\mu g/m^3$	Micrograms per cubic meter
USD	United States Dollar ($)
W	West
WB	World Bank
%	Percent
@	at the rate
<	Less than
>	Greater than

Chapter – 1
Introduction and Scope of Work

CHAPTER - 1

INTRODUCTION & SCOPE OF WORK

1.1 INTRODUCTION

TL Cement LDA (TLC), a Timor-Leste based company, is having head-office at Perth, Western Australia and project office at Dili, Timor-Leste. **TLC** is contemplating to put up a clinker and cement manufacturing plant in Baucau district, Timor-Leste. **TLC** is a subsidiary of TL Cement Pty. Ltd., a private company based in Australia.

TLC is in the process of installation of 5,000 tons per day clinkerization unit at Baucau district in Democratic Republic of Timor-Leste. The limestone for the proposed clinkerization project is to be met from the Bucoli limestone deposit, located about 120 km east of Dili, capital of Democratic Republic of Timor-Leste. **TLC** has been granted mineral licence for prospecting over an area of 38.4 sq km spreading across in three blocks.

TLC associated **Holtec Consulting Private Limited (HOLTEC), India** for preparation of Mining Plan for their captive limestone mine to supply limestone for their proposed cement plant.

Incorporated in 1967, **Holtec Consulting Private Limited** is an ISO-certified consulting company, primarily positioned to service the entire gamut of consulting needs of the global cement industry. Its portfolio spans services in all disciplines of Engineering, Business Consulting, Geology & Mining, Project & Construction Management, Environment Management, Performance Enhancement, Logistics, etc.

Since its inception, **HOLTEC** has delivered significant value to its 800+ clientele comprising of cement producers, equipment & service providers, EPC & construction firms, infrastructure developers, investing & funding bodies and all other relevant stakeholders through 3,600+ consulting assignments in over 80 countries executed by its 340+ multi-disciplinary staff with an experience inventory of 6,300+ person-years.

HOLTEC has extensive experience in the area of geological investigation, deposit evaluation and preparation of Mining Plans and Mine Closure Plans in India & abroad. **HOLTEC** is a **Recognized Qualified Person (RQP)**, approved by **Indian Bureau of Mines** under Rule 22(c) of Mineral Concession (Amendment) Rules'2014 for preparation of Mining Plan and Mine Closure Plans. The copy of RQP certificate is enclosed as **Annexure 1.1.**

The present assignment entrusted by **TLC** to **HOLTEC** shall cover the following aspects of Mining Plan and Mine Closure Plan:

- Data analysis

- Construction of digital Deposit Block Model by application of state of the art software **“Computer Aided Deposit Evaluation (CADE) and Quarry Scheduling Optimization (QSO)”** and evaluation of the results.
- Preparation of Mine Closure Plan.

The Mine Closure Plan for Bucoli limestone deposit is implemented / realized on the basis of the following documents:

- Draft Mining Code, August 2013 of Democratic Republic of Timor-Leste.
- The acceptance of Proposal No. Q-34-R1/2015-16 (Revised) of 7th May 2015 between TL Cement and Holtec Consulting Private Limited for consultancy services for preparation of Bulk samples, Mine Planning and Mine Closure Plan for Bucoli Limestone Deposit, Timor-Leste.

Chapter – 2
Project Overview

CHAPTER - 2

PROJECT OVERVIEW

2.1 INTRODUCTION

TLC is contemplating to put up 5,000 tons per day clinkerization unit at Baucau district in Democratic Republic of Timor-Leste. The limestone for the proposed clinkerization project is to be met from the Bucoli limestone deposit, located about 120 km east of Dili, capital of Democratic Republic of Timor-Leste. **TLC** has been granted mineral licence for prospecting over an area of 38.4 sq km spreading across three blocks.

2.2 LOCATION

The Bucoli limestone deposit is located at a crow fly distance of about 10 km NW of Baucau, which is approximately 125 km east of Dili, capital of Democratic Republic of Timor-Leste. The mineral licence areas namely Block I-1, Block I-2 and Block II are bounded within the following geographical coordinates:

Longitude : E 126° 20' 34.4" – E 126° 25' 26.4"

Latitude : S 08° 26' 24.2" – S 08° 34' 02.4"

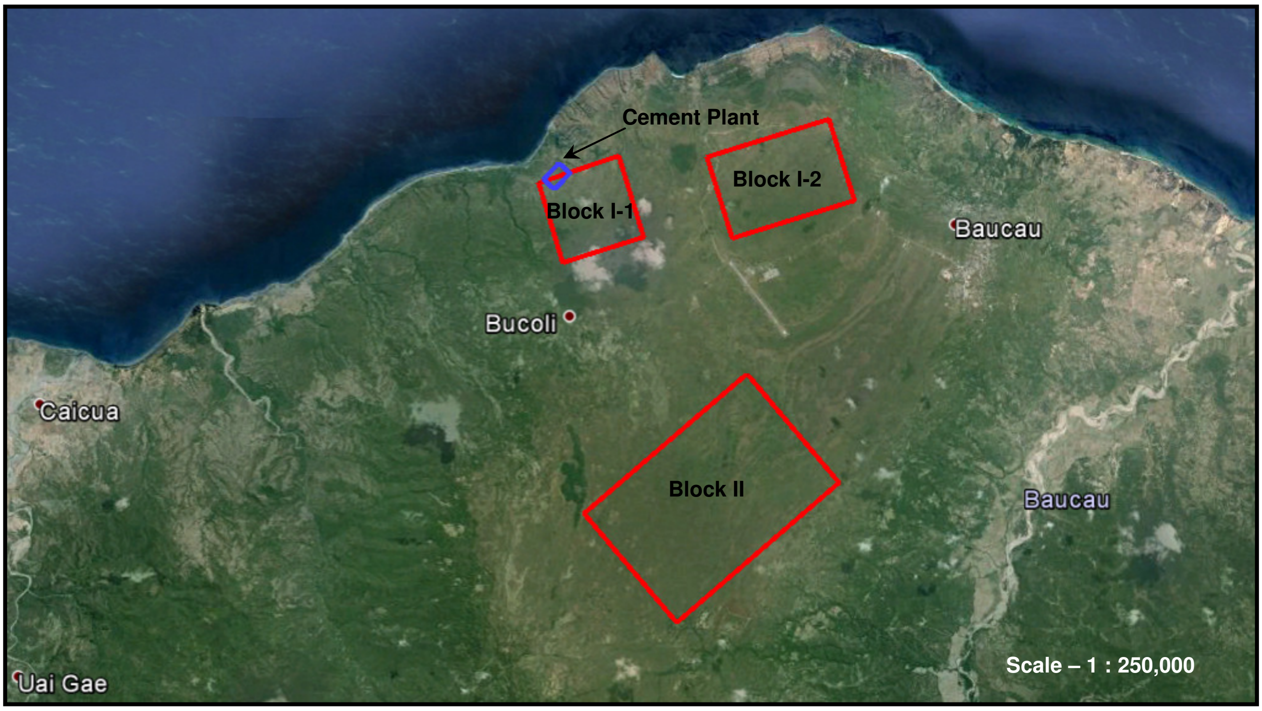


Fig. 2.1: Location of Mineral Licence Areas

The location plan is enclosed as **Drg. No. 15113-05-CP-01.**

2.3 ACCESSIBILITY

The Bucoli limestone deposit is accessible from Dili along the Dili – Baucau highway through Hera-Manatuto-Laleia-Caicua. From Caicua, by following about 8 km on Dili-Baucau highway, an un-metalled road bifurcates towards northeast direction leading to Ponta Bondura, passes close to the Block I-1.

Timor-Leste has no rail network.

The nearest international airport for access to the deposit is at Dili, which is about 120 km west of the deposit area.

The nearest commercial seaport is at Dili, located about 120 km west of the limestone deposit.

2.4 MINERAL CONCESSION STATUS

TLC has been granted mineral licence for prospecting over three blocks, viz., Block I-1 (Bucoli North Area-1), Block I-2 (Bucoli North Area-2) and Block II (Bucoli South area) covering area of 5.76 sq km, 8.64 sq km and 24 sq km respectively vide Mineral License No. 1/2014 dated 26 Feb 2014. The GPS coordinates of the mineral concession area are given in **Table 2.1.**

Block	Point No.	UTM Coordinates	
		Latitude	Longitude
I – 1 (Bucoli North)	1	9064335	207421
	2	9062048	208147
	3	9062773	210434
	4	9065081	209709
I – 2 (Bucoli North)	1	9065023	212207
	2	9062738	212932
	3	9063823	216364
	4	9066111	215638
II (Bucoli South)	1	9055024	208825
	2	9051997	211440
	3	9055918	215981
	4	9058946	213367

Table 2.1: Coordinates of Mineral Licence Areas

A plan showing the concession area is enclosed as **Drg. No. 15113-05-CP-02** and the copy of the mineral licence area is enclosed as **Annexure 2.1.**

2.5 TOPOGRAPHY AND DRAINAGE OF DEPOSIT

Physiographically, the area around Bucoli limestone deposit forms an undulating terrain with small hills and valley mainly consisting of limestone, marl and clay. The elevation within Block I-1 and I-2 rises gently from north to south. The northwestern part of Block I-1 has an elevation of 25 m above mean sea level (AMSL) whereas the southeastern part has an elevation of about 395 m AMSL. In Block I-2, the northwestern part has an elevation of 430 m AMSL whereas the southeastern part has an elevation of 510 m AMSL. The Block II has maximum elevation of 680 m AMSL towards west while the minimum elevation is 500 m AMSL towards east of the concession area.

Photoplate showing topography of the concession area

The limestone deposits are located within the hilly area and the drainage of the area is controlled by local streams. The local streams originate from the areas of higher elevation within the deposit area and flow towards the north and finally merge into sea. These local streams get active during precipitation only.

2.6 EXPLORATION

TLC has been granted mineral licence no. 1/2014 for prospecting of limestone over an area of 38.4 sq km covering three blocks namely Block I-1 (Bucoli North Area 1), Block I-2 (Bucoli North Area 2) and Block II (Bucoli South). The plan showing mineral licence areas of **TLC** is enclosed as **Drg. No. 15113-05-CP-02.**

The objective of exploration in the area was to establish the limestone reserves suitable for manufacturing of cement.

The summary of exploration carried out in the mineral licence areas is given in **Table 2.2.**

Activity	Quantum of work			
	Block I-1		Block I-2	Block II
	Phase I	Phase II	Phase I	Phase I
Topographical Survey	5.76 sq km		Nil	Nil
Diamond Core drilling	4 boreholes (289.1 m)	8 boreholes (541.0 m)	6 boreholes (331.5 m)	2 boreholes (115.5 m)
Core Logging	830.1 m		331.5 m	115.5 m
Core Sampling and Analysis	442		181	56

Table 2.2: Summary of Exploration carried out in the area

The boreholes drilled in the area established that the core recovery in the top 20 to 30 m depth is +90% and thereafter a conglomerate zone of thickness about 10 m to 20 m have been encountered. The conglomerate zone contains pebbles and gravels rich in silica within the limestone matrix. Thereafter the limestone encountered in the boreholes is generally soft and the core recovery is comparatively less in this zone.

2.7 GEOLOGY OF THE AREA

The limestone is exposed on the surface with sporadic occurrences of soil in the area. The interpretation of local geology is based on the data generated during the course of exploration. The individual litho-units encountered and identified within the concession area are described below in their stratigraphic sequence from top to bottom:

Top Soil

Top soil is reddish brown in color and silty in nature. Its occurrence is only observed in relatively flat to gentle area. The thickness of top soil as encountered in boreholes varies from 1.0 m to maximum 3.8 m (Borehole MI-02).

Limestone

The limestone belongs to Baucau formation and is of greyish to brownish in colour. The limestone is fossliferous in nature, have bio-clast in matrix, deposited in coral reef condition of marine environment. The thickness of limestone as encountered in boreholes varies from 3.7 m to maximum 91.5 m (Borehole AD-08).

Conglomeritic Limestone

Conglomeritic limestone is of pale white to brownish colour having calcareous matrix. The thickness of conglomeratic limestone varies from 1.5 m to maximum 14.7 m (Borehole AD-04).

Sandy Limestone

Sandy limestone is of pale greyish to brownish colour having sandy appearance due to assemblage of sand pebbles within limestone. The thickness of sandy limestone varies from 4.0 m to maximum 24.0 m (Borehole MI-01).

Clay

It is lower most litho-unit present in concession area. The clay is dark greyish to purple in colour and fine grained in nature. The thickness of clay as encountered in boreholes varies from 1.1 m to maximum 41.8 m (AD-06).

The typical geological cross section of the area is given in **Fig. 2.2**.

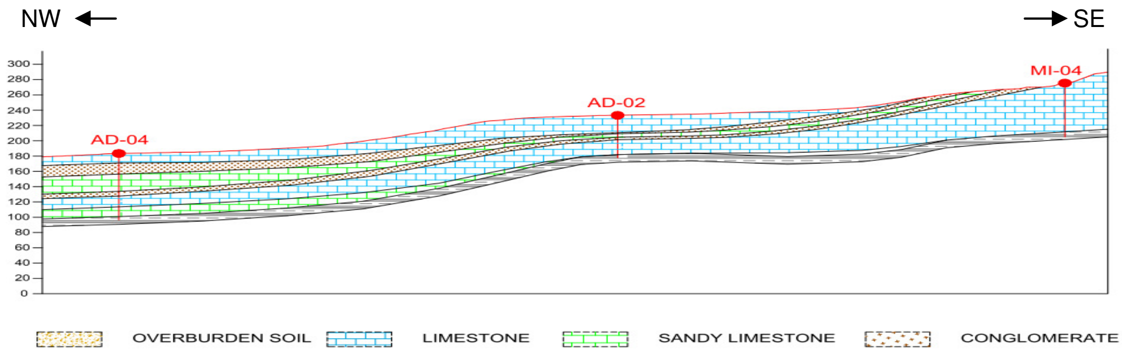


Fig. 2.2: Typical Cross section of the Exploration area

2.8 RESOURCES/RESERVES

Out of the total 5.76 sq km mineral licence area in Block I-1, an area of 1.82 sq km was delineated as potential mining area for general exploration and hence has been considered for estimation of reserves. The other two areas viz. Blcok I-2 and Block II have been explored by drilling on a wide spread grid of 1000 to 1200 m and hence only limestone resources have been estimated in these two areas.

The limestone and associated rock formation in the area are horizontal to gently dipping and shows undulating structure. The bottom level of limestone encountered in the drilling varies from 221.4 m to 96.3 m AMSL and thus for the purpose of resource estimation, the mining limit at depth has been considered at 90 m AMSL in Block I-1.

The estimation of resources and reserves has been carried out by **Computer Aided Deposit Evaluation (CADE)** by construction of Deposit Block Model for Block I-1. The resources within Block I-2 have been estimated by cross sectional area method and the Block II has been estimated by surface area method. The methodology and norms considered for estimation of resources and reserves are described in detail in the mining plan.

The summary of resources and reserves of limestone is given in **Table 2.3**:

Category	**Block I-1**	**Block I-2**	**Block II**
Mineral Resources	105.07	399.44	792.00
Mineral Reserves	92.84	Shall be estimated after carrying out detailed exploration	
Global Recovery Ratio (Limestone : Reject)	1 : 0.56		

Table 2.3: Limestone Resources and Reserves in Mineral Licence Area

The limestone exploited from the quarry shall be a captive source of raw material for the proposed cement plant. Also a part of conglomeratic limestone, sandy limestone and clay shall be utilized along with the limestone during formation of benches in mining. Thus the optimized reserve of RoM limestone works out to **105.71 million ton**. Considering the use of limestone to the extent of 81.88% as per the optimal raw mix, 5,000 tpd clinkerization plant running for 330 days per annum at raw meal to clinker conversion factor of 1.55, the annual requirement of limestone works out to 2.10 million ton/annum. With the presently available data, the optimized reserves of 105.71 million ton of limestone, available in Block I-1, with consumption @ 2.10 million ton per annum shall last for about **50 years**. Adequate reserves of clay are available in nearby Wailacama area for entire life of the plant.

2.9 MINING METHODOLOGY

The mining operations are proposed to be carried out by fully mechanized opencast method, utilizing Heavy Earth Moving Machinery (HEMM) in conjunction with deep hole drilling and blasting with the use of suitable explosives.

2.9.1 ULTIMATE PIT LIMIT

Opencast pit mining methodology can only be started after finalization of ultimate pit limit and cut-off grade estimation and directly depend upon the economic viability of the ore. The ultimate pit limit is the limit of vertical and lateral extents of the economically mineable pit boundary. The ultimate pit limit is determined on the basis of following:

- Total extent of the area granted
- Extent of ore at depth as established by exploration

- Cut-off grade and stripping ratio (Ore:Reject)
- Cost of per ton of ore and its net present value (NPV)

In case of Bucoli limestone deposit (Block I-1), the ultimate pit limit in two dimensions on the surface is guided by the mineralization of limestone in the explored area, which is free from all mining constraints and is economically mineable. No constraints are foreseen within the identified 1.82 sq km potential mining area within Block I-1.

The following mining parameters are proposed to be maintained in the mine:

Type of Working	:	Opencast Mechanized
Bench Height	:	10 m
Bench Width	:	min. 30 to 35 m (working benches) 5 m (Ultimate stage)
Bench Face Angle	:	80^{o} from horizontal
Overall pit slope	:	56^{o} (at the Ultimate Stage)
Dewatering Sump	:	5 m below the lowermost bench
Dump Height	:	10 m level wise in stages (Overburden) 20 m level wise in stages (Inter-burden)
Dump Slope	:	30^{o} from horizontal for each level

It is planned to keep the bench height of 10 m, sloped at an angle of 80^{o} from the horizontal keeping a minimum bench width of 35 m during the period of mine operation. During conceptual stage, it is planned to reduce width of benches to 5 m keeping the height of 10 m, which will give final pit slope angle of about 56^{o} to the horizontal as shown in ultimate pit cross sections (**Drg. No. 15113-05-CP-15a**) and is considered to give stable slopes. Since the limestone of the area is hard rock and also sufficient width has been left over the benches, thus no problem is foreseen for the stability of bench slopes during the operations and conceptual stage. However slope stability study is proposed to be carried out, if desired for any statutory permission.

It is proposed to work the mine in two shifts of 8 hr/day for 6 days in a week. The effective working and actual utilization of mining machinery is anticipated to be 6 hr/shift.

A general layout is planned for establishment of various facilities like haul road, mine office, crusher, mineral storage, waste dump yards etc. for development and operation of the quarry and is enclosed as **Drg. No. 15113-05-CP-05.**

The limestone of the area is exposed on the surface with sporadic occurrences of soil in the area. Thus initial mine development shall involve meager quantity of overburden removal for development of limestone bench.

The initial mine development shall involve the following task:

- Site clearing (Removal of vegetation, if any)
- Construction of main haul road from quarry to crusher
- Construction of road to waste dump yards and mine office area
- Construction of Auxiliary area i.e. mine office, workshop etc.
- Construction of embankment and garland drain with sediment settling pits
- Construction of access roads to 250 m AMSL bench
- Development of bench at 250 m AMSL.

The initial mine development plan is enclosed as **Drg. No. 15113-05-CP-06** to **15113-05-CP-08.**

During initial development of quarry, excavation of about 4,395 m^3 of overburden soil and 20,000 ton of limestone is involved. The limestone encountered during this stage of development shall be stacked in the material storage yard near crusher and shall be used during commissioning of crusher and subsequently in plant operations. The overburden soil is proposed to be transported to OBS dump yard.

The entire mineral licence area within Block I-1 is mineralized with limestone, thus an area of 11.85 ha towards northwest of the mining area for temporary dumping of overburden soil and 44.75 ha area towards northeast corner of the mineral licence area for dumping of inter-burden reject has been identified. The sites have been chosen on the following parameters:

- The overburden soil dumping area lies within the 500 m safety zone of cement plant and no mining activities are proposed to be carried out in the safety zone even in future. The overburden soil shall be dumped in this area temporarily and later it shall be used for afforestation and plantation purposes.

- Based on the geology and structure of the area, the thickness of limestone within the proposed inter-burden dumping area is comparatively less than the area lying towards south of the potential mining area. In view of this fact, the mining activities are expected to be extended towards south of the existing potential mining area in future. Thus, with the available information, the presently selected site for temporary dumping of inter-burden waste seems to be ideal. Also the site selected is for temporary dumping of inter-burden reject and later entire inter-burden shall be backfilled in exploited area for reclamation and rehabilitation.

The initial quarry development is expected to be completed in about 6 to 8 months.

The regular exploitation of quarry shall involve following steps:

- **Removal of Overburden** – The potential mining area has sporadic occurrence of overburden soil at places. The overburden soil, as and when encountered, after scrapping with the bulldozer shall be transported separately to the overburden soil dump area (OBS-1) and shall be utilized for green belt development and afforestation purposes.

- **Exploitation of Limestone** – The limestone shall be exploited by carrying out drilling and blasting. The hydraulic drills shall be used for drilling of blast holes, which shall be then loaded with suitable explosive for blasting. The blasting shall be either carried out by **TLC** or can also be outsourced to a local authorized agency. The limestone after blasting shall be loaded by hydraulic excavators and shall be transported to crusher by dump trucks. The inter-burden reject comprising of conglomeratic limestone and sandy limestone shall be segregated at the bench and shall be transported to its earmarked waste dump yard (WD-1) for stacking.

The mine development plan at the end of 1st year, 5th year, 10th year, 15th year and 20th year of operation is enclosed as **Drg. No 15113-05-CP-09** to **15113-05-CP-13** and year-wise pit and dump cross sections in **Drg. No. 15113-05-CP-14a to 14c**.

- **Raw meal requirement** – The estimated raw meal requirement i.e. limestone, clay and iron ore is about 2.56 million tons at 100% capacity utilization of the cement plant (5,000 tons per day clinker). The daily requirement of limestone from the quarry works out to 7,761 tons per day considering 300 days/annum operation of quarry. The clay is available near Wailacama village, situated about 15 km southwest of the plant area. Iron ore is not available in the country and thus is proposed to be imported from Indonesia.

- **Quarry Tailings** – No processing / beneficiation of the mineral limestone is required other than crushing and sizing, which are normal functions carried out at crushing plant. The final output of the limestone after crushing is envisaged to be of -75 mm size (90%). The limestone from crusher shall be transported by covered belt conveyors to the plant for its use in manufacturing of clinker.

As there is no processing or beneficiation of the mineral being exploited, thus there shall not be any tailing or waste from the crusher plant for disposal.

- **Transportation** – The limestone from the quarry shall be transported by dump trucks to crusher, located about 3.64 km north of the quarry, after being loaded by hydraulic excavators. The limestone after crushing shall be transported by covered belt conveyors to the plant for storage in stockpile.

The summary of year wise material handling from the quarry is given in **Table 2.4.**

Year	Limestone (mio t)	Overburden Soil (mio t)	Inter-burden (mio t)	Reject Ratio (Limestone: Reject)
Initial Development	0.02	0.01	0.00	1 : 0.35

Year	Limestone (mio t)	Overburden Soil (mio t)	Inter-burden (mio t)	Reject Ratio (Limestone: Reject)
1st Year	2.07	0.20	0.49	1 : 0.33
2nd Year	2.10	0.02	0.31	1 : 0.15
3rd Year	2.10	0.10	0.81	1 : 0.43
4th Year	2.10	0.02	1.14	1 : 0.56
5th Year	2.11	0.15	1.00	1 : 0.55
6th to 10th year	10.49	0.20	5.47	1 : 0.54
11th to 15th year	10.53	0.17	5.39	1 : 0.53
16th to 20th year	10.50	0.05	4.78	1 : 0.46
21st to end of life of mine	63.69	0.45	38.42	1 : 0.61
Total	**105.71**	**1.36**	**57.81**	**1 : 0.56**

Table 2.4: Year-wise material handling

- **Waste Dump yards** – The overburden in the form of top soil and inter-burden comprising of conglomeratic limestone and sandy limestone generated during the course of mining operations shall be stacked in area identified towards northwest and northeast of the quarry respectively. Based on the presently available exploration data, the limestone reserves of the Block I-1 and associated overburden and inter-burden has been estimated. It is anticipated that total 0.85 million m^3 of overburden soil and 26.28 million m^3 of inter-burden shall be generated upto conceptual stage. The total area of the overburden soil dump yard located towards northwest of the quarry is 11.85 ha and 44.75 ha for inter-burden reject waste dump yard located towards northeast of the quarry.

- **Inundation and Pumping –** The average annual rainfall during April'2010 to March'2014 was 1642.55 mm and 90% of it occurs from October to May. The average number of rainy days varies from 100 to 140 with an average of 125 days during the year.

No ground water has been encountered during the core drilling carried out for geological exploration upto 43.6 m AMSL. Thus it can be inferred that water table is well below the ultimate pit limit of 90 m AMSL.

The potential mining area of 1.82 sq km within Block I-1 forms part of slope of hilly terrain and since the mine workings shall be concentrated well above the water table; no ground water shall be encountered. Only rain water may get accumulated on the benches, which can be guided down the hill by digging small drains, if required along the foot of the face and connecting these drains to the existing natural channels.

In light of the above, the possibility of the inundation of the mine during initial 20 years of mine operation due to rainwater directly falling over the mining area is foreseen. During conceptual stage, a pit shall be formed and thus a sump is proposed to be created on the lowermost working bench for pumping of water. The bottom level of sump is proposed to be 5 m below the lowermost working bench working for efficient pumping operations.

Following measures are proposed to avoid flow of surface water into mining pit:

- Construction of embankment of at least 2 m height towards south of the potential mining area boundary to prevent entry of surface run-off water into the working area.
- It is also proposed to construct a peripheral garland drain with de-silting pits outside the embankment towards south of the mining area to channelize the surface run-off water.
- Also a garland drain with de-silting pits is proposed towards north of the potential mining area to check the flow of silt from the dumps and quarry during rains.
- Garland drains with de-silting pits are also proposed outside the crest of the overburden soil and inter-burden dumps for storm water management

The location of embankment and garland drain with de-silting pits is shown in General Layout **Drg. No. 15113-05-CP-05.**

- **Mining machinery -** The adequacy and type of machinery proposed to be deployed in mining operations and calculation of main mining machinery is discussed in detail in the mining plan.

The summary of mining and ancillary equipments proposed to be deployed is given in **Table 2.5.**

Sn	Description of equipment	Capacity / Size	Nos. required	Broad Specification
Main Mining Equipment				
1	**Drilling**			
1.1	Drilling Machine	110-152 mm dia	3	Crawler mounted, hydraulic type with on board compressor
1.2	Hydraulic Excavator with Rock breaker	Suitable for 30 t class excavator	1	Hydraulic rock breaker suitable for 1.9 m^3 bucket capacity backhoe fitted with about 3.0 ton class rock breaker.
2	**Loading**			
2.1	Hydraulic Excavator	4.5 m^3 bucket capacity	3	Crawler mounted, diesel engine operated, of about 475 hp, minimum digging reach upto 10m

Sn	Description of equipment	Capacity / Size	Nos. required	Broad Specification
2.2	Loader	4.0 m^3 bucket capacity	1	Tyre mounted, articulated, about 350 HP engine power
3	**Transportation**			
3.1	Off-Highway dump trucks for limestone & inter-burden	Payload capacity 36 ton	10	Rigid body, Rear dump truck
Ancillaries				
4	Bulldozer with ripper	300 to 350 hp	1	Crawler mounted, fully hydraulic, straight blade
5	Explosive Van	2 ton carrying capacity	1	
6	ANFO Mixer	5 ton capacity	1	
7	Exploders and blasting accessories		2 sets	
8	Grader	140 to 150 hp	1	Tyre mounted motor grader, blade length 3.50 m to 3.70 m.
9	Jeeps - Double Axle drive		2	
10	Water sprinkler (Truck chassis mounted)	10 KL	1	Truck mounted fixed tank with sprinkler system at the rear end of the tank.
11	Fuel tanker with pump and metering	5 KL	1	Fuel tanker on truck chasis with pump and metering arrangement
12	Mobile Service Van		1	
13	Portable Tower Lights		4	
14	Workshop			Work shop with all modern maintenance facilities like Fork Lift, Crane, Compressor, Welding M/c, Tyre handler, Tyre inflator etc. to maintain heavy earth moving equipment

Table 2.5: Summary of proposed Mining Machinery

Chapter – 3
Baseline Environment Data

CHAPTER - 3

BASELINE ENVIRONMENT DATA

3.1 INTRODUCTION

TLC appointed **WorleyParsons (WP)** to prepare an Environmental Impact Statement (EIS) and Environmental Management Plan (EMP) in line with requirements of the National Directorate of Environment, Government of Timor-Leste and good international industry practice (GIIP) based on the IFC Performance Standards.

The baseline environment monitoring data has been collected by **Advisian**, a subsidiary of **WP**. The baseline data has been collected for limestone area; cement plant, jetty and clay area. The baseline environment monitoring data as presented in the above draft report is summarized in following paragraphs:

3.2 LAND USE

The land use of the Block I-1 is limited, with much of the site existing in its natural state under a variety of vegetation types. Anthropogenic land use does occur, but is limited to subsistence type agriculture at few places.

The area is located across NE to NW facing stepped slopes and plains on limestone outcrops with higher slopes on the southern edge of the site and flatter plains towards the northern boundary. The site is predominantly uniform woodland to open woodland (95%) with isolated small patches of closed forest (5%) occurring in minor ravines and gullies and grassland. The site is characterized by shallow soils and extensive scattered, small to medium sized limestone rock outcrops. There are around 50 households located within the mine site.

3.3 CLIMATE AND AIR QUALITY

The Koppen Climate Classification describes the regional climate as falling within the "A" Climate type (tropical moist climates). This climate type extends northward and southward from the equator to about 15 to 24 degrees of latitude. In this climate type, average monthly temperatures are greater than 18ºC and annual precipitation is greater than 1500 mm.

The "A" climate type has three subdivisions based on rainfall:

- Af – Tropical wet with precipitation occurring all year round.
- Am – Tropical monsoon climate with annual rainfall equal to or greater than Af but occur in the seven to nine hottest months.
- Aw – Tropical wet and dry or savannah climate. Winter is dry and summer is wet. Annual precipitation is usually less than 1000 mm.

The Baucau area falls in the "Aw" climate type. The average temperature in coastal areas is around 27°C and around 25°C in the highlands. However, the daily temperatures vary widely during the day.

Meteorological data for the period April'2010 to March'2014 as recorded at Baucau Observatory has been collected from Meteorological Department at the Nicolau Lobato International Airport at Dili and is presented below:

3.3.1 RAINFALL

The average annual rainfall during April'2010 to March'2014 is 1642.55 mm and 90% of it occurs from October to May. The average number of rainy days varies from 100 to 140 with an average of 125 days in a year. The rainfall is distributed throughout the year with negligible rains during the month of August. The average monthly rainfall profile is shown in **Fig. 3.1**.

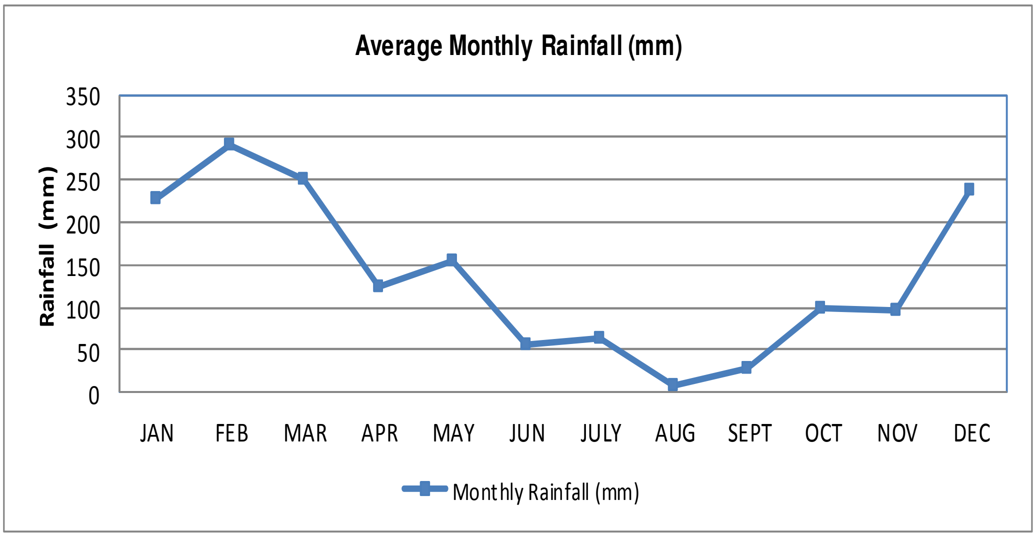


Fig. 3.1: Average Monthly Rainfall for the period April'10 to March'14 as recorded at Baucau Meteorological Observatory

3.3.2 RELATIVE HUMIDITY

The average Relative Humidity (RH) is high throughout the year and varies from 59% to 90% during the year. The RH is low during the months of August to October during the year. The monthly variation of average Relative Humidity at Baucau during the period from April'10 to March'14 is shown in **Fig. 3.2.**

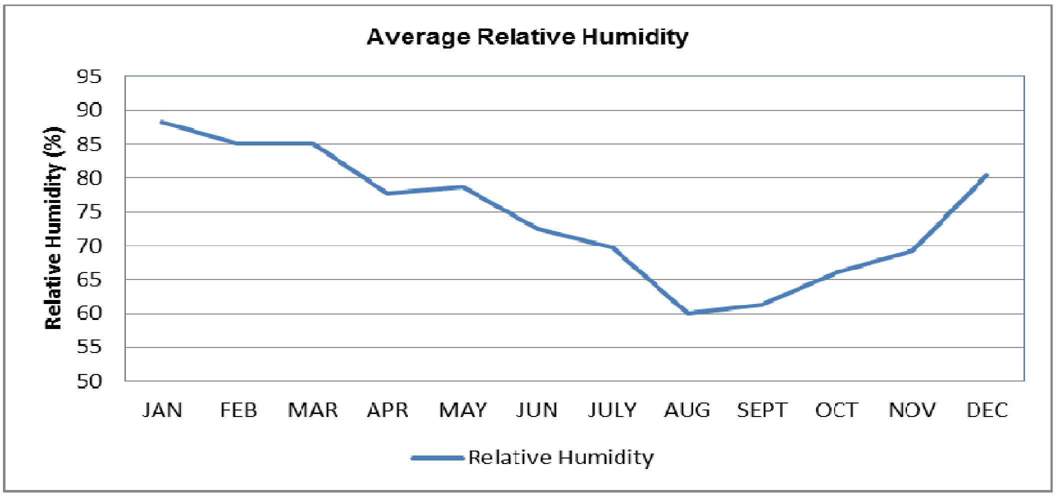


Fig. 3.2: Average Relative Humidity for the period April'10 to March'14 as recorded at Baucau Meteorological Observatory

3.3.3 TEMPERATURE

The monthly average maximum temperatures are in the month of November and December, at around 31.3 ℃ while August has the lowest monthly average temperature of about 16.4 ℃ during the year. The variation in minimum and maximum monthly temperature as recorded at Baucau Observatory during April'2010 to March'2014 is shown in **Fig. 3.3**.

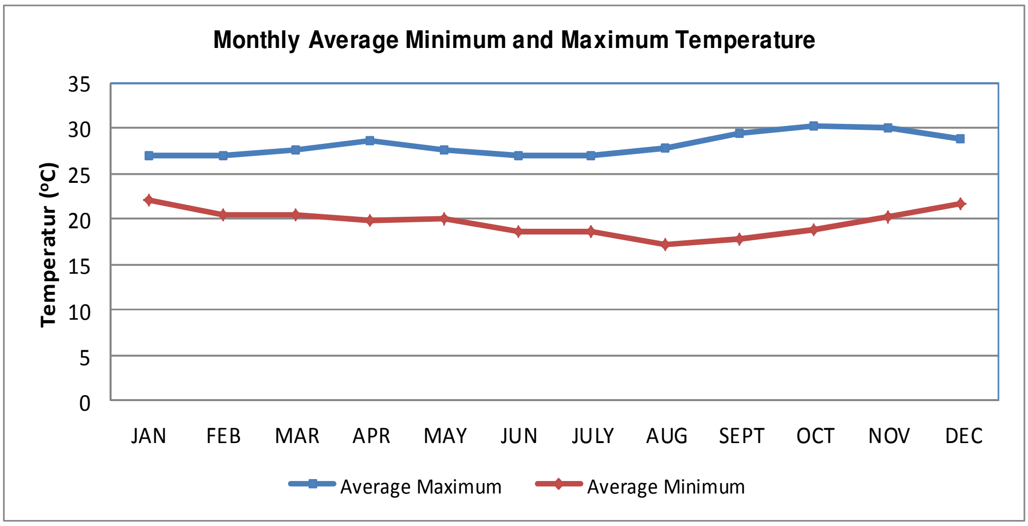


Table 3.3: Variation of Monthly Average Minimum & Maximum Temperature for the period April'10 to March'14 as recorded at Baucau Meteorological Observatory

3.3.4 WIND

The average wind speed varies from 5 to 11 km/ hr and was highest during the month of Jul 2013 at 11 km/ hr. The predominant wind direction is SE during

April to November and W during December to March. The monthly average wind speed at Baucau is shown in **Fig. 3.4**.

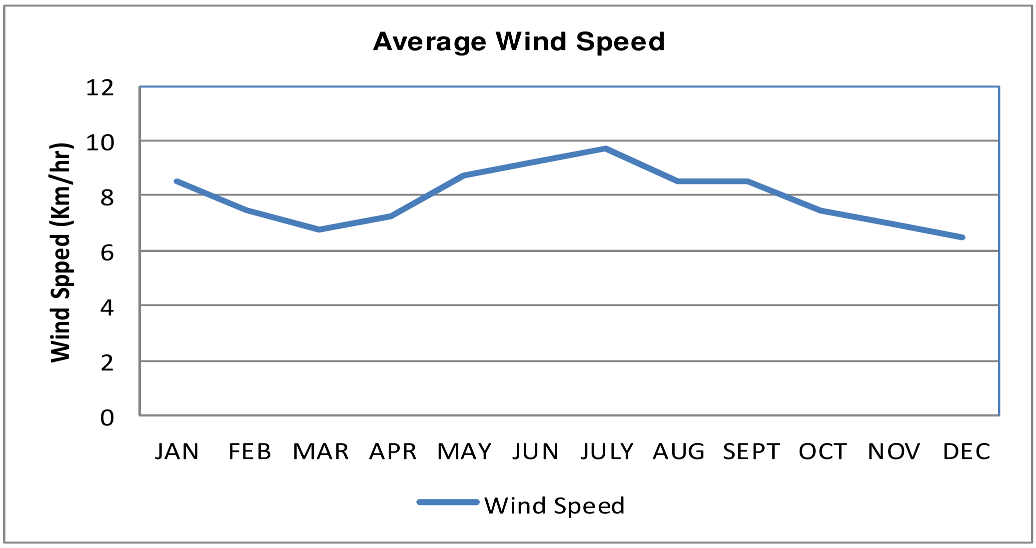


Fig. 3.4: Average Wind Speed for the period April'10 to March'14 as recorded at Baucau Meteorological Observatory

3.3.5 AMBIENT AIR QUALITY

The ambient air quality data was collected at seven locations in the Baucau region from 21st to 30th May 2015. The locations of monitoring stations are given in **Table 3.1** and are shown in **Fig. 3.5.**

S. No.	Location	Coordinate	Description	Note
1.	AQ-1 Bahu	S 8°27'46.48" E 126°25'40,31"	Settlement Area	East – south east of cement plant activities
2.	AQ-2 Check Point Triloca	S 8°29'24.7" E 126°22'12.49"	Settlement Area	South of cement plant activities
3.	AQ-3 Aldeia Parlemento	S 8°26'43.62" E 126°23'11.41"	School Area	East of cement plant and north east of limestone mine
4.	AQ-4 Aldeia Osso-ua	8°26'57.35", 126°21'30.4"	Settlement Area	Within the Plant Area
5.	AQ-5 Jetty Plan	8°26'43.21", 126°20'39.07"	Jetty Area	Within the Jetty Area
6.	AQ-6 Wailacama	8°29'22.47", 126°18'48.46"	Settlement Area	North east of clay quarry

S. No.	Location	Coordinate	Description	Note
7.	AQ-7 Bucoli	8°29'15.49", 126°20'44.92"	Settlement Area	South of mine and plant, North east of clay mine

Table 3.1: Sampling Locations for Ambient Air Quality Monitoring

Fig. 3.5: Ambient Air Quality Monitoring Stations

The sampling locations were selected based on the following considerations:

- Locations which will undergo the impact of dispersed air pollutant emitted from the cement plant, jetty and mining activities; and
- Locations which are occupied by local people

3.3.5.1. PM_{10} AND $PM_{2.5}$

Particulate is the term of dispersed air pollutant in the solid or liquid form in the atmosphere. PM_{10} is the dispersed solid particulate with a diameter of 10 micrometers or less, while $PM_{2.5}$ has diameter of 2.5 µm or less. These particulates are likely responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. All measured PM_{10} concentrations were below the standard (150 µg/m^3) according to US EPA

(2013) and WHO (2005) (Refer to Error! Reference source not found.). Similarly, 24 hour PM ambient concentrations of $PM_{2.5}$ were also below the standard (75 µg/m^3) according to WHO (2005), and the standard (35 µg/m^3) according to US EPA (2012) (Refer to Error! Reference source not found.).

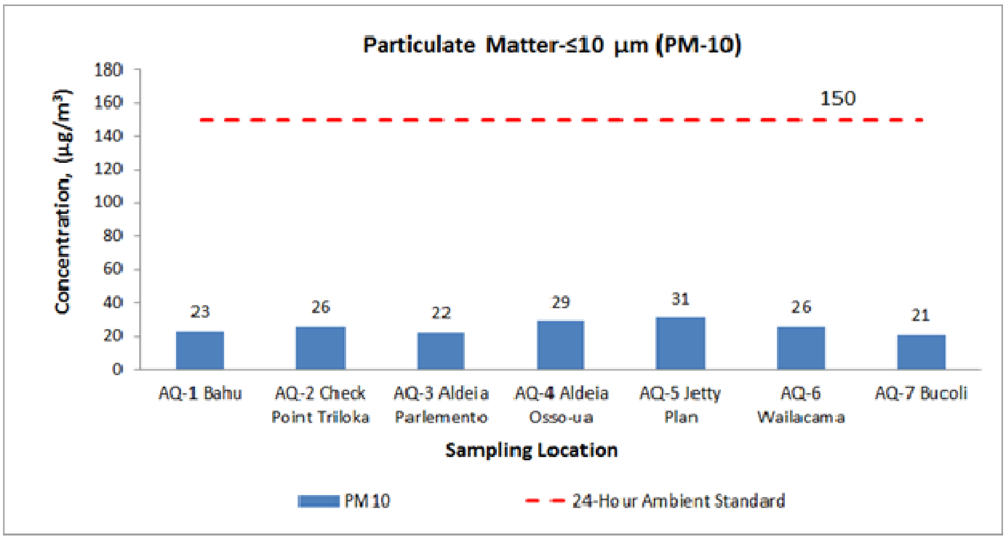


Fig. 3.6: 24 Hour-Ambient Concentration of PM_{10}

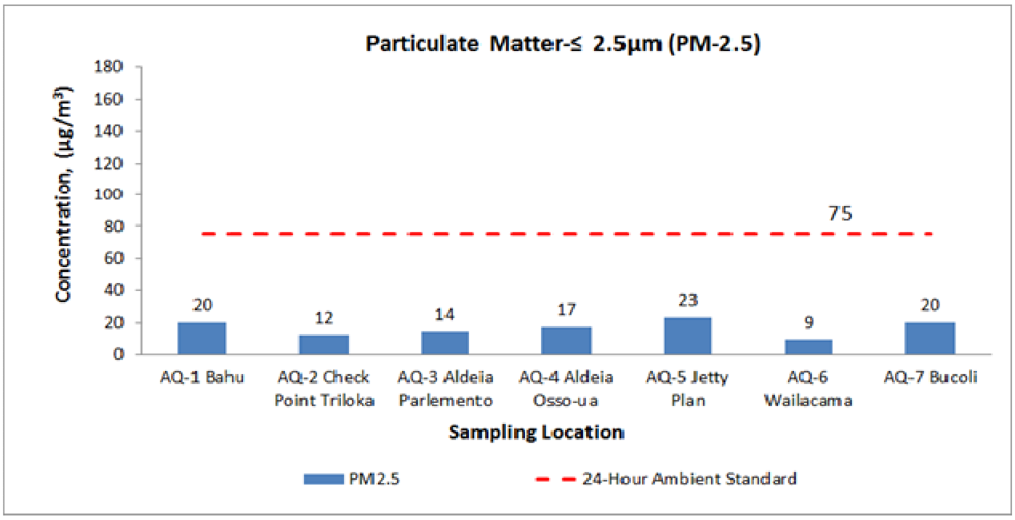


Fig. 3.7: 24 Hour-Ambient Concentration of $PM_{2.5}$

3.3.5.2. CARBON MONOXIDE

Carbon monoxide is a colorless, odorless, tasteless, and very stable gas which has lifetime between 2 until 4 months in the atmosphere. The results of CO_2 monitoring indicated that the one hour CO_2 concentration ranged between 218 and 481 µ/Nm^3, which is far below the 1 hour standard of 30,000 µg/m^3 according to WHO(2010) (Refer to Error! Reference source not found.).

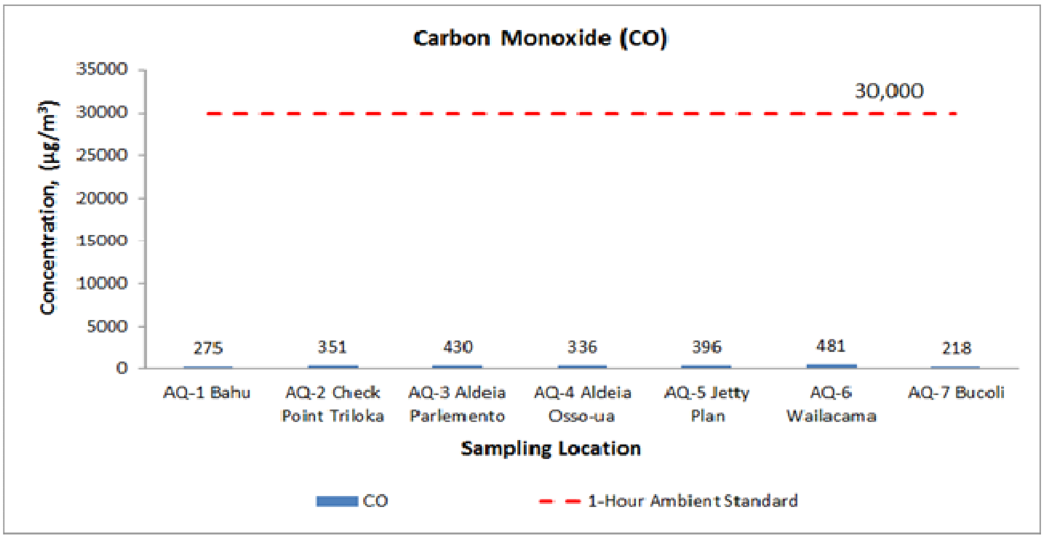


Fig. 3.8: One Hour Ambient Concentration of CO

3.3.5.3. NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) and nitrogen monoxide (NO) are compounds containing nitrogen in the atmosphere, and are important indicators of air pollution.

One hour nitrogen dioxide concentrations in the Baucau area were below the standard (200 µg/m^3) according to WHO (2005) (Refer to **Fig. 3.9**)

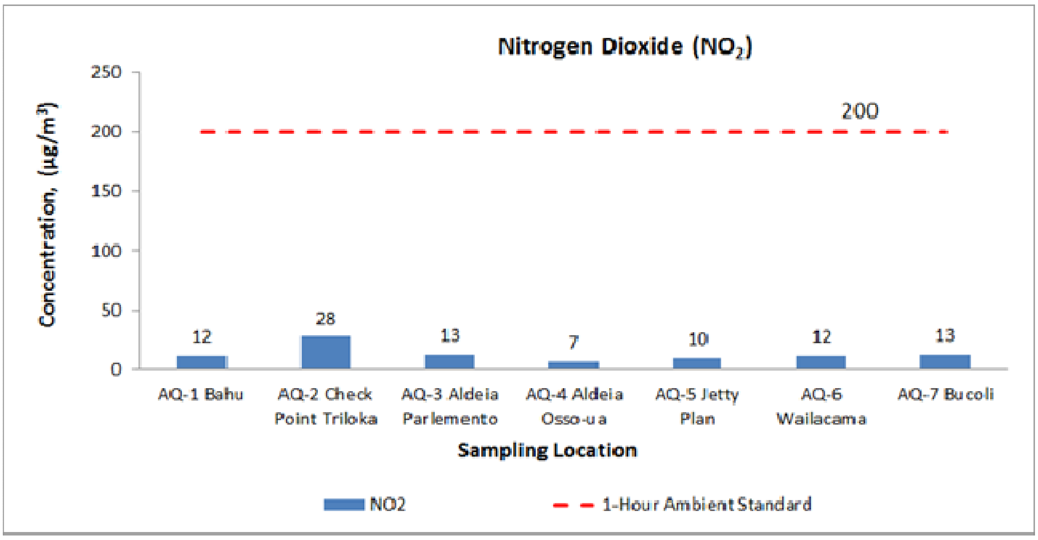


Fig. 3.9: One Hour Ambient Concentration of NO_2

3.3.5.4. SULPHUR DIOXIDE

The results of SO_2 measurements (Refer Error! Reference source not found.) show that SO_2 concentration is far below the standard (196 µg/m^3) according to WHO (2005).

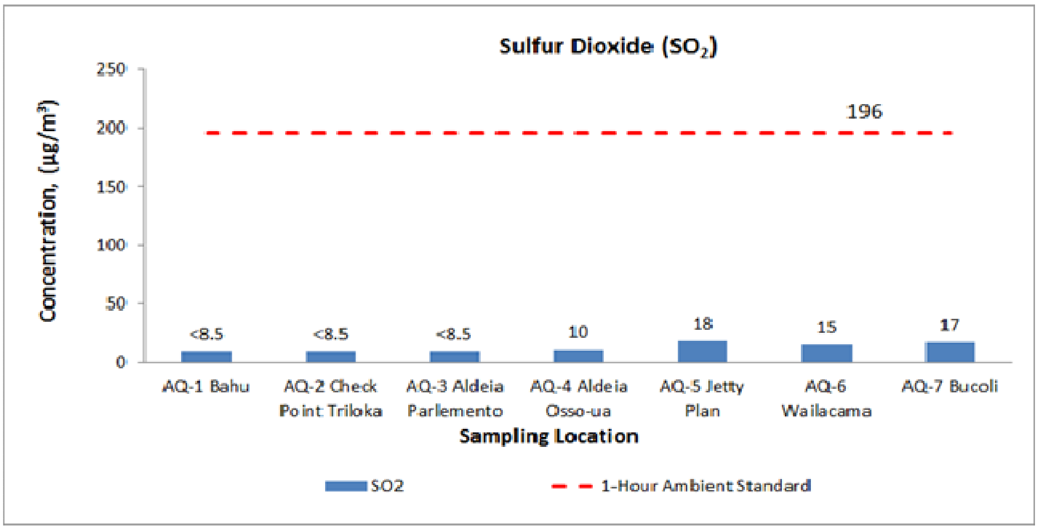


Fig. 3.10: One Hour Ambient Concentration of SO_2

3.3.5.5. HYDROCARBON

Low concentrations of trace hydrocarbon gases such as methane, isoprene and terpene may be present in the atmosphere.

The sampling results (Refer Error! Reference source not found.) indicate that the 3 hour ambient concentration of non-methane hydrocarbon (NMHC) is below the US EPA standard of 160µg/m^3. All measured concentrations were below the detection limit (< 1 µg/m^3).

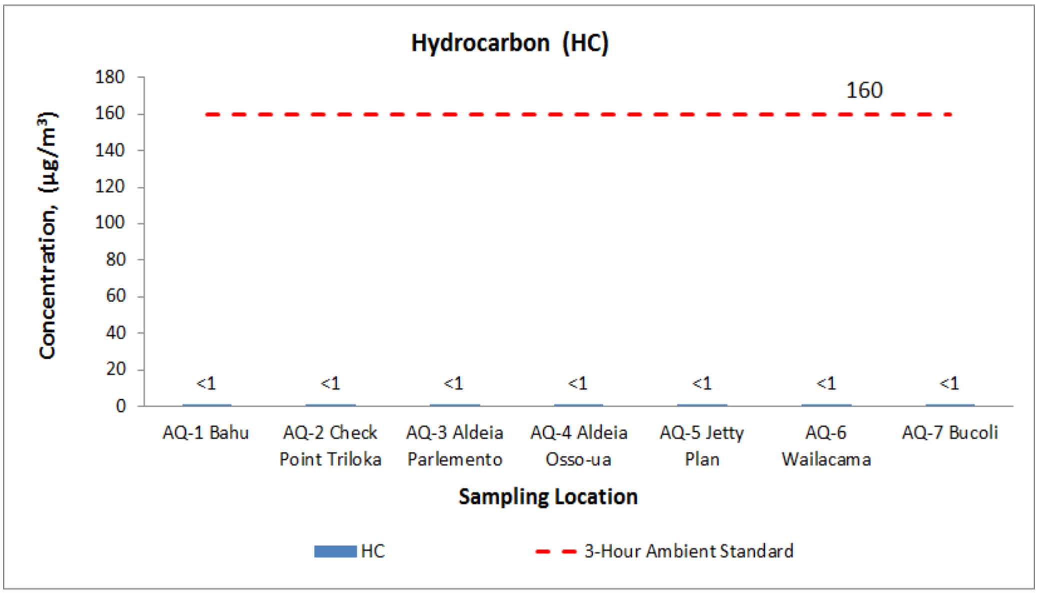


Fig. 3.11: One Hour Ambient Concentration of Hydrocarbon

3.3.5.6. OZONE (O_3)

Natural ozone in lower atmosphere (troposphere) has concentration of 20 ppb (40 µg/m^3). Natural processes such as chemical reactions in the troposphere and movement of ozone from the stratosphere to the troposphere may increase the ozone concentration in the atmosphere. Anthropogenic activities may cause an increase in ozone concentration.

The sampling results show that the ambient concentration of ozone is below the US EPA 1997 standard of 235µg/Nm^3 (Error! Reference source not found.).

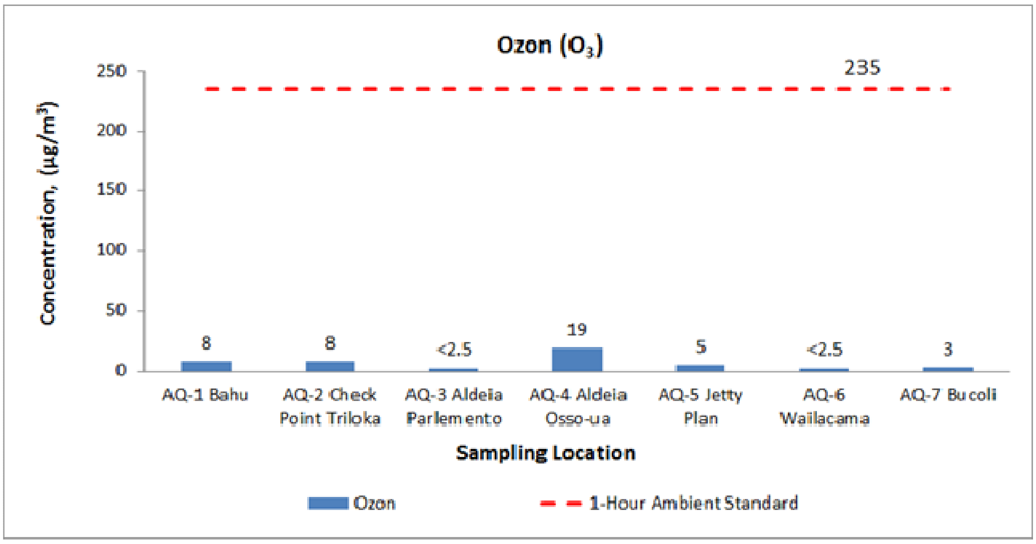


Fig. 3.12: One Hour Ambient Concentration of Ozone

3.4 WATER

There is no fresh surface water source within or near the mining area. Water supply to this area is maintained by the Govt. by water pipelines but the supply is erratic.

The hydrogeology of Baucau consists of a limestone karst aquifer featuring springs, caves, collapsed caves, sink holes and sharp outcrop.

Groundwater in the karst is derived from directly permeating rainfall that readily enters the vuggy limestone through a thin terra rosa soil. The groundwater exists in a bimodal aquifer of low to medium porosity slowly draining into caves with very high permeability and flow times of days to weeks

A desktop review of existing hydro-geological and geological reports and a site visit was undertaken to obtain information on potential water supply sources and water quality data in the region. The main karst features of the Baucau plateau are outlined in **Fig. 3.13.**

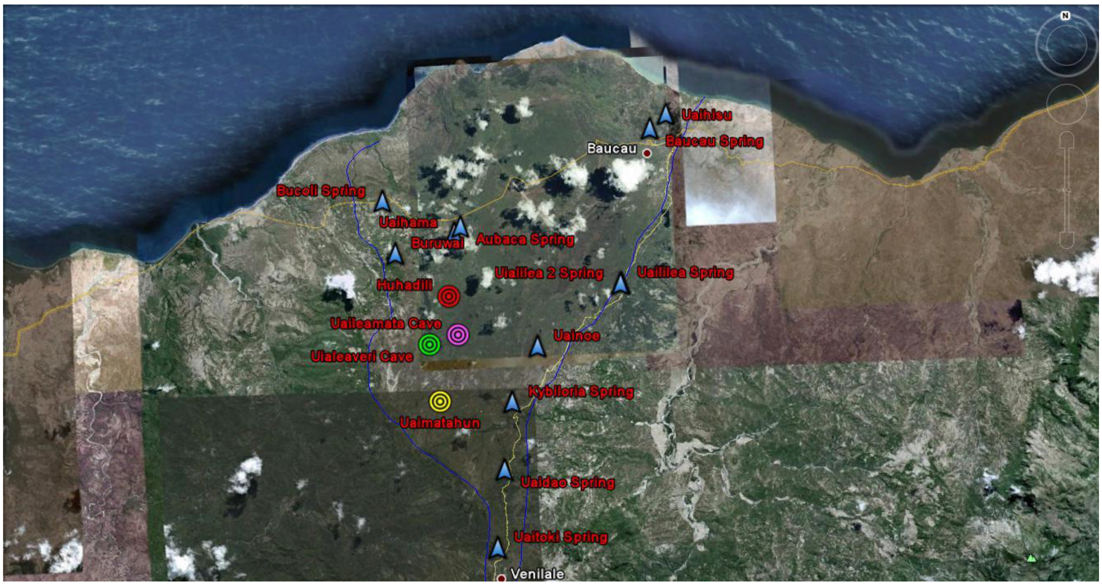


Fig. 3.13 – Karst features of Baucau Plateau

The two largest springs are Uaisarake and Uaililia on the eastern side of the plateau and produce 200 l/s and 50 l/s, respectively. The aquifer is recharged by infiltrating rainfall on the plateau during the wet season. The infiltration rate is very high (c.f. Jocson et al 2002) due to the exposed karst features and probably about 40% of the annual rainfall that varies from about 1,200 mm in Bacau (1956 – 1992) to 1,764 mm on the plateau (Venilale 1952 – 1974). Recharge has been observed by monitoring cumulative rainfall and cave river levels at Uaileaveri Cave. Recharge only takes an hour or two in a storm to infiltrate to the cave stream (about 6 metres below ground level).

Discharge at the main spring in Baucau has been monitored over several years and has been observed that there is a delay of about 9 months between the wet season rainfall and peak flow of the spring. This observation supports the theory that the karst aquifer is bimodal in storage and transmission of water. Fast recharge and flow occurs through fractures and caves whereas very slow flow occurs in the low porosity of the limestone rock mass into the caves.

The flow of the Baucau plateau has been conceptualized based on observations of the elevations of the ground surface and the elevation of water in caves and springs. The general flow pattern of groundwater in the karst is from the high in the south-west to the low in the north-east at Baucau, but also there is lateral movement to the springs in the east and west of the plateau.

The results of a geophysical survey undertaken in Baucau in 2012 estimated that approximately 10 sq km area collects recharge and drains towards the mine area. With an annual rainfall of 1,200 mm and an estimated recharge rate of 0.4, this is equivalent to 4.8 Gl/yr and is sufficient to meet the mine demand of 1.15 Gl/yr with sufficient through flow to meet village water supplies and environmental requirements. The pathway(s) of the water flow and flow rates of individual streams are not known. It is clear that recharge occurs across the plateau and that discharge occurs around the edges of the plateau where the limestone thins and springs surface.

3.4.1 GROUND WATER QUALITY

The karst water is very fresh (Timor and WHO standards) and is suitable for all uses except for boiler where it will need treatment to remove calcium and possibly silica. A typical analysis of metals and metalloids from Uailia Spring at Baucau is given in **Table 3.2**.

Metal	Unit	Baucau Uidasime/ Uailili Spring	Baucau Town Uailia Spring
Aluminium	mg/L	0.01	0.01
Boron	mg/L	<0.04	<0.04
Barium	mg/L	0.008	0.008
Beryllium	mg/L	<0.0002	<0.0002
Calcium	mg/L	51	84
Cadmium	mg/L	<0.004	<0.004
Cobalt	mg/L	<0.005	<0.005
Chromium	mg/L	<0.004	<0.004
Copper	mg/L	< 0.005	< 0.005
Iron	mg/L	0.007	0.006
Mercury	mg/L	<0.01	<0.01
Potassium	mg/L	0.63	0.65
Magnesium	mg/L	13	14
Manganese	mg/L	<0.001	<0.01
Molybdenum	mg/L	<0.005	<0.005
Sodium	mg/L	3	3
Nickel	mg/L	<0.005	<0.006
Lead	mg/L	<0.01	<0.01
Sulphur	mg/L	3.2	1.2
Antimony	mg/L	<0.07	<0.07
Selenium	mg/L	<0.04	<0.04
Silica	mg/L	8.2	6.1
Tin	mg/L	<0.02	<0.02
Strontium	mg/L	0.26	0.5
Titanium	mg/L	<0.004	<0.004
Vanadium	mg/L	<0.003	<0.003

Table 3.2: Analysis of metals and metalloids from Uailia Spring

3.5 NOISE

Noise baseline was measured every 5 seconds for 10 minutes for each measurement. The measurement is carried out to determine the equivalent noise level (Leq) through a calculation based KepMen LH No. 48 of 1996 on the Standard of Noise Level.

Basically, noise measurement was conducted to describe activities and noise background for 24 hours at TL Cement by measuring a minimum of 4 times at noon and 3 times at night. The measurement must be able to represent an interval of 16 hours during the day (6:00 to 22:00) and 8 hours during night (22:00 to 06:00).

The noise baseline measurement was undertaken at seven monitoring locations (**Refer Fig. 3.14**).

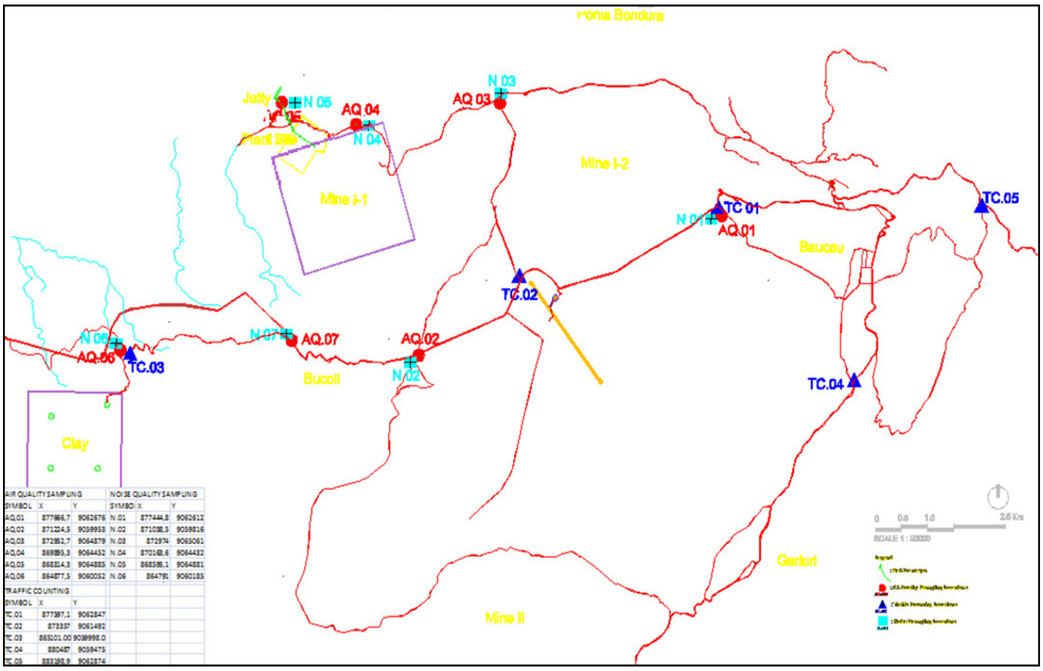


Table 3.14: Noise baseline Monitoring Stations

The result of baseline monitoring at above locations is given in **Table 3.3**.

	S. No.	Measurement Point						
		N01	**N02**	**N03**	**N04**	**N05**	**N06**	**N07**
Measurement of LA_{eq} (dBA)	1	54.00	60.20	55.50	56.30	50.50	63.80	58.30
	2	54.40	58.80	43.60	52.80	49.90	57.40	55.90
	3	55.60	54.30	45.10	53.30	51.10	62.40	54.90
	4	64.20	60.10	48.90	48.60	51.60	62.80	58.10
	5	60.70	58.20	50.30	51.70	42.60	55.90	58.30
	6	53.60	59.40	50.20	49.70	47.30	41.20	58.10
	7	54.10	59.00	51.10	50.20	47.90	55.90	46.90

S. No.		Measurement Point						
		N01	**N02**	**N03**	**N04**	**N05**	**N06**	**N07**
	8	52.80	57.90	46.20	50.00	47.90	38.30	43.70
	9	52.60	48.40	46.50	50.30	49.80	46.90	40.70
	10	57.50	53.30	47.50	49.50	50.20	54.10	43.60
	11	58.10	52.90	45.90	55.20	49.50	39.10	43.10
	12	52.50	56.40	50.20	52.80	49.20	56.50	50.60
Ldn (dBA)		**58.45**	**58.97**	**50.99**	**54.83**	**51.92**	**59.48**	**55.34**
Ld (dBA)		**58.43**	**58.87**	**50.67**	**52.80**	**49.83**	**60.67**	**57.46**
Ln (dBA)		**53.53**	**54.07**	**46.57**	**51.66**	**48.78**	**52.85**	**46.06**

Table 3.3: Noise baseline measurement data LA_{eq} and calculated L_d, L_n, and L_{dn}

Based on above table, the value of L_{dn} at seven measurement points is varying from 50.99 - 59.48 dBA. At the measurement point N03, N04, N05, and N07, Ldn values meet the noise quality standards with 3 dBA tolerance. While at the measurement point N01, N02, and N06, Ldn values slightly exceeded the noise quality standards. Some measurement points with higher noise level were due to the cars or motorcycles that passed by during measurement. Therefore it is necessary to eliminate incidental noise from cars or motorcycles. Noise baseline level that has been adjusted by eliminating the incidental noise is given in **Table 3.4**.

S. No.		Measurement Point						
		N01	**N02**	**N03**	**N04**	**N05**	**N06**	**N07**
Measurement of LA_{eq} (dBA)	1	54.00	-	-	56.30	50.50	-	-
	2	54.40	-	43.60	52.80	49.90	-	-
	3	55.60	54.30	45.10	53.30	51.10	-	-
	4	-	-	48.90	48.60	51.60	-	-
	5	-	-	50.30	51.70	42.60	-	-
	6	53.60	-	50.20	49.70	47.30	41.20	-
	7	54.10	-	51.10	50.20	47.90	-	46.90
	8	52.80	-	46.20	50.00	47.90	38.30	43.70
	9	52.60	48.40	46.50	50.30	49.80	46.90	40.70
	10	-	53.30	47.50	49.50	50.20	-	43.60
	11	-	52.90	45.90	55.20	49.50	39.10	43.10
	12	52.50	-	50.20	52.80	49.20	-	50.60
Ldn (dBA)		**56.27**	**55.52**	**50.20**	**54.83**	**51.92**	**46.34**	**50.71**
Ld (dBA)		**53.98**	**54.30**	**49.17**	**52.80**	**49.83**	**41.20**	**50.32**
Ln (dBA)		**53.53**	**50.77**	**46.57**	**51.66**	**48.78**	**42.03**	**46.06**

Table 3.4: Noise baseline measurement data LA_{eq} and calculated L_d, L_n, and L_{dn} without incidental noise

The ambient noise levels at all the monitoring stations are well below the permissible limits of 70 dB(A) for Industrial activity as per the IFC guideline for Noise management.

3.6 SOIL

Three main types of soil are found in Timor-Leste. These are cambisols, vertisols and fluvisols. (Ref : The National Biodiversity Strategy & Action Plan of Timor-Leste (2011-2020).

In parts of Baucau district with lower altitude, the soils are of Mesozoic & Cainozoic Carbonates type as shown in **Fig. 3.15**.

Figure 3.15: Occurrence of Mesozoic & Cainozoic Carbonates type soil in Timor-Leste (Ref: Geology and Soils in Timor-Leste, S.J. Thompson, 2011).

3.7 FLORA AND FAUNA

A desktop review and flora and fauna survey was undertaken in May 2015.

3.7.1 FLORA

The flora of Timor is poorly known, but a review of available data was given by Cowie (2006) with at least c. 1,488 plant species listed for Timor (I. Cowie pers. comm.). The flora is transitional between those of the tropical rainforests of Sundaland and the Australo-Papuan region (Roos et al. 2004). A large proportion of the dry tropical forest plants of Timor occur also in northern Australia, and often more widely in Malesia (Cowie 2006). A small number of Timor or Lesser Sunda endemic plants are from predominantly Australian families or genera (*e.g. Diuris freya [Orchidaceae], Eucalyptus urophylla, E. alba, E. orophila [Myrtaceae], and Casuarina junghuhniana timorensis [Casuarinaceae]*) (Monk et al. 1997; Cowie 2006).

The dominant natural vegetation types are broadly savanna woodlands (often dominated by *Eucalyptus, Acacia, Borassus and Corypha*), open forest, Closed canopy tropical forest ("monsoon forest", "rainforest"; from high rainfall evergreen forest to drier types, typically driven by interactions of elevation-rainfall-geology and topography). Closed Tropical Forest is biologically rich with diverse tree and shrub communities. It also provides habitat for rich communities of endemic bird, mammal, and reptile communities. Historically much Closed Tropical Forest on Timor has been converted to agriculture, harvested during colonial times, or converted during Indonesian administration to reduce safe havens for resistance fighters.

In Timor-Leste loss or conversion of closed tropical forest is the major driver of population loss and decline of biologically significant tropical forest and species listed by the IUCN as threatened with extinction. This includes at least three tree species, a species of shrew, the Vulnerable Western Naked-backed Bat *Dobsonia peronii*, the Near threatened Long-tailed Macaque *Macaca fascicularis*, one Critically endangered bird (Yellow-crested Cockatoo *Cacatua sulphurea*) three Endangered birds (Timor Green Pigeon *Treron psittaceus*, Wetar Ground Dove *Gallicolumba hoetdi* and Timor Imperial Pigeon *Ducula cineracea*) and an additional 13 Near threatened bird species. Loss or conversion of tropical forest is the most important driver of population decline of most of these species, but hunting and or trade has been important driver of population decline for several species such as the Yellow-crested Cockatoo and pigeons. Recent invasions are also driving declines: the Black-spined Toad *Bufo melanostictus* has been implicated in the decline of some native snakes and amphibians, but remains very poorly known.

The Eucalyptus woodlands have typically been given little conservation attention in Timor-Leste, as they have been assumed to be less biologically significant than Closed Tropical Forests. In terms of tree and plant richness, bird and bat richness this clearly is the case. *Eucalyptus alba* was originally described as a species from specimens collected on Timor, and under present-day taxonomy occurs widely in northern Australia, as well as Flores, Alor, Wetar and other islands in the Lesser Sundas. Martin and Cossalter (1977) state that "*E. alba* does not pose any problem of botanical nomenclature; the species present in the Sunda Isles is exactly the same as the one found in the north of Australia". However, *E. alba* on Timor and neighboring islands is clearly a different species to the tree present in northern Australia (I. Cowie pers. comm. 2010), and may consist of several endemic islands forms. Quite extreme morphological variation in *E. alba* is described for the Timor-Leste region by Martin and Cossalter (1977), and further research might recognize taxa within Timor.

3.7.2 FAUNA

Timor has a classical island fauna characterized by low overall species richness and high levels of endemism. A feature of Timor is the high proportion of wildlife that is strongly associated with tropical forest. Timor's present-day fauna is the result of natural colonization by overwater dispersal and more recent human-mediated introductions (from the Orient, Australo-Papuan, Wallacea and Old World, with some tramp ants from Africa and South America), subsequent in-situ speciation and extinctions over the last 4 My.

Historical collecting and observation of Timor's birds was summarized in a major monograph *The Birds of Wallacea* (White and Bruce 1986) with 212 birds listed. Subsequent field observations including species status and habitat use have been summarized in a field guide (Trainor et al. 2007a). Endemism is high. There are 126 resident landbirds (excluding migrants/visiting birds and water birds). On current information there is at least seven species endemic to Timor Island, at least 39 species (31% of resident landbirds) are globally restricted-range (with distributions of less than 50,000km2) and 44 species (35%) are endemic to the Wallacean region (CRT unpubl data). About 80 birds are considered forest specialists and these species particularly susceptible to forest loss and conversion.

At least 52 mammal species are known from Timor, but remarkably, other than bats few native land mammal species have been recorded since 1800 – the Thin Shrew *Crocidura tenuis* and Timor Rat *Rattus timoriensis* and undescribed shrews. The Long-tailed Macaque (*Macaca fascicularis*) has long been considered as an introduced species, but recent molecular work shows that it has existed on Timor for c. 1 Mya. Bats are the most speciose group, with at least 33 species. A single monograph covers the bats of Timor (Goodwin 1979) but a series of surveys by the Western Australian Museum (Kitchener et al. 1992, 1995), and more recently (Helgen 2004; Armstrong 2006) has added new island records and clarified the taxonomic status of some species including endemic and undescribed taxa. At least 17 mammals have been introduced to Timor (Glover 1986).

Knowledge of the taxonomic status amphibian and reptile faunas has improved greatly over the past 10 years. Of c.55 species listed in 2015 (excluding marine species/turtles), approximately 26 species may be undescribed (O'Shea et al. 2015). This includes at least two amphibians, eight geckos, 14 lizards and two snake species (O'Shea et al. 2015). The habitat use, distribution and status of most amphibian and reptiles species remains very poorly known. Current knowledge suggests that many species may be highly localized on Timor (O'Shea et al. 2015) but this may also be caused by low survey effort. Habitat use patterns are also poorly known making conservation assessments problematic.

3.7.3 FLORA SURVEY RESULTS

Jetty Site

The Jetty is located at the nearby beach and will include a conveyor belt to the plant site. The area is flat and already highly modified by temporary dwellings, grazing and some agriculture. The general environment is characterized by sandy soils and established breadfruit *Artocarpus altilis* and *Corypha sp* palm groves. The area is also severely infested with weeds.

The overall site is dominated by a relatively uniform coastal Closed Tropical Forest (70%) which is most likely a combination of existing forest and mature plantation trees. The remaining area (30%) is cleared grazing land and residential farms.

The coastal Closed Tropical Forest is dominated by *Borassus flabelifer*, *Corypha utan* and *Artocarpus integer*. Additional examples of *Artocarpus atilis*, *Cocos nucifera*, *Persea americana* and *Tamarindus indica* were recorded for the upper stratum. The height range within the Closed Tropical Forest systems is 20 to 30m. The middle stratum was largely absent but included some juvenile representatives of the upper stratum. The lower stratum is primarily dominated by a heavy infestation of the weed *Lantana camara* with other areas characterized by high leaf litter from the overhead palms.

Overall, the jetty site is a heavily modified plantation environment with a severe infestation of *Lantana camara* throughout. The biological diversity at these sites was very low and overall the site was not representative of a pristine coastal/beach forest. No plant species listed by the International Union for Conservation of Nature (IUCN) were found at the Jetty site

Plant Site

The plant site is located on NNE facing slopes and plains relatively close to the beach, road and proposed jetty area. The site is characterized by shallow limestone soils with scattered limestone rock outcrops, minor ridges and gullies sloping towards the beach. The site consists predominantly of very open savannah woodland (95%) which has been extensively modified for agriculture and grazing in places. The remaining areas were isolated patches of Closed Tropical Forest systems (5%), occurring in depressions and drainage floors and often surrounded by introduced *Lantana camara*. For representative purposes surveys were conducted in each of these two systems.

The open woodland environment at the plant site is dominated by *Eucalyptus alba* and *Ceylon Oak Schleichera oleosa* (Tetum: Aidak) ranging in height from 8 to 10 m. Canopy cover in this area was very sparse at less than 10%. Native species present in the middle stratum included, *Eucalyptus alba* juveniles, *Canarium vulgare* (Tetum: Kai Tudo) and *Annona squamosa* (Tetum: Ai Ata) but both the middle and lower stratums are primarily dominated by introduced invasive species, including, *Ziziphus mauritiana* (Chinee Apple), *Lantana camara* and *Chromolaena odorata* (Siam Weed). Some grassland is intact with the dominant grass being *Iseilma minutiflorum*. The Closed Tropical Forest environment is dominated by *Ficus species* (unidentified) ranging in height from 10 to 15 m and the invasive *Tecoma stans* (Tetum: Ai funan kinur) as a secondary dominant small tree. The Closed Tropical Forest site had a dense canopy of approximately 70%. Additional native trees recorded at this site include, *Intsia bijuga* (Borneo Teak), *Tamarindus indica*, *Senna timoriensis* and *Streblus asper*. The middle stratum was dominated by juvenile representation of the upper storey with 70% coverage of leaf litter

The open woodland site had an 80% level of disturbance from weed infestations and grazing. The Closed Tropical Forest area had a 30% level of disturbance from weeds on its edges but was relatively weed free and undisturbed at its centre. The dominant weeds across the two sites include, *Tecoma stans*, *Lantana camara*, *Jatropha gossypifolia*, *Chromolaena odorata* and *Hyptis suaveolens*, *Intsia bijuga* (Borneo Teak) was present at survey site P002 and is listed as Vulnerable by the International Union for Conservation of Nature (IUCN) Red List.

Mine Site

The mine site is located across NE to NW facing stepped slopes and plains on limestone outcrops with higher slopes on the southern edge of the site and flatter plains towards the northern boundary. The site is predominantly uniform woodland to open woodland (95%) with isolated small patches of Closed Tropical Forest (5%) occurring in minor ravines and gullies, and grassland. The site is characterized by shallow limestone soils and extensive scattered, small to medium sized limestone rock outcrops. Nine separate survey locations were undertaken. These sites radiated out from the test drill locations and targeted different vegetation assemblages wherever available.

The open woodland environment (95%) at the mine site is dominated by relatively uniform *Eucalyptus alba* and *Schleichera oleosa* assemblages, ranging in height from 8 to 10 m. Additional native species occurring in lesser numbers in the upper stratum includes, *Acacia sp*, *Alstonia actinophylla*, *Gmelina arborea*, *Dalbergia timoriensis*, *Miliusa sp*, *Santalum album*, *Senna timoriensis* and *Syzigium nervosum*. The middle stratum is largely absent but includes examples of dominant juveniles and various invasive weeds including, *Ziziphus mauritiana*, *Lantana camara* and *Chromolaena odorata* (Siam Weed). The lower stratum is grassland, predominantly *Iseilma minutiflorum*, with mixed herbs including *Indigofera linifolia* and *Uraria lagopodiodes*.

The Closed Tropical Forest (5%) patches are characterized by canopy cover in excess of 70% and are typically dominated by mature *Schleichera oleosa* but also included lesser examples of *Acacia sp*, *Cryptocarya foetida*, *Dalbergia timoriensis*, *Syzigium nervosum* and *Santalum album*. The height range within the Closed Tropical Forest systems is 8 to 10 m. The middle stratum within these isolated Closed Tropical Forest systems exhibited the greatest species richness of all sites surveyed and included examples of *Dichapetalum timorense*, *Dischidia major*, *Neoalsomitra podagrica*, *Tricolor Lindle*, *var insignis* and *Wrightia pubescens*. The lower stratum within the Closed Tropical Forest patches is characterized by higher than average leaf litter and mixed herbs and grasses including, *Breynia cernua*, *Imperata cylindrical*, *Iseilma minutiflorum*, *Justicia procumbens*, *Phyllanthus virgatus*, and *Uraria lagopodiodes*.

The mine site open woodland (95%) varies in the degree of disturbance and degradation dependent on physical barriers such as excessive exposed limestone outcrops, which appears to restrict grazing animal access somewhat. However, across the majority of open woodland sites weed species, including *Hyptis sauvleons*, *Chromolaena odorata*, *Jatropha gossypifolia*, *Lantana camara*, *Tecoma stans* and *Ziziphus mauritiana* were usually secondary dominant species in each of the stratum. The percentage of weed infestation varied from 3% to 45% across the surveyed locations. On average the canopy cover in the open woodland environments is approximately 10%.

Clay mine site

The clay mine site is located in the Wailacama village area and is characterised by greater topographic relief than the other project locations with steep slopes ranging in aspect from E to WNW, incised rivers and heavy grey clay soils. The overall site is dominated by Closed Tropical Forest (60%) and degraded woodland (40%). However, vegetation communities within the 23 survey localities of the 4 test pit sites includes, Closed Tropical Forest (30%), bamboo forest (20%) and degraded open woodland (50%). These survey sites radiated out from the test drill locations and targeted different vegetation assemblages wherever available.

The Closed Tropical Forest (30%) patches are characterized by canopy cover in excess of 70% and are primarily dominated by *Peltophorum pterocarpum* but also included lesser examples of *Hibiscus hirtus*, *Terminalia cattapa*, *Ziziphus oenopolia* and *Ziziphus timoriensis*. The height range within the Closed Tropical Forest systems is 10 to 15 m. The middle stratum within the Closed Tropical Forest systems exhibited only moderate diversity with the majority of the stratum taken up by juvenile representatives of the upper stratum. Lesser examples found include, *Citrus sp*, *poss gracilis*, *Pometia pinnata*, *Schleichera oleosa* and *Miliusa sp*. The lower stratum within the Closed Tropical Forest patches is characterized by high leaf litter. Both Closed Tropical Forest survey sites were heavily infested with *Lantana camara* and lesser amounts of *Jatropha gossypifolia* and *Chromolaena odorata*.

The bamboo forest environments (20%) were concentrated in the south of the project area and were usually concentrated in isolated patches with only limited diversity through the middle and lower stratums. The dominant bamboo species present across both sites is a thorny clumping style *Dendrocalamus sp* with a canopy cover between 30 to 45% and a height range from 10 to 15 m. Lesser examples of *Acacia leucophloea*, *Peltophorum pterocarpum*, *Pterocarpus indica*, *Senna surattensis* and *Sesbania grandiflora* and *Tectona grandis* are also present. The middle stratum is limited and included examples of small *Acacia nilotica* and *Senna surattensis*. The lower stratum in the bamboo forest systems exhibits a higher degree of diversity and includes examples of *Ageratina riparia*, *Brucea javanica*, *Canavalia papuana*, *Desmodium gangeticum* and *Gliricidia sepum*. Both bamboo survey sites have high levels of *Chromolaena odorata* and *Acacia nilotica* (juvenile) infestations.

The open woodland environment (50%) across the clay mine site is characteristically located on hills and slopes between sections of Closed Tropical Forest and located largely on the eastern side of the site between Test Pits 01 and 04. The majority of these sites was heavily degraded, particularly through grazing and weeds infestations. Of the five survey sites undertaken two had extremely low biological diversity. Canopy cover at these sites was less than 10% with a tree height range from 8 to 15 m. In the upper stratum, *Acacia leucophloea* and *Peltophorum pterocarpum* were the dominant species, with lesser examples of *Pterocarpus indicus* and *Eucalyptus alba*. The middle stratum is largely absent or dominated by well-established invasive species including *Acacia niloticus*, *Lantana camara* and *Ziziphus mauritiana*. The lower stratum ranged from exposed soils with scattered limestone outcrops to relatively diverse grassland of *Iseilma minutiflorum*, with mixed herbs including *Indigofera linifolia* and *Thecanthes concreta*. Most lower stratum sample sites also included *Acacia nilotica*, *Hyptis sauvleons*, *Lantana camara* and *Chromolaena odorata*.

Overall, the clay mine site has a mixture of either Closed Tropical Forest or bamboo forest on the steeper slopes and heavily degraded open woodlands on the hills and rises between. The Closed Tropical Forest environments exhibits a higher than average biological diversity, whereas the open woodland sites had very low biological diversity. Across the majority of open woodland sites weed species, including *Hyptis sauvleons*, *Chromolaena odorata*, *Jatropha 25 gossypifolia*, *Lantana camara*, and *Ziziphus mauritiana* were usually secondary dominant species in each of the stratum. The percentage of weed infestation varied from 10% to 100% across the surveyed locations.

Pterocarpus indicus was identified at survey site TP01-002 and is listed as Vulnerable on the International Union for Conservation of Nature (IUCN) Red List. *Indigofera linifolia* was present at survey site TP03-001 and is listed as Least Concern

3.7.4 FAUNA SURVEY RESULTS

A total of 78 vertebrate fauna species were recorded during the survey including two amphibians (one native species), eight reptiles (six native species), 11 mammals (two native species) and 57 bird species. The fauna was highly typical of lowland woodland habitats on Timor in particular, with some forest specialized birds present, particularly associated with the Clay mine.

A large proportion of the recorded fauna, especially among amphibians, reptiles and mammals consisted of introduced/tramp or invasive species which are not native to Timor-Leste. Some introduced species were common e.g. Black-spined Toad (*Bufo melanostictus*), Tokay Gecko (*Gekko gecko*), with livestock species such as Water Buffalo, Banteng/cattle, horse and sheep regularly observed at the Mine and Clay sites.

The greatest number of species was recorded in the largest study sites with 52 fauna species recorded in the Mine and 63 fauna species recorded in the Clay site, and fewer species at the Camp Bore, Jetty and Plant. Only two individual native frogs were recorded, but the invasive Black-spined Toad was frequent in the Mine and Clay areas. The Indonesian Short-nosed Fruit Bat was the only native mammal directly recorded with small numbers observed under palm fronds at the Jetty site, but local villagers reported that the IUCN Near threatened Long-tailed Macaque (Macaca fascicularis) was present at the Plant, Mine and Clay Site.

3.8 SOCIO-ECONOMIC CONDITIONS

Agriculture is the chief occupation of the people in the area. The crops being cultivated include peanuts, coconut, corn and vegetables like beans, tomatoes, cassava, potatoes, etc. The important fruit trees are banana and papaya.

There are around 15 households whose lands shall be located on the proposed mining in Block I-1. Some households are also located along the fringes of the plant area and they shall also be displaced.

3.8.1 EDUCATION

There are a number of Government schools in Baucau. Baucau also has a Government College which is a sub-branch of a college in Dili.

3.8.2 HEALTH

There is a Government Hospital in Baucau which caters to the total population of the district. Also each sub-district has a health center.

TLC shall also set up suitable Health Care facilities at their plant premises for their employees which could be extended to the locals in case of emergencies

3.8.3 SOCIO- ECONOMIC SURVEY OF THE STUDY AREA

The total population of Baucau district is 111,694 as per Census 2010. Bucoli village has a total population of 2,179 in 372 households. An average household has about 5-6 members.

A detailed socio-economic survey shall be undertaken in the study area around the proposed project site to provide the baseline data on the socio-economic status of the inhabitants of the affected areas on the likely impacts of the project on their general socio-economic wellbeing. The survey shall be carried out by using a structured questionnaire survey, direct observation, as well as oral discussions with some key elements in the villages falling within 10 km radius area from the proposed project site. Questionnaires shall be designed for survey at Household, Sub-Suco, Suco and Sub-District levels.

3.8.4 CULTURAL, HISTORICAL & ARCHAEOLOGICAL FEATURES

Bondura Mountain extending over a length of 2 km located at a distance of around 0.5 km from the plant site is considered to be holy by the local population. **TLC** shall protect the mountain and measures shall be taken so that industrial activity does not adversely impact the mountain nor impact the local's rights for visiting and carrying out rituals at the mountains.

The detailed EIS/EMP report is under preparation for submission to National Directorate of Environment, Government of Timor-Leste for Environment Clearance.

Chapter – 4
Closure Plan Strategy

CHAPTER - 4

CLOSURE PLAN STRATEGY

4.1 CLOSURE MANAGEMENT STRATEGY

The purpose of the strategy is to derive the most appropriate option for mine closure in terms of performance and cost. The development of the strategy is a stepped approach based on:

- Understanding of current and predicted future impacts;
- Derivation of realistic objectives and targets set to manage identified impacts;
- Setting an overall vision for closure;
- Identifying and evaluating alternative closure scenarios based upon agreed criteria;
- Providing a framework for ongoing consultation with all stakeholders (authorities, employees, communities and others);
- Establishing a system for the ongoing review and updating of the closure strategy and plan based on the above steps.

4.2 CURRENT AND FUTURE IMPACTS

The impacts of the mine construction and operational activities as well as impacts that will persist post-closure were considered for the following parameters:

- Soils, land use and land capability
- Air quality
- Surface water
- Groundwater
- Noise
- Traffic
- Ecology and biodiversity
- Ecosystems services
- Socio-economics

The anticipated impacts during the life of the operation have been assessed and are given below:

4.2.1 IMPACTS DURING CONSTRUCTION

The summary of impacts during construction phase of the quarry and the mitigation measures is given below:

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
1. Visual Impacts			
Loss of sense of place affecting local communities due to site clearing and construction activities	Medium	Low	❑ Minimize the disturbed footprint as far as practically possible; ❑ Clearing of vegetation in phases so that only those area required for immediate development are cleared; ❑ Undertake stripping and excavation in the area as per the Mine Plan; ❑ Simultaneous plantation in the area as per mine plan; ❑ Implementation of waste management as per the Mine Plan; ❑ Implement measures to control air, water, noise pollution.
2. Soils, Land capability and land use			
Placement of quarry infrastructure, resulting in a temporary loss of soil resource and change in soil characteristics, land capability and land use	Medium	Medium	❑ Minimize the disturbed footprint as far as practically possible; ❑ Undertake stripping, stockpiling and waste management as per Mine Plan for reuse on footprint; ❑ Since GOTL has classified this as State Land, GOTL to implement livelihood restoration and compensation measures in areas where livelihood are impacted by the loss of agricultural lands; ❑ Implement the Mine Closure Plan as described in Chapter 5 of

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			this document.
Placement of permanent quarry infrastructure, resulting in a permanent loss of soil resource and change in soil characteristics, land capability and land use	Medium	Medium	❑ Contain the disturbance to as small a footprint as practically required for the activity; ❑ Preserve topsoil for rehabilitation by stripping soil during construction as per Mine Plan; ❑ GOTL to assist community members where livelihood impacted with establishing new agricultural areas on land of equal or better land capability; ❑ Implement the Mine Closure Plan.
Spillage of chemicals and seepage from waste resulting in permanent loss of soil resource, and change in soil characteristics, land capability and land use	Medium	Low	❑ Preparation of procedures to ensure that spillage during mobile equipment maintenance is minimized; ❑ Ensure maintenance of mining equipment at workshops; ❑ The provision of appropriate secondary containment in areas where hydrocarbons, solvents and other potentially hazardous materials are stored; ❑ Formulate and implement emergency preparedness and response measures.
Site clearance resulting in a permanent loss of soil resource, and potential change in soil characteristics, land capability and land use as a	Medium	Low	❑ Minimize the area of disturbance; ❑ Implement storm water control measures around infrastructure as per Mine Plan; ❑ Topsoil dump yard (stockpile) management as per mine plan.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
result of increased erosion			
3. Air Quality			
Increase in PM_{10} and $PM_{2.5}$ emissions resulting from land clearing, earthworks and vehicular movement	Low	Low	❑ Regular water sprinkling on the roads and application of dust suppressants to sections of roads used routinely by vehicles that pass through and close to habitation; ❑ Design road alignments to minimize travel distances and eliminate unnecessary traffic; ❑ Locate dump yards within site boundaries considering the location of potential sensitive receptors and the predominant wind direction; ❑ Set speed limits to minimize the creation of fugitive dust within the concession area during transportation; ❑ Routine air quality monitoring.
Increase in gas (SO_2 , NO_x , CO and Volatile Organic Compounds) emissions resulting from vehicle exhaust emission and biomass burning	Low	Low	❑ Limit vehicle idling and keep vehicles well maintained to minimize particulate and gaseous emissions; ❑ Where possible, biomass burning should be considered and a schedule should be maintained to allow for pollutants to disperse into the atmosphere in a short duration of time; ❑ Biomass burning should be conducted during the day and possibly in summer months; ❑ Routine air quality monitoring.
4. Water Resources			

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Chemical contamination of surface water resulting from accidental spills during transportation and handling and seepage from waste	Low	Low	❑ Where contaminants are transported, emergency contaminant and mitigation measures must be developed to minimize impacts should accidental spillages occur along the transport routes; ❑ Equip all trucks and equipment carrying fuels or oil with spill response materials and train personnel in the use of such materials; ❑ Store all potential sources of contamination in secure facilities with appropriate Storm Water management systems in place to ensure that contaminants are not released to the water resource through Storm Water runoff.
Sedimentation of surface water resulting from erosion and runoff from exposed surfaces and roads	Low	Low	❑ Construct access roads and infrastructure in a way that sensitive ecosystems are avoided; ❑ Construction of embankments, garland drains with de-silting pits to manage storm water runoff in a manner that minimizes sediment transport to the receiving water resource and minimizes erosion along runoff channels.
Contamination of groundwater resulting from seepage from sewage and other waste	Low	Low	❑ Manage waste in accordance with the Mine Plan; ❑ Prioritize construction of a properly lined and designed waste landfill site and sewage treatment system during construction.
Contamination of groundwater resulting from Acid Mine	Medium	Low	❑ Diversion of ditches; ❑ Use of alkaline additives, pH control;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Drainage (AMD)#			❑ Blending of mineral waste; ❑ Application of anionic surfactants; ❑ Microencapsulation (coating).
# - No iron rich rock is available in the area. The top soil available in the area contains meager amount of iron in oxide form. None of the potential AMD causing materials i.e. pyrite, sulphide etc. are present in the rocks available in the area. However, petrography and detailed geo-chemical characterization study of rocks of the area shall be carried out and in case of presence of any potential AMD causing mineral, suitable mitigation measures as per above shall be adopted.			
5. Noise and Vibration			
Continuous noise impact on habitation near the mining area resulting from night-time construction at the quarry	Low	Low	❑ Construction activities in the quarry to be planned during day time hours i.e. 7:00 am to 7:00 pm.
Air-blast noise impact on habitation near the mining area resulting from blasting at the quarry during construction	Low	Low	❑ Possibility of use of surface miner shall be explored to avoid blasting; ❑ Construction phase blasting at the quarry proposed in afternoon hours during 1:00 pm to 2:00 pm.
6. Ecology and Biodiversity			
Loss of habitat due to site clearing and earthmoving activities	Medium	Low	❑ Minimize the disturbance footprint as far as practicable; ❑ Site clearing to be conducted sequentially; ❑ Sequential rehabilitation to be conducted as soon as quarrying of an area has been concluded;

<table>
<tr><th rowspan="2">Aspect/Impact</th><th colspan="2">Significance</th><th rowspan="2">Mitigation Measures</th></tr>
<tr><th>Before Mitigation</th><th>After Mitigation</th></tr>
<tr><td></td><td></td><td></td><td>❑ Topsoil to be stockpiled separately from overburden/inter-burden for rehabilitation purposes and protected against loss from run-off;
❑ Implementation of the EIS and EMP and Mine Closure Plan that will be developed to inform TLC's protection and management of biodiversity in the entire concession, taking cognizance of ecosystem services currently utilized by the local communities. The biodiversity of the project area has been conducted in the baseline surveys of flora and fauna (to complement the existing limited flora data) during the EIS preparation. The baseline surveys and further actions must be updated at least every 5 years to facilitate adaptive management, or more frequently if required.</td></tr>
<tr><td>Loss of forest habitat due to site clearing and earthmoving activities</td><td>Medium</td><td>Low</td><td>❑ Minimize the disturbance footprint as far as practicable;
❑ Preserve the Closed Tropical Forest locations identified within the mine area as far as practicable;
❑ Site clearing to be conducted sequentially as required, not all at once;
❑ The area degraded during the construction phase shall be restored to their natural, pre-construction condition;
❑ Spoiling of material to be conducted sequentially and concentrated in a single area at a time to the greatest practical extent possible;
❑ Implementation of the EIS and EMP and Mine Closure Plan</td></tr>
</table>

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			that will be developed to inform TLC's protection and management of biodiversity in the entire concession.
Loss or disturbance of species of special concern due to site clearing and construction activities	Medium	Low	❑ Sessile fauna, if present, at construction sites to be relocated by relevant ecological experts prior to the commencement of site clearing and construction; ❑ Site clearing to be conducted sequentially and from one corner of the site to the other, to enable highly mobile species to leave the construction area; ❑ No fauna are to be hunted or destroyed by any project personnel; ❑ An environmental education training programme to be developed and implemented, including regular refresher sessions; ❑ Effective penalties (e.g. fines) must be imposed for the hunting or harm to fauna by any staff; ❑ Implementation of the EIS and EMP and Mine Closure Plan that will be developed to inform TLC's protection and management of biodiversity in the entire concession.
Modification or degradation of aquatic habitats due to altered hydrological regimes and surface or groundwater quality	Medium	Low	❑ The storm water management has been considered for both the construction and operational phases of the project for storm water run-off volumes, velocity, water quality to minimize impacts on natural areas; ❑ Leak and spill management systems to be in place at all

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			potential major sources of pollution such as fuel, lubricant, vehicle servicing areas and workshops; ❑ All vehicles to be services at designated workshop areas; ❑ Implementation of the EIS and EMP and Mine Closure Plan that will be developed to inform TLC's protection and management of biodiversity in the entire concession
Introduction of alien invasive plants due to site clearing and disturbance of vegetation	Medium	Low	❑ Minimize cleared or disturbed areas; ❑ The specification for mining machinery contractors must include the washing of machinery prior to it being dispatched to the concession area; ❑ A programme for the control of alien invasive plants in the concession to be developed and implemented as a component of the EIS and EMP.
Impeded photosynthesis and transpiration rate of plants due to dust generation	Low	Low	❑ Dust suppression methods i.e. water sprinkling is proposed at cleared areas, construction sites and material and overburden/topsoil stockpiles on regular basis.
7. Socio-economic			
Influx of potential job seekers into the area and associated risks	Medium	Low	❑ Optimize the use of local labour as far as practically possible; ❑ TL Cement will continue to engage with project stakeholders identified in the EIS public consultation throughout the life of the project; ❑ Implementation of a programme of HIV/AIDS screening,

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			counseling and (where necessary) treatment by TLC for its employees; ❑ Develop and communicate a clear and concise employment and recruitment mechanism to prevent opportunistic job seekers from settling in the area
Increased chances of the spread of communicable diseases such as HIV/AIDS and STDs linked to influx of predominantly male job-seekers and workers	Low	Low	❑ Facilitate education and awareness programme throughout the lifespan of the project which should include the following: ● Awareness campaigns targeting project workers, senior management, contractors, sub-contractors and their spouses ● Prevention, voluntary counseling for communicable diseases, as well as anti-retroviral treatment for employees
Increased pressure on healthcare infrastructure due to project related influx	Medium	Low	❑ Develop a MOU with the Local Healthcare Centers in Baucau for service provision to the local workforce and their dependents; ❑ Within the overall GOTL Health Management frame work for the region, TLC to assist partially through its CSR activity, to identify NGOs in the area that might support operations, at the nearby health centers, with special focus on refurbishment of key areas, equipment and building maintenance, as well as, improved health care management information systems;
Physical displacement of households residing in the	High	Medium	❑ Since the project area is classified as state land GOTL to manage displacement as per its Resettlement Action Plan

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
mining area.			(RAP) ❑ GOTL is advised for compliance with IFC's Performance Standard 5 "Land Acquisition and Involuntary Resettlement",
Generation of direct, indirect and induced employment and income	Medium	Medium	❑ Employment of local workers if applicants with the appropriate skills are available; ❑ Facilitation for local skills training programme to improve the opportunities for local procurement of skills; ❑ Procure goods and services locally, if available and cost competitive and improve opportunities through the development of local supply chain; ❑ Work closely with the community before and during the project to identify and publicize skills and resources that the local community could provide.
Safety impacts to local communities and other road users due to increased road accident	Medium	Low	❑ Internal Quarry haul road of 17.0 m wide carriage way is proposed to be constructed and the bench access roads are proposed to be of 15 m width; ❑ The roads in the quarry shall be solely used by the company equipments only; ❑ Clear signage shall be displayed; ❑ Speed limit shall be limited; ❑ Formulate and implement traffic rules in the concession area.
8. Eco-system services			

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Reduced availability of natural resources and ecosystem services to local communities	Medium	Low	❑ Comply with Good International Industry Practices (GIIP) for air emissions, water (storm water and effluent) discharge quality and solid waste disposal to minimize impacts on ecosystem services; ❑ Implement mitigation measures recommended above at point no. 6 to minimize impacts on ecological resources; ❑ Implement mitigation measures recommended in operation phase and GOTL's Resettlement Action Plan to maximize community resilience and ensure fair compensation where resources are directly affected.

4.2.2 IMPACTS DURING OPERATIONS

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
1. Air Quality			
Significance of impact of PM_{10} and $PM_{2.5}$ from the quarry	Medium	Low	❑ Drilling machines are proposed to be equipped with wet drilling arrangements or dust collectors; ❑ Rock breaker is proposed to be used for breaking over size boulders in order to reduce dust and noise generation, which otherwise will be generated due to secondary blasting; ❑ Optimum use of explosive energy will help in reducing the air pollution; ❑ Water spray on bench access roads, waste dump yard roads & proper periodic maintenance of roads will be done; ❑ Development of green belt/plantation around the quarry, waste dumps and other places will be carried out to control the air pollution; ❑ Personal Protective Equipments (PPE) like dust mask, ear plugs, helmets will be provided to all employees; ❑ Periodic air quality monitoring will be carried out; ❑ Proper maintenance of vehicles will be done to limit gaseous emissions.
Significance of impact of dust from the haul roads	Medium	Low	❑ The main haul road from crusher to quarry entry is proposed to be constructed of WBM to reduce the dust emission by vehicles. The road maintenance to be carried out periodically;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ Continuous water sprinkling is proposed to minimize the dust generation during transportation; ❑ The haul road alignment is designed in a way to minimize travel distances and eliminate unnecessary traffic; ❑ The speed limit of vehicles on the main haul road is proposed to be limited to about 40 km/hr.
Significance of impact of dust from materials handling at the overburden and reject dump	Medium	Low	❑ Attend to dust control when loading and unloading trucks by minimizing the drop heights; ❑ Prevent overloading of material in the dump trucks; ❑ Spraying of water over the blasted muck pile as and when required before loading of materials to reduce the dust emissions; ❑ Water spraying over the overburden and reject dumps as and when required and its road to check the dust emission.
Increase in gas (SO_2 , NO_x and CO) emissions resulting from vehicle exhaust emission	Medium	Low	❑ Limit vehicle idling and keep vehicles well maintained to minimize particulate and gaseous emissions; ❑ Proper maintenance of vehicles is proposed to limit gaseous emissions; ❑ Routine air quality monitoring.

<table>
<tr><th rowspan="2">Aspect/Impact</th><th colspan="2">Significance</th><th rowspan="2">Mitigation Measures</th></tr>
<tr><th>Before Mitigation</th><th>After Mitigation</th></tr>
<tr><td colspan="4">2. Noise and Vibration</td></tr>
<tr><td>Continuous noise resulting from daytime operations of the quarry, haul road and associated infrastructure</td><td>High</td><td>Low</td><td>❑ Drilling is proposed to be carried out with the help of sharp drill bits which will help in reducing noise;
❑ Secondary blasting shall be totally avoided and Hydraulic rock breaker is proposed to be used for breaking boulders;
❑ Proper maintenance, oiling and greasing of machines at regular intervals will be done to reduce generation of noise;
❑ Adequate silencers will be provided in all the diesel engines;
❑ Acoustic cabin in mining machinery will protect the operator from high noise level;
❑ Personal Protective Equipments (PPE) like dust mask, ear plugs, helmets will be provided to all employees;
❑ Green Belt/Plantation will be developed around the mining activity area and along haul roads. The plantation minimizes propagation of noise;
❑ Periodical monitoring of noise will be done.</td></tr>
<tr><td>Air blast pressure and vibration resulting from blasting at the quarry</td><td>High</td><td>Medium</td><td>❑ Possibility of use of Surface Miner shall be explored to avoid blasting.
❑ Use of down the hole initiation technique, which produces less vibration and noise;
❑ Effective burden will not be excessive and free faces will be kept long and free;</td></tr>
</table>

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ Effective stemming of the explosives is proposed to be done in the drill holes; ❑ Number of blast holes per delay are proposed to be kept minimum possible; ❑ Blast maximum possible holes towards free face; ❑ Non-electric (NONEL) system of initiation is proposed to minimize the AOP/Noise; ❑ The blasting is proposed to be carried out during favorable atmospheric condition and less human activity timings i.e. during lunch interval or during change of shifts.
3. Ecology and Bio-diversity			
Loss or disturbance of fauna species of special concern, if any due to collisions and noise disturbance	Medium	Medium	❑ Site clearing to be conducted sequentially and from one corner of the site to the other, to enable highly mobile species to leave the area; ❑ Sessile fauna, if present, at the site to be relocated by relevant ecological experts; ❑ No fauna are to be hunted or destroyed by any project personnel; ❑ An environmental education training programme to be developed and implemented, including regular refresher sessions; ❑ Effective penalties (e.g. fines) must be imposed for the hunting

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			or harm to fauna by any staff; ❑ Implementation of the EIS and EMP and Mine Closure Plan that will be developed to inform TLC's protection and management of biodiversity in the entire concession.
Introduction of alien invasive flora and fauna	Medium	Low	❑ An invasive alien species control programme to be developed and implemented as a component of the EIS and EMP, including adaptive management measures;
Increased hunting/ poaching of wildlife	Medium	Low	❑ An environmental education programme to be developed and implemented for all TLC employees, their families, and habitation within and surrounding the concession area; ❑ Effective penalties (e.g. severe fines) to be implemented for project staffs that are found to be hunting or purchasing wildlife. Current villagers that are not employed by TLC should be allowed to continue hunting as a form of livelihood, but measures to ensure such hunting is undertaken within sustainable limits should be identified with the community as a component of the EIS and EMP.
Modification or degradation of aquatic habitats due to pollution or nutrient loading	High	Medium	❑ Embankment, garland drains with de-silting pits are proposed as a part of storm water management to address storm water run-off volumes, velocity, and water quality to minimize impacts on natural areas; ❑ Impermeable surfacing to be constructed around all potential major sources of pollution such as fuel and lubricant storage facilities, vehicle servicing areas, and workshops;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ All vehicles to be serviced within the designated workshop areas or at appropriately designated off-site facilities; ❑ No discharge of treated or untreated effluent to be permitted into any wetlands;
Impeded photosynthesis and transpiration rate of plants due to dust generation	Medium	Low	❑ Dust suppression measures (e.g. water sprinkling) is proposed at all dust generation points in the quarry, haul roads, access road, waste dump site and crusher on regular basis.
4. Soil, land capability and Land use			
Chemical spills and release of contact water resulting in permanent loss of soil and change in soil characteristics, land capability and land use	Medium	Low	❑ Prepare a procedure to ensure minimization of spillage during mobile equipment maintenance; ❑ Impermeable surfacing to be constructed around fuel and lubricant storage facilities, vehicle servicing areas, and workshops; ❑ Implement emergency preparedness as per EIS and EMP.
Operational activities causing increased erosion, resulting in a permanent loss of soil resource, and change in soil characteristics, land capability and land use	Medium	Low	❑ Minimize the area of disturbance; ❑ Implement storm water control measures around infrastructure; ❑ Appropriate topsoil and reject stockpile management as per mine plan.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
5. Water Resources			
Discharge of contaminated pit water to surface water resources affecting downstream users	High	Low	❑ The pit water shall be discharged into a sediment settling tank, where sediments will be allowed to settle and the clean water shall be used in dust suppression and plantation as proposed in mine plan during conceptual stage; ❑ Garland drains with de-silting pits are proposed all around the mining pit to check the erosion and arrest of silt as a part of storm water management.
Dewatering of the quarry resulting in groundwater draw down and reduced contribution to surface water base flows and wetlands, affecting users	High	Medium	❑ Monitor groundwater levels to determine extent of dewatering impact during conceptual stage; ❑ Ensure water supply for dewatering purposes from pit water in quarry and or boreholes from cement plant to avoid impact on domestic and agricultural purposes of the communities affected; ❑ The water from the pit is proposed to be pumped to a sediment settling tank and after settling of silt, the water shall be used for dust suppression and plantation and agriculture use, if required before discharge in to the local streams; ❑ Monitor discharge water quality to ensure it is compliant with the necessary applicable guidelines.
Storm water inflows into the pit, reducing surface water flows and availability to users	High	Medium	❑ Embankment, garland drains with de-silting pits have been proposed in the mine plan around the quarry and waste dump yard areas to restrict the entry of storm water;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ The water during the rains shall be pumped out to a sediment settling tank and after settling of silt, the water shall be used first for dust suppression and plantation and agriculture use, if required before discharge in to the local streams.
Seepage from waste affecting surface and groundwater quality	Medium	Medium	❑ Embankment, garland drains with de-silting pits have been proposed in the mine plan around the quarry and waste dump yard areas to restrict the entry of storm water; ❑ Surface and groundwater monitoring and sampling as per EIS and EMP.
Wastewater effluent discharge to streams, affecting water quality for downstream users	High	Medium	❑ No waste water generation is anticipated in the quarry; ❑ The waste water generated during washing of mining machinery in the workshop will be passed through oil/grease water separator tank for separation of oil contents and also soil contents. The clear water will be used in crusher for dust suppression and plantation; ❑ The waste water generated from the mine office, will be disposed off in soak pits via septic tanks; ❑ The water to be discharged will comply with maximum concentrations of contaminants in waste water as per standard; ❑ Monitoring up-gradient and down gradient of the discharge point as per EIS and EMP.
Sinkhole formation resulting from dewatering of subsurface	High	-	❑ The limestone formation of the area is having cavities, which is a normal phenomenon of areas hosting calcareous rocks like

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
cavities, resulting in safety and structural stability risks			limestone. Chances of sink hole formation are very remote; ❑ Appropriate measures shall be addressed in Emergency Response plan.
Impact of mining on environmental surface water quality as well as other water users	High	Medium	❑ Embankment, garland drains with de-silting pits and sediment settling tank are proposed around the quarry, waste dump yard to arrest the silt and flow of clean water in the sources (Ref. Mine Plan); ❑ Divert clean water from dirty areas;
Impact of reduced run off due to mining infrastructure	Medium	Medium	❑ Embankment, garland rain with de-silting pits and sediment settling tanks are proposed to arrest the silt in the running water and not to reduce the run off; ❑ Only clean water shall be discharged from the sediment settling tank.
Impact of flooding on mining	Medium	Low	❑ Embankments are proposed outside the quarry in the areas to check flooding of the quarry.
6. Visual Impacts			
Loss of sense of place affecting local communities due to project infrastructure and illumination	Medium	Low	❑ Minimize the disturbed footprint as far as practically possible; ❑ Undertake stripping, stockpiling and stockpile management as per Mine Plan (Chapter 13); ❑ Clear vegetation at the quarry in phases so that only those areas required for immediate development are cleared; ❑ Implement the waste management as per Mine Plan;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ Implement dust control measures under para 4.2.1 Impact 3 (Air Quality) above; ❑ Use directional lighting in areas operating at night, if communities are affected by lighting.
7. Traffic			
Increased road accident rates, affecting road safety of other users	Medium	Low	❑ Within the fenced of Quarry, 2 lane main haul road of 17.0 m carriage way with 5% overall gradient has been proposed; ❑ The bench access roads shall be of 15 m width with 6.25% gradient; ❑ The roads shall be solely used by company's equipments and no outsider vehicle shall be allowed; ❑ Clear signage shall be displayed; ❑ Speed limit shall be restricted and speed retarder shall be installed in all transport equipments; ❑ All traffic rules shall be followed.
8. Socio-economic Impacts			
Influx of potential job seekers into the area and associated risks	Medium	Low	❑ Optimize the use of local labour as far as practically possible; ❑ TL Cement will continue to engage with project stakeholders identified in the EIS public consultation throughout the life of the project; ❑ Implementation of a programme of HIV/AIDS screening, counseling and (where necessary) treatment by TLC for its

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			employees; ❑ Develop and communicate a clear and concise employment and recruitment mechanism to prevent opportunistic job seekers from settling in the area
Increased chances of the spread of communicable diseases such as HIV/ AIDS, STDs and malaria linked to influx of job-seekers and workers	Low	Low	❑ Develop a comprehensive HIV/AIDS program to employees through employee wellness programme which should include the following: ● Awareness campaigns targeting project workers, senior management, contractors, sub-contractors and their spouses ● Prevention, voluntary counseling for HIV testing, as well as anti-retroviral treatment for employees; ❑ Collaborate with local health authorities and other relevant stakeholders to develop an integrated mosquito control strategy, which should include: ● Awareness campaigns to inform employees of symptoms and treatment available for workers; ● Elimination of potential breeding habitats for mosquito larvae such as pools of unusable standing water; ● Spraying residual insecticide to walls of living quarters of employees; ● Provision of prophylactic drugs to non-immune workers; ❑ Formulate health and safety measures for the employees.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Increased pressure on healthcare infrastructure due to project related influx	Medium	Low	❑ Develop a MOU with the Local Healthcare Centers in Baucau for service provision to the local workforce and their dependents; ❑ Within the overall GOTL Health Management frame work for the region, TLC to assist partially through its CSR activity, to identify NGOs in the area that might support operations, at the nearby health centers, with special focus on refurbishment of key areas, equipment and building maintenance, as well as, improved health care management information systems;
Generation of direct, indirect and induced employment and income	High	High	❑ Employment of local workers if applicants with the appropriate skills are available; ❑ Provide on-the-job and other skills training for local workers ; ❑ Procure goods and services locally, if available and cost competitive and improve opportunities through the development of local supply chain ; ❑ Work closely with the community before and during the project to identify and publicize skills and resources that the local community could provide.
Reduced availability of natural resources and ecosystem services to local communities	Low	Low	❑ Comply with GIIP for air emissions, water (storm water and effluent) discharge quality and solid waste disposal to minimize impacts on ecosystem services; ❑ Implement mitigation measures recommended above at point no. 6 (Impacts during construction) to minimize impacts on

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			ecological resources; ❑ Implement mitigation measures recommended in operation phase and in the GOTL's Resettlement Action Plan to maximize community resilience and ensure fair compensation where resources are directly affected.
9. Health and Safety Risks			
Blasting, resulting in fly rock	-	-	❑ Delineation of danger zone associated with each blast of at least 300 m and clear workers from this zone before, during the blast; ❑ An audible warning at least three minutes before a blast is fired; ❑ Blasting shelter for the blaster; ❑ Drilling parameters like over burden, depth, diameter and spacing will be properly designed to give proper blast; ❑ Appropriate charge per hole.
Community exposure to toxic or hazardous substances	-	-	❑ Hazardous substances that will be stored and used on the site include diesel, oil, coolant and hydraulic fluid for mining equipment. Impacts resulting from spills, seepage and contamination of water resources are discussed and rated under Impacts at para no. 4.2.2 point no. 5 (Water Resources) above.
Fire or explosions due to storage of explosives and use of	-	-	❑ The explosives are proposed to be stored in the area approved by the statutory authority or else the blasting operations can be outsourced to a local authorized agency;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
combustible materials			❑ The blasting shall be carried out under strict supervision and control of person as authorized by law; ❑ Standard international good practice will be followed with regard to storage and handling of fuel, hydraulic oil, coolant etc., and occupational health and safety guidelines with regard to safe working conditions and use of PPE will be adhered to; ❑ Fire extinguishers will be provided at storage areas for flammable substances, and a fire water system will be installed at plant site which will serve the quarry also.
Effect of Ammonia during blasting on air and water	High	Medium	❑ Identification of wet blast holes and Implementation of loading procedures of wet holes; ❑ Spillage to be handled properly; ❑ Blast areas must be cleared of smoke, dust and gases before anyone is permitted to enter; ❑ Use of instruments to check the oxygen level and the toxic gas concentrations in blast areas; ❑ Develop and implement explosive management practices; ❑ Evaluate and improve the level of blasting efficiency; ❑ Use water resistant explosive, as far as practicable; ❑ Monitoring of surface and ground water and air emissions

4.2.3 IMPACTS DURING DE-COMMISSIONING AND CLOSURE PHASE

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
1. Ecology and Biodiversity			
Re-establishment of habitats or creation of new habitats via rehabilitation	Medium	Medium	❑ After quarrying has been concluded, sequential reclamation and rehabilitation is proposed by backfilling of exploited pits; ❑ In case the waste dumps mature much earlier than complete exploitation of pits, then afforestation by plantation is proposed to be carried out to stabilize the dumps; ❑ The top soil stored separately during the operation phase shall be used for afforestation and plantation only. Local species shall be planted in the area; ❑ The auxiliary area hosting the crusher house building shall be dismantled. The machinery shall be sold to other industries for use or to authorized scrap dealers. The area shall be brought to its original state.
Introduction of alien invasive flora and fauna	Medium	Medium	❑ An invasive alien species control programme to be developed and implemented as a component of the EMP, including adaptive management measures; ❑ EMP should be reviewed every five years with emphasis on control of alien invasive flora and fauna; ❑ All invasive alien species control measures specified in the EMP must be implemented.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Loss or disturbance of fauna species of special concern due to collisions and noise disturbance	Medium	Medium	❑ Sequential rehabilitation to be conducted as soon as possible at the completion of operation; ❑ Reclamation and rehabilitation of the area as proposed in Mine Plan and Mine Closure plan to restore the area in natural, pre-construction condition; ❑ Environmental education training program, including refresher sessions, for all employees, contractors and their families; ❑ EMP should be reviewed every five years.
Increased hunting/ poaching of wildlife and loss of habitats for crop production	Medium	Medium	❑ No fauna are to be hunted or destroyed by any project personnel; ❑ Effective penalties (e.g. fines) must be imposed for the hunting or harm to fauna by any employee of TL Cement; ❑ An environmental education programme to be developed and implemented for all TLC employees, their families and villages within the concession.
2. Water Resources			
Chemical contamination of surface water resulting from accidental spills during transportation and handling and seepage from waste	Low	Low	❑ Emergency contaminant and mitigation measures must be developed to minimize impacts should accidental spillages occur along the transport routes; ❑ Equip all trucks and equipment carrying fuels or oil with spill response materials and train personnel in the use of such materials;

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			❑ Store all potential sources of contamination in secure facilities with appropriate Storm Water management systems in place to ensure that contaminants are not released to the water resource through Storm Water runoff.
Sedimentation of surface water resulting from erosion and runoff from exposed surfaces and roads	Low	Low	❑ Minimize disturbance of soil and vegetation; ❑ Implement rehabilitation and re-vegetation as soon as possible; ❑ Refer to dust and erosion suppression measures listed above.
Contamination of groundwater resulting from seepage from hazardous materials and waste	Low	Low	❑ Manage waste in accordance with the Environmental Management Plan; ❑ Refer to mitigation measures for Impact Water Resources above.
3. Waste Management			
Generation of debris from mine infrastructure	Medium	Low	❑ The auxiliary area hosting the crusher house building shall be dismantled. The machinery shall be sold to other industries for use or to authorized scrap dealers; ❑ The office equipments like table, chairs, computers etc. can be donated or auctioned for its use; ❑ The debris generated from dismantling of building shall be used in backfilling of exploited pits.
Generation of solid waste in the form of mining and ancillary	Medium	Low	❑ The mining and ancillary equipment shall be either sold to other industries for its use or authorized scrap dealers.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
equipments			
Management of overburden waste dump	Medium	Low	❑ The overburden and inter-burden solid waste generated during the mining operations shall be used in reclamation and rehabilitation of exploited pits by backfilling. Top soil shall be spread over the backfilled area and plantation shall be carried out to suit the natural ecology of the area in guidance of a horticulturist; ❑ The overburden waste dumps that will mature prior to exploitation of pits shall also be spread with top soil and plantation shall be carried out on the top and slopes to prevent from erosion and stabilization; ❑ An attempt shall be made to restore the quarry area into its natural position.
4. Socio-economic Impacts			
Direct impacts on project employees and their families	High	Medium	❑ Communication with internal stakeholders i.e. employees to discuss the implications of closure; ❑ Phased programme of retrenchments and retirements to ensure that the full impact of reduction in employment is spread over several years to ensure that the impact is absorbed as far as possible; ❑ Career counseling and capacity building; ❑ Development of a skills register and dissemination of the register to alternative employers, government etc.

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Loss of economic benefits to the project supply chain	High	High	❑ Early communication with stakeholders i.e. service providers including local service providers, bulk service providers and the business community to discuss the implications of closure; ❑ Liaison with other industries to discuss opportunities for service providers within their supply chain.
Loss of support to the local government and other government levels with respect to taxes and royalty incomes	High	High	❑ Timely engagement of local, regional and national government to advise of closure and the implications this will have on the government revenue from taxes and royalties; ❑ Gradual transfer/return of responsibilities to local government with respect to service provision where the project has played an active role in service provision.
Loss of community benefits in the form of project funded community development programme	High	Medium	❑ Early engagement of stakeholders to discuss and scenario plan the transfer of usable assets to the community, local government and other stakeholders; ❑ Provision of information on the maintenance and management costs of assets and typical maintenance programme; ❑ Capacity building for asset management.
Loss of Employment and Income due to retrenchment	High	Medium	❑ Develop the TLC grievance procedure to capture and address grievances arising due to retrenchments and downscaling for the employees; ❑ Compliance with IFC's Performance Standard 2 "Labour and Working Conditions"; ❑ Actively promoting the development of different economic

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
			sectors from an early stage e.g. through incentivizing other industries to locate in the area, and promoting an increase and diversity of skills in the local population; ❑ Develop a decommissioning and closure plan which is updated every five years increasing in detail as closure approaches, and actively engaging with a range of stakeholders throughout the life-of-project to discuss potential consequences of decommissioning and possible mitigation.
5. Eco-system Services			
Reduced quality of natural resources and ecosystem services to local communities due to emissions to air, water or soil	Medium	Low	❑ To minimize impacts, the project must comply with GIIP for air emissions, water (storm water and effluent) discharge quality and solid waste disposal.
6. Soils, land capacity and land use			
Remediation of contaminated soils and demolition of project infrastructure, resulting in re-establishment of baseline soil characteristics and land capability	Medium	Low	❑ The contaminated soils during de-commissioning and closure should be excavated and disposed off; ❑ Implementation of reclamation and rehabilitation of mine as per Mine Closure Plan
7. Air Quality			

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
Increase in PM_{10} and $PM_{2.5}$ emissions resulting from land clearing, earthworks and vehicular movement	Low	Low	❑ Continuous water spraying on roads used routinely by vehicles; ❑ Set speed limits to minimize the creation of fugitive dust within the project boundary; ❑ Continue with the routine air quality monitoring program; ❑ Minimize the disturbed footprint as far as practically possible; ❑ Undertake stripping, stockpiling and stockpile management as per the Mine Plan (Chapter 13); ❑ Revegetate and landscape disturbed areas as soon as possible.
8. Visual Impacts			
Dust generation and site disturbance due to earth moving and removal of infrastructure, affecting the visual character for communities	Medium	Low	❑ Minimize the disturbed footprint as far as practically possible; ❑ Undertake stripping, stockpiling and stockpile management as per Mine Plan (Chapter 13); ❑ Revegetate and landscape disturbed areas as soon as possible to reflect the surrounding topography and vegetation as much as possible; ❑ Implement the waste management as per Mine Plan and Mine Closure Plan; ❑ Implement dust control measures given above.

4.2.4 Impacts During Post Closure

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
1. Ecology and Biodiversity			
Increased hunting/ poaching of wildlife and loss of habitats for crop production	Medium	Low	❑ The locals should be encouraged to utilize the cash income, during employment for investments that will assist with increasing productivity of the local agricultural sector; ❑ An environmental education programme to be developed and implemented for all TLC employees, their families.
2. Water Resources			
Pit lake formation due to inflow of ground and surface water, resulting in safety risks to animals and humans and environmental contamination	Low	Low	❑ Backfill of the remaining open void as much as it is possible with excavated soil to minimise a pit lake formation; ❑ Restrict access (and ingestion of pit water) by animals and humans by fencing the pit.
3. Economic Impacts			
Loss of Employment and Income due to retrenchment	High	Medium	❑ Develop the TLC grievance procedure to capture and address grievances arising due to retrenchments for its employees; ❑ If practical, shift the employees to other businesses of the group company; ❑ Compliance with IFC's Performance Standard 2 "Labour and Working Conditions".

Aspect/Impact	Significance		Mitigation Measures
	Before Mitigation	After Mitigation	
4. Ecosystem Services			
Reduced quality of natural resources and ecosystem services to local communities due to contamination of water or soil	Medium	Low	❑ Comply with GIIP for air emissions, water (storm water and effluent) discharge quality and solid waste disposal.
5. Soils, land capacity and land use			
Demolition and restoration of project infrastructure, resulting in re-establishment of baseline soil characteristics and land capability	Medium	Low	❑ Infrastructure like buildings, access roads etc. having potential post mining benefit, if desired shall be handed over to stakeholders; ❑ The areas not required by stakeholders shall be decommissioned and the area will be rehabilitated by replacing soils and adding nutrients, if necessary; ❑ Rehabilitation measures for the quarry are well documented in Mine Plan and Mine Closure Plan and with demolition of infrastructure and replacement of soils, the land capability can be returned to baseline conditions.
6. Visual Impacts			
Re-establishment of baseline visual character due to rehabilitation of the site and removal of project infrastructure	Medium	Medium	❑ Landscaping and re-vegetation in accordance with the surrounding vegetation and topography ❑ Implement Mine Closure and Mine Plan

4.3 ENVIRONMENT MANAGEMENT PLAN

The Environmental Management Plan (EMP) will be used to ensure that the proposed quarry is operated with minimum environmental impact within permissible Environmental Quality Standards relating to quarries and cement plant and abiding by the Mining Code of Timor-Leste.

The total Environment Management System will comprise of the following:

- Environmental Management Plan
- Environmental Monitoring Plan
- Resources Implementation and Training Program

The Environmental Management Plan includes the protection, mitigation and environment enhancement measures to be implemented to minimize the adverse impact on the environment. The adverse environmental impacts during the operational phase of the quarry under normal operating conditions are mainly from air, water, noise, soil and solid waste.

The scheme for Environmental Management, the proposed abatement measures to minimize the likely environmental degradation that may be caused due to the mining Operations at Baucau Limestone Deposit (Block I-1) are outlined below.

Considering the scale and methodology of mining operations as discussed in the Mining Plan, no major significant environmental degradation is expected. The micro level ecosystem and socio-economic setup of the villages will also improve. Environmental control measures and techniques are discussed below to mitigate any adverse effect owing to the proposed mining activities.

4.3.1 TEMPORARY STORAGE OF OVERBURDEN SOIL AND ITS UTILIZATION

In Block I-1 within the mineral licence area, limestone is exposed on the surface with sporadic occurrences of soil. The overburden soil is reddish brown to brown in color and silty in nature. Its occurrence is only observed in relatively flat to gentle area. The thickness of top soil as encountered in boreholes varies from 1.0 m to maximum 3.8 m.

During the construction and operational phase of the quarry, the top soil will be scrapped by bulldozer or excavated by hydraulic excavator and will be transported to overburden soil waste dump yard (OBS-1), located towards northwest of the quarry between N9063640 to N9064085 and E207635 to E208260. It is estimated that about 0.85 million m^3 of top soil will be generated till conceptual stage from the quarry area. About 11.85 ha area has been earmarked for dumping and storage of top soil till conceptual stage. The area selected for waste dump yard is undulating land. The ground elevation of the proposed overburden soil dump area (OBS-1) is varying from 120 m AMSL to 99 m AMSL and the overburden soil dumping is proposed to be carried out in stages with 10 m height of each stage. Each 10 m height of the dump is sloped at the angle of its natural repose, which is likely to be around 30^o from horizontal. A berm width of 15 m is proposed to be left between each stage of dumping at conceptual stage. The OBS dump shall achieve levels of 120 m AMSL and 110 m AMSL at the conceptual stage with an average height of 5.7 m with ultimate slope of about 12°. No problem is foreseen for the stability of dump slopes during the operations and during the conceptual stage.

After closure of mine, the overburden top soil will be completely utilized for the afforestation and plantation purposes. During operation period of the mine, it is proposed to plant 50,000 samplings @1000sapling/year within the concession area. The overburden soil shall be utilized in spreading over the earmarked 55 hectare area for development of green belt during the operation period of quarry as well as over the 144.6 hectares backfilled area within the pit for afforestation during conceptual stage.

The development of vegetation covers by afforestation and plantation within the concession area during the operation and at conceptual stage will have a positive impact on the environment. It will help in

- Stabilizing slopes of backfilled area and preventing erosion
- Dust control
- Minimizing surface run off
- Reducing noise, and
- Enhancement of aesthetic value

The location of plantation proposed to be carried out is given in Environment Plan **Drg. No. 15113-05-CP-16.**

4.3.2 LAND RECLAMATION

With the available exploration data at this stage, the ultimate pit limit at depth has been considered at 90 m AMSL. The available optimized limestone reserves of 105.71 million ton will sustain the 5,000 ton per day (1.65 million ton/annum) clinkerization plant for about 50 years.

The mining boundary of 1.82 sq km has been finalized in two dimensions considering the exploration carried out in the area and 500 m safety zone of plant boundary.

The limestone of the area is following the slope of the hill and is dipping about 5° to 10° due north. The borehole drilled within the potential mining area boundary has proved the limestone mineralization depth till 93.6 m AMSL. Thus based on the exploration data, the ultimate mining limit with the present exploration data has been conceived at 90 m AMSL.

It is planned to keep the bench height of 10 m, sloped at an angle of 80° from the horizontal keeping a minimum bench width of 35 m during the period of mine operation in limestone and inter-burden. During conceptual stage, it is planned to reduce width of benches to 5 m keeping the height of 10 m in limestone and inter-burden. This will give final pit slope angle of about 56° to the horizontal as shown in ultimate pit cross sections (**Drg. No. 15113-05-CP-15a)** and is considered to give stable sides. Since the limestone of the area is hard rock and also sufficient width has been left over the benches, thus no problem is foreseen for the stability of bench slopes during the operations and during the conceptual stage. However slope stability study is proposed to be carried out, if desired for any statutory permission.

During conceptual stage, entire limestone shall be exploited in the earmarked 1.82 sq km potential mining area, thus the pit shall be reclaimed by the backfilling. During conceptual stage, out of the total 182.41 ha exploited area, about 133.6 ha area shall be backfilled with the inter-burden reject and 37.8 ha area shall be converted into water reservoir. An area of about 11.0 ha over the abandoned benches shall also be reclaimed and rehabilitated by plantation. The backfilled area shall be rehabilitated by spreading overburden soil and plantation shall be carried out. The species adapted to local environment shall be selected for plantation in the area.

4.3.3 WASTE DUMP MANAGEMENT

The inter-burden reject comprising of conglomeratic limestone, sandy limestone and part of limestone in contact of inter-burden shall be transported to the earmarked waste dumps yard (WD-1).

With presently available data, it is estimated that a total of 26.28 million m^3 of waste in the form of conglomeratic limestone, sandy limestone and part of limestone in contact with inter-burden shall be generated till the conceptual stage.

An area of 44.75 hectare has been identified towards northeast corner of mineral licence area for dumping of inter-burden reject. Based on the geology and structure of the area, the thickness of limestone within the proposed inter-burden dumping area is comparatively less than the area lying towards south of the potential mining area. In view of this fact, the mining activities are expected to be extended towards south of the existing potential mining area in future. Thus, with the available information, the presently selected site for temporary dumping of inter-burden waste seems to be ideal. Also the site selected is for temporary dumping of inter-burden reject and later entire inter-burden shall be backfilled in exploited area for reclamation and rehabilitation

The locations of various dumps have been marked on the Mine Development plans **Drg. No. 15113-05-CP-09** to **Drg. No. 15113-05-CP-13** and Conceptual plan **Drg. No. 15113-05-CP-15** and the coordinates are given in **Table 4.1.**

Dump	Northing	Easting	Total Area (in hectares)
Top Soil (OBS-1)	9063640 - 9064085	207635 - 208260	11.85
Inter-burden (WD-1)	9064055 - 9065020	208900 - 209750	44.75

Table 4.1: Location coordinates of Dump areas

The area selected for the respective waste dump yards is undulating land. The ground elevation of the proposed overburden soil dump area (OBS-1) is varying from 120 m AMSL to 99 m AMSL and the overburden soil dumping is proposed to be carried out in stages with 10 m height of each stage. The OBS dump shall achieve levels of 120 m AMSL and 110 m AMSL at the end of 20th year of operations with an average height of 5.7 m. The ground elevation of inter-burden dump area WD-1 is also varying from 230 m AMSL to 88 m AMSL and inter-burden dumping is proposed to be carried out in stages with 20 m height for each stage from 230 m AMSL to 110 m AMSL. The average height of the inter-burden waste dump at the end of 20th year of operations shall be 23.4 m.

The dumps are designed to be sloped at the angle of their natural angle of repose, which is likely to be around 30^{o} for inter-burden reject and overburden soil. A berm width of minimum 15 m is proposed to be left between each stage of dumping. The overburden soil and inter-burden dumps at the end of 20th year of operations will have an ultimate slope of about 12^{o}. The dumps are designed to be built up in almost rectangular shape and will have flat top surface. No problem is foreseen in subsidence of dumps due to stability of dump slopes during operations and during conceptual stage.

During operations, water sprinkling shall be carried out on the dump yard roads to be used for transportation of overburden soil and inter-burden reject from the quarry and over the individual dump yards as and when required to control the air pollution. In view of hilly topography of the area, garland drains with de-silting pits are proposed at the crest of the dumps, to channelize the runoff water from dumps. The de-silting pits within the garland drain shall be cleaned regularly.

At the conceptual stage, the inter-burden generated shall be simultaneously used in backfilling of the exploited area from top and the overburden soil is proposed to be spread over the backfilled area and plantation shall be carried out.

Based on the geology and structure of the area, the limestone is also extending outside the potential mining area of 1.82 sq km and it is almost certain that quarrying will take place outside the potential area within the mineral licence area in future, which will be established by additional exploration in due course of time during conceptual stage.

In view of above, the entire inter-burden reject from the temporary waste dump yard (WD-1) shall be utilized in backfilling of the exploited pit and soil shall be spread over the backfilled area and plantation shall be carried out. This will result in stable landform analogous with the surrounding topography.

4.3.4 AIR QUALITY MANAGEMENT

Both ambient air quality and meteorology will be monitored. The ambient air monitoring for PM_{10}, $PM_{2.5}$, dust fall rate, SO_2, NO_2, CO and VOC monitoring shall be carried out in the quarry and nearby locations with the start of construction activity. The monitoring shall be in line with the guidelines of in country requirements.

Meteorological parameters like wind speed, wind direction, temperature, relative humidity and rainfall shall also be recorded continuously at mine area.

The existing environmental condition of the concession area is summarized in Chapter 3 (Baseline Environment Data) of this Mine Closure Plan and in detail in EIS Report of **TLC**.

The Environment Plan showing proposed air quality monitoring stations in the mineral licence area is enclosed as **Drg. No. 15113-05-CP-16.**

The following corrective measures shall be done for prevention of air pollution to maintain it well within the prescribed limits:

- Drilling machines will be equipped with wet drilling arrangements or dust collectors;
- Rock breaker will be used for breaking over size boulders in order to reduce dust and noise generation, which otherwise will be generated due to secondary blasting;
- Optimum use of explosive energy will help in reducing the air pollution;
- Regular water sprinkling on unpaved roads, waste dump yards & proper maintenance of unpaved roads will be done;
- Water sprinkling on blasted muck pile before loading of materials, especially in dry weather conditions;
- Adequate water sprinkling in crusher hopper;
- Limit vehicle idling and proper scheduled maintenance of vehicles will be done to limit gaseous emissions;
- Setting speed limit for vehicles to minimize the fugitive dust;
- Reduced burning of bio-mass;
- Development of green belt/plantation within mineral licence area, around crusher, cement plant, jetty area to control the air pollution;
- Personal Protective Equipments (PPE) like dust masks, helmets, earplugs will be provided to all employees;
- Periodic air quality monitoring will be carried out.

4.3.5 STORM WATER AND WATER QUALITY MANAGEMENT

No perennial source of water is available within the mineral licence area. The limestone deposits are located within the hilly area and the drainage of the area is controlled by local streams. The local streams originate from the areas of higher elevation within the deposit area and flow towards the north and finally merge into the sea. These local streams get active with precipitation only.

The average annual rainfall during April'2010 to March'2014 was 1642.55 mm and 90% of it occurs from October to May. The average number of rainy days varies from 100 to 140 with an average of 125 days during the year. As per the data available from Meteorological Department for Baucau Observatory, the maximum rainfall recorded in a single day during past four years i.e. April'10 to March'14, was 203.1 mm.

In light of the above, the possibility of the inundation of the mine during initial 20 years of mine operation due to rainwater directly falling over the mining area is foreseen. During conceptual stage, a pit shall be formed and thus a sump is proposed to be created on the lowermost working bench for pumping of water. The bottom level of sump is proposed to be 5 m below the lowermost working bench working for efficient pumping operations. The hydrological study of the area is under progress and the impact of the ground water sources shall be firmed up after the study.

The chances of the water quality getting affected due to mining activity are very remote, as no chemical having toxic element will be used in carrying out mining activity. Surface water monitoring shall be carried out in local streams and ground water monitoring shall be carried out as per applicable local environmental law/guidelines, and best industry practices.

No waste water shall be generated after water spraying on benches, un-paved haul roads and waste dump yards for dust suppression. The natural ground shall absorb the water or it shall percolate through porous strata or run down or get evaporated. Only limited quantity of water used under high pressure for washing and cleaning of mining equipments in the workshop shall be collected in a separate tank. Since the specific gravity of oil and grease is less than water, thus it will float over water. The minor quantity of oil and grease floating over the water will be separated mechanically and thereafter the clean water shall be used for plantation/dust suppression. The separated oil/grease shall be sent to the plant for its disposal, which may be used as fuel in kiln.

Acid Mine Drainage (AMD) is acidic water (pH <5.0), laden with iron, sulfate and other metals, that forms under natural conditions when geologic strata containing pyrite are exposed to the atmosphere or oxidizing environments. The rock having meager quantity of iron available in the area is top soil, which contains iron in oxide form. None of the potential AMD causing materials i.e. pyrite, sulphide etc. are present in the rocks available in the area. However, petrography and detailed geo-chemical characterization study of rocks of the area shall be carried out and in case of presence of any potential AMD causing mineral, suitable mitigation measures as per below can be adopted.

- Diversion of drains
- Use of alkaline additives, pH control
- Blending of mineral waste
- Application of anionic surfactants
- Microencapsulation (coating)

In order to restrict the flow of surface water/storm water into the quarry and control erosion, environment protection measures have been considered.

Following measures are proposed in the Mine Plan to avoid flow of surface water into mining pit:

- Construction of embankment of at least 2 m height towards south of the mineable area boundary to prevent entry of surface run-off water into the working area. The embankment is proposed to be constructed from the material generated during construction of main haul road;

- It is also proposed to construct a peripheral garland drain with de-silting pits outside the embankment towards south of the mining area to channelize the surface run-off water;
- Also a garland drain with de-silting pits is proposed towards north of the potential mining area to check the flow of silt from the quarry during rains;
- A garland drain with de-silting pits is proposed at the crest of the overburden soil (OBS-1)and inter-burden waste dump (WD-1) yards to channelize the surface run-off water
- No waste water will be generated from mining operations
- No harmful effluent will be generated during mining operation which may pollute the surface or ground water;
- Septic tanks and soak pit will be provided for the disposal of effluent generated from mine office;
- Periodic checking and cleaning of embankment and garland drains before onset of rainy season.
- Periodic monitoring of surface and ground water as per local environment law/guidelines, and good industry practices.

The location of embankment and garland drain with de-silting pits is shown in yearly development plans **Drg. No. 15113-05-CP-09** to **15113-05-CP-13** and plan showing Ultimate Pit configuration (Conceptual Plan) **Drg. No. 15113-05-CP-15.**

The location of proposed water monitoring stations is shown in Environment Plan **Drg. No. 15113-05-CP-16.**

4.3.6 NOISE AND VIBRATION MANAGEMENT

4.3.6.1 Noise Management

The operation of heavy earth moving machines and allied mining operations such as transport, workshop activities etc. produces noise pollution in the mining area. The noise sources shall not generate sound levels above L_{Aeq} >70 dBA during day and night respectively as per WB/IFC guidelines for Industrial area.

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

- Drilling will be carried out with the help of sharp drill bits, which will help in reducing noise;
- Secondary blasting will be totally avoided and Hydraulic rock breaker will be used for breaking boulders;
- Blasting with proper spacing, burden, stemming and optimum charge/delay will be maintained;
- The blasting will be carried out during favorable atmospheric condition and less human activity timings i.e. during lunch interval or during change of shifts;

- Proper scheduled maintenance, oiling and greasing of machines at regular intervals will be done to reduce generation of noise;
- Adequate silencers will be provided in all the diesel engines;
- Acoustic cabin in mining machinery will protect the operator from high noise level;
- Green Belt/Plantation will be developed around the mining activity area and along haul roads. The plantation minimizes propagation of noise;
- Periodic monitoring of noise will be done as per local environmental law/guidelines and good industry practices.

4.3.6.2 Vibration Levels (Due to Blasting)

The blasting operations in the mine will be carried out by deep hole drilling and blasting using delay detonators, which will reduce the ground vibrations. Further, the ground vibrations will be controlled by using modern shock tubes with delay non-electric detonators. The use of surface miner shall be explored to avoid, drilling and blasting operations in future.

The measures that are generally followed and currently proposed for abatement of ground vibration, air blast and fly rocks are detailed below:

- Blasting will be performed strictly as per the guidelines specified under Mining Regulations;
- Proper design of blast with correct spacing, burden & optimum charge/delay. Drilling parameters like over burden, depth, diameter and spacing will be properly designed to give proper blast;
- Supervision of drilling and blasting operations to ensure blast design geometry;
- Sub-drilling will be kept just adequate to tear-off the bench bottom;
- Blasting operations will be carried out only during day time;
- Proper warning signals will be used;
- Adequate safe distance from habitation as per standards from center of blasting will be maintained;
- Effective stemming of the explosives will be done in the drill holes;
- Non- Electric detonators (NONEL) will be used for bottom initiation.

The location of proposed noise and vibration monitoring stations is shown in Environment Plan **Drg. No. 15113-05-CP-16.**

4.3.7 AFFORESTATION AND PLANTATION PROGRAMME

Afforestation / plantation will be carried out in the mineral licence area with a view to provide green belt and give an aesthetic look, for eliminating fugitive emissions and controlling impact of noise etc. Plantation will be decided and executed with active co-operation of the local community, mainly aiming at:

- Protection from fugitive emissions

- Protection from noise
- Medicinal and Energy plantations (social forestry)

A tree plantation programme and efforts to set up green belt/afforestation in the area shall form the single most important activity among the various environmental protection measures. The job of plantation shall be taken up even during the life cycle of the mine as the workings advance downwards. Leaving aside the land required for pit, haul roads, infrastructure etc., peripheral area shall be brought under plantation. Suitable mixed plantation will be taken up for landscaping purposes. Fertilizers will be sprayed to enrich the ground and hasten growth of plants. The plantation shall be carried out under the supervision and guidance of **TLC**'s horticulturist along with the advice of local forest authorities.

The tentative programme of afforestation proposed to be adopted is given in **Table 4.2.**

Year	Nature of Plantation	Area (ha)	No. of Saplings
1st Year	Green belt	1.0	1,000
2nd Year	Green Belt	1.0	1,000
3rd Year	Green Belt	1.0	1,000
4th Year	Green Belt	1.0	1,000
5th Year	Green Belt	1.0	1,000
6th to 10th Year	Green Belt	5.0	5,000
11th to 15th Year	Green Belt	5.0	5,000
16th to 20th year	Green Belt	5.0	5,000
21st year to End of Life of Mine	Green Belt/Afforestation	35.0	30,000
Total		**55.00**	**50,000**

Table 4.2: Green belt /Afforestation Programme

The area of green belt and afforestation is shown in Environment Plan **Drg. No. 15113-05-CP-16.**

4.4 ENVIRONMENT MONITORING PLAN

An impact assessment study comprises of two main phases:

- Assessment of the present situation with regards to environmental problems;
- Prediction of the impact of future development and/or alteration in the operation and design of existing installation.

Usually, as in the case of the study, an impact assessment study is carried over a short period of time and the data cannot bring out all variations induced by natural or human activities. Therefore, regular monitoring program of environmental parameters is essential to take into account the changes in the environment. The objective of monitoring is:

- To verify the result of the impact assessment study;
- To follow the trend of parameters which have been identified as critical;
- To check or assess the efficiency of the controlling measures;
- To ensure that new parameters, other than those identified in the impact assessment study do not become critical during construction and operation or through the modification in the operation of existing facilities;
- To check assumptions made with regard to the development and to detect deviations in order to initiate necessary measures;
- To establish a database for future Impact Assessment studies.

The attributes, which merit regular monitoring, are specified below.

- Air Quality
- Water and Waste water Quality
- Noise Levels
- Soil Quality
- Vibration Levels
- Greenbelt development

The proposed environment monitoring plan is given in **Table 4.3.**

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
CONSTRUCTION					
WATER: Drinking Water quality	Conductivity, pH, turbidity, calcium, magnesium, sodium nitrate and nitrite, potassium, zinc, fluoride, chloride, arsenic, total hardness, iron, manganese, oil and grease, COD and BOD_5, Faecal Coliform, Total Coliform bacteria and free residual chlorine	Point of use (tap that is regularly used in site office)	One sample on **weekly** basis, Sample bottles must be sterilized for the coliform samples. Free chlorine, pH and electrical conductivity must be measured on site Calcium and Magnesium samples to be taken in borosilicate glass bottles	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Water: Surface Water Quality	Temperature, oil and grease, BOD5, acute toxicity, pH, Suspended solids, arsenic, copper, total cyanide, iron, lead, mercury, nickel, zinc and total petroleum hydro-carbons Additionally: Total chrome, nitrate and nitrite (measured as N) and total phosphate(PO_4) and measured as (P) alkalinity	Local Streams	**Monthly** pH and electrical conductivity must be measured on site Calcium and Magnesium samples to be taken in borosilicate glass bottles If not using a commercially purchased pre-acidified container for the dissolved metals in water, filtered metals in water samples should be preserved. Holding time for acid preserved samples is six months except for mercury	TLC	National Directorate of Mineral Resources, /National Directorate of Environment

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
			which is 28 days. After collecting the sample and adding the preservative, the container must be placed back in a plastic bag for shipping.		
Water: Surface Water	Flow rate in m^3/s	Up and down gradient of the quarry area in local streams	**Daily**	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
WATER: Groundwater Quality	Temperature, oil and grease, pH, arsenic, copper, iron, manganese, lead, mercury, nickel, zinc, and total petroleum, calcium, magnesium, sodium, potassium, aluminium, chromium, cadmium, cobalt, sulphate, phosphate, chloride, nitrate and fluoride. Full analysis for first year and thereafter reduce the number of metals depending on the results of first year analysis.	Up and down gradient of the quarry area.	**Half Yearly**	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Water: Ground Water	Flow rate in m3/s	Up and down gradient of the	Boreholes to be equipped with flow meters	TLC	National Directorate of Mineral

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
		quarry area.			Resources, /National Directorate of Environment
Ecology: Rehabilitation of disturbed habitats (including forest and aquatic habitats)	As per monitoring parameters to be determined in Rehabilitation and Restoration Plan (e.g. % vegetative cover, vertical structure of vegetation, plant health, richness and abundance of indicator species, type and extent of erosion, present and extent of invasive alien plants).	All borrow pits, degraded and temporarily disturbed land not occupied by permanent infrastructure	Throughout construction period	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Ecology: Rehabilitation of spoil areas	Rehabilitation of spoil and topsoil deposited sites or backfill sites	All concerned areas	Throughout construction period	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Waste Management	Ensure waste is disposed of according to Internationally accepted good practices Keep record of all waste and materials	All the points/sites of waste generation	Throughout construction period	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Air Quality	PM10, PM2.5, CO, NOx,	All emission	Continuous monitoring for	TLC	National

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
	SO2, O3	locations within construction area	PM_{10} and $PM_{2.5}$ Quarterly monitoring for other parameters		Directorate of Mineral Resources, /National Directorate of Environment
Noise: Ambient Noise	LAeq (A-weighted equivalent continuous sound pressure level) Monitor daytime and night-time levels focusing on worst case levels expected at night Log noise in 10-minute averaging intervals (LAeq, 10 min)	Construction area and nearby habitation area	Monitoring survey covering at least **one 24-hour period per month**	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Noise: Blasting	L Pk (Linear peak sound pressure level) produced by air-blast	Nearby habitation village- monitoring equipment to be set up at nearest receptor location. Review and as necessary, move monitoring location in accordance with blast locations.	As per blast frequency, capture all planned blast events	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Soil	Soil quality	Quarry and all points of area disturbed	Annually	TLC	National Directorate of Mineral Resources,

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
					/National Directorate of Environment
Traffic	Monitoring road worthiness of all vehicles (TLC, contractors and sub-contractors) entering or leaving the site. Monitor speed limits on all mine related traffic.	At site access control point. Random points on haul and access roads	**Daily** (random inspections of a portion of vehicles). Continuous	TLC	-
OPERATION					
WATER: Drinking Water quality	Conductivity, pH, turbidity, calcium, magnesium, sodium nitrate and nitrite, potassium, zinc, fluoride, chloride, arsenic, total hardness, iron, manganese, oil and grease, COD and BOD_5, Faecal Coliform, Total Coliform bacteria and free residual chlorine	Point of use (tap that is regularly used in Mine office)	Monthly after commissioning of water treatment plant, Sample bottles must be sterilized for the coliform samples. Free chlorine, pH and electrical conductivity must be measured on site. Calcium and Magnesium samples to be taken in borosilicate glass bottles	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Water: Surface Water Quality	Temperature, oil and grease, BOD5, acute toxicity, pH, Suspended solids, arsenic, copper, total cyanide, iron, lead, mercury, nickel, zinc and total petroleum hydro-carbons	Local Streams	**Monthly** pH and electrical conductivity must be measured on site Calcium and Magnesium samples to be taken in borosilicate glass bottles	TLC	National Directorate of Mineral Resources, /National Directorate of Environment

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
	Additionally: Total chrome, nitrate and nitrite (measured as N) and total phosphate(PO_4) and measured as (P) alkalinity		If not using a commercially purchased pre-acidified container for the dissolved metals in water, filtered metals in water samples should be preserved. Holding time for acid preserved samples is six months except for mercury which is 28 days. After collecting the sample and adding the preservative, the container must be placed back in a plastic bag for shipping.		
WATER: Surface Water Flow	Flow rate in m^3/s	Local Streams	**Daily**	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
WATER: Groundwater Quality	Temperature, oil and grease, pH, arsenic, copper, iron, manganese, lead, mercury, nickel, zinc, and total petroleum, calcium, magnesium, sodium, potassium, aluminium, chromium, cadmium, cobalt,	Up and down gradient of the quarry area.	**Half Yearly** pH and electrical conductivity must be measured on site Calcium and Magnesium samples to be taken in borosilicate glass bottles	TLC	National Directorate of Mineral Resources, /National Directorate of Environment

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
	sulphate, phosphate, chloride, nitrate and fluoride. Full analysis for first year and thereafter reduce the number of metals depending on the results of first year analysis.		If not using a commercially purchased pre-acidified container for the dissolved metals in water, filtered metals in water samples should be preserved. Holding time for acid preserved samples is six months except for mercury which is 28 days. After collecting the sample and adding the preservative, the container must be placed back in a plastic bag for shipping.		
Water: Ground Water Quality	Flow rate in m^3/s	Up and down gradient of the quarry area.	Boreholes to be equipped with flow meters	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Air Quality	TSP, PM_{10}, $PM_{2.5}$ CO, NOx, SO_2, O_3	Quarry, Waste dump yard, Mine Office	Monthly	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Noise: Ambient Noise	L_{Aeq} (A-weighted equivalent	Loading point in	Monitoring survey covering	TLC	National

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
	continuous sound pressure level) Monitor daytime and night-time levels focusing on worst case levels expected at night Log noise in 10-minute averaging intervals (L_{Aeq}, 10 min)	quarry, Crusher area,	at least **one 24-hour period per month**		Directorate of Mineral Resources, /National Directorate of Environment
Noise: Blasting	L Pk (Linear peak sound pressure level) produced by air-blast	Nearby habitation village- monitoring equipment to be set up at nearest receptor location. Review and as necessary, move monitoring location in accordance with blast locations	**As per blast frequency**, to capture all blast events over a period of one month. If levels recorded in one-month survey are below acceptable 120 dB limit, repeat survey (for one month duration) every six month. If levels recorded in any one month survey exceed acceptable limit, continue survey to capture and monitor all blast.	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Waste Management	Required TLC Regulations	Ensure that all waste is duly collected, segregated and disposed of according to legal requirements of the country	Regular in connection with environmental and safety requirements	TLC	National Directorate of Mineral Resources, /National Directorate of Environment

Environment Component	Monitoring parameters	Monitoring Point	Monitoring Frequency	Implementing Agency	Regulatory Body
		Keep records of the solid wastes disposed.			
Soils	Soil quality	Quarry and all points of area disturbed	Annually	TLC	National Directorate of Mineral Resources, /National Directorate of Environment
Traffic	Monitoring road worthiness of all vehicles	At site access control point.	**Daily** (random inspections of a portion of vehicles).	TLC	-

Table 4.3: Environment Monitoring Plan

The plan showing location of proposed environment monitoring stations is enclosed as **Drg. No. 15113-05-CP-16.**

Chapter – 5
Mine Closure Plan

CHAPTER - 5

MINE CLOSURE PLAN

The Mine Closure Plan (MCP) has been prepared considering a number of interrelated components i.e. legal and other obligations, closure objectives, environmental and social considerations, technical mine design criteria, closure assumptions and relinquishment conditions. The combination of these aspects provide the key considerations used in the development of the plan.

5.1 REGULATORY FRAMEWORK

5.1.1 LOCAL LEGISLATION

The legislation is contained in Draft Mining Code for Democratic Republic of Timor-Leste under Chapter V – Environmental Regime specifically in Articles 69 to 81. These articles describe the general provisions of environmental licensing, environmental assessment and protection of environment which includes mitigation required during operations and closure of site including Environmental Bond i.e. financial guarantee to ensure payment of the costs of rehabilitation and removal from site at closure of the Mineral Operations. In addition, the Draft Mining Code also covers the Health and Safety, Labour Regime, Employment of Expatriates and Training of National Citizens.

5.1.2 EHS GUIDELINE – MINING

In addition to the local legislation, international good practice guidelines that apply include the Equator Principles (III) and the IFC/World Bank Group's Policies and Performance Standards on Social and Environmental Sustainability.

A whole series of EHS guidelines has been developed for different industrial sectors, with guidance given that is specific to that sector. However, the General EHS Guidelines contain information on cross-cutting environmental, health and safety issues potentially applicable to all industry sectors.

Closure requirements are specified in the Mining Sector guideline, and outline the requirements for the preparation of a Mine Closure Plan (MCP) in draft form prior to the start of production. The EHS guidelines also recommend that both physical rehabilitation and socio-economic considerations should be an integral part of the project life cycle and should be designed so that:

- Future public health and safety are not compromised;
- The after-use of the site is beneficial and sustainable to the affected communities in the long term;
- Adverse socio-economic impacts are minimized and socio-economic benefits are maximized.

5.2 VISION FOR CLOSURE

The vision for closure is

- To ensure a self-sustaining vegetative cover on areas disturbed by mining activities where this is appropriate;
- To provide sustainable end land uses in keeping with the needs of local communities;
- To ensure economic sustainability for affected communities.

5.3 OBJECTIVES

The primary objective of the reclamation plan will be to return, where practical, all areas disturbed by mining operations to acceptable land use and capability.

The closure objectives for the mining operations are:

- Adhere to all statutory and other legal requirements;
- Ensure safety & health of all stakeholders during closure and post closure and that communities using the site after closure are not exposed to unacceptable risks;
- Ensure that closure supports productive uses considering pre-mining conditions and are in agreement with commitments to and requirements of stakeholders;
- Physically and chemically stabilize remaining structures, if required, to minimize residual risks;
- Promote bio-diversity and biological sustainability; and
- Utilize closure strategies that promote a self-sustaining condition with little or no need for on-going care and maintenance.

5.4 POST CLOSURE LAND USE

The decision regarding specific post closure land use will be addressed in updated closure plan in future after discussion with various internal and external stakeholders including local government, municipality, local communities and other stakeholders as identified.

With the available exploration data for the explored area of 1.82 sq km within the mineral licence area of 5.76 sq km (Block I-1) at this stage, the ultimate pit limit at depth has been considered at 90 m AMSL. The available optimized limestone reserves of 105.71 million ton shall sustain the 5,000 ton per day (1.65 million ton/annum) clinkerization plant for about 50 years.

The limestone of the area is exposed on the surface with sporadic occurrences of soil in the area. The limestone and associated rock formation in the area are horizontal to gently dipping and shows undulating structure attributable to depositional environment. The limestone of the area is following the slope of the hill and is dipping about 5^o to 10^o due north. The borehole drilled within the potential mining area boundary has proved the limestone mineralization depth till 93.6 m AMSL. Thus based on the exploration data, the ultimate mining limit with the present exploration data has been conceived at 90 m AMSL

As per the mine plan, the overburden soil and the inter-burden reject comprising of conglomeratic limestone, sandy limestone and limestone in contact with the inter-burden generated during mine operations shall be stacked in the temporary waste dump yards. The top soil shall be exclusively utilized for afforestation and plantation while the inter-burden reject shall be used in reclamation of exploited pit by way of backfilling and later soil shall be spread over it and plantation shall be carried out. Also a part of the pit area shall be converted into water reservoir.

The dumps yards of overburden soil and inter-burden reject shall be of temporary nature and thus reclamation and rehabilitation of the dump yards is not applicable. However, the material in dump yards shall be stacked temporarily keeping in mind their angle of repose to maintain the stability of the dumps. The overburden soil shall be used in afforestation and plantation in the area. The detailed action plan is discussed in subsequent paragraphs.

With the available data, the anticipated land use of the quarry area during operations stage and at the end of life of mine is given in **Table 5.1.**

Out of the total 5.76 sq km mineral licence area (Block I-1), a total of 302.57 hectare land will be utilized during the life time of the quarry and with the presently available data; about 98.4% (297.7 ha) area shall be reclaimed and rehabilitated up to the conceptual stage. A total of 258.7 hectare area shall be reclaimed and rehabilitated by afforestation and plantation, 37.8 hectare by water reservoir. Thus post-mining, the land used will be equivalent or better the existing land use of the area.

The final land use as given in **Table 5.1** will be influenced with the proposed detailed exploration in mine plan and generation of more data in the area and also may be due to any regional and socio-economic developments. Thus the changes shall be addressed in subsequent reviews of the Closure Plan and finally before the end of life of mine.

S.No.	Area Head	Area disturbed in mining operations (in hectares)							Area reclaimed & rehabilitated (in hectare)	Remarks
		End of 1st Year	End of 5th year	End of 10th year	End of 15th year	End of 20th year	End of life of mine*	Total		
1	Quarry (Pit)	16.30	68.45	86.64	97.55	109.82	182.41	182.41	**182.41**	Backfilling and Afforestation (133.61 hectare), Afforestation over bench slope (11.0 hectare) and Water reservoir (37.8 hectare)
2	Storage for Top soil	3.18	6.61	10.09	11.85	11.85	11.85	11.85	**11.85**	Top soil to be used in plantation. Area to be covered by soil and Afforestation
3	Overburden/ Inter-burden Dump	2.07	11.07	25.71	42.49	44.75	44.75	44.75	**44.75**	Entire stacked material to be used in backfilling of exploited pit and then cover the area by soil and plantation.
4	Mineral storage	0.50	0.50	0.50	0.50	0.50	0.50	0.50	**0.50**	Cover by soil and Afforestation.
5	Infrastructure (Mine Office, workshop etc.)	1.20	1.20	1.20	1.20	1.20	1.20	1.20	**1.20**	To be refurbished & handed over to local community for use.
6	Roads (Quarry area)	11.80	9.53	9.03	7.38	6.83	4.16	4.16	**1.49**	Part of the haul road from crusher to quarry and waste dump yard roads to be scarified and Afforestation.
7	Crusher	0.50	0.50	0.50	0.50	0.50	0.50	0.50	**0.50**	Dismantle, dispose, backfill area and Afforestation
8	Green belt	1.00	5.00	10.00	15.00	20.00	55.00	55.00	**55.00**	
9	Others#	1.80	1.80	1.80	1.80	1.80	2.20	2.20	**Nil**	Environment protection structures will be utilized.
	Total	**38.35**	**104.66**	**145.47**	**178.27**	**197.25**	**302.57**	**302.57**	**297.70**	

 # - Includes area for environment protection measures like embankment, garland drains with de-silting pits and sediment settling tank.

** - With the available data, the Life of mine is 50 years.*

Table 5.1: Land use in Mining Operations

5.5 CLOSURE ACTIONS

The closure strategy will be to undertake closure activities that will result in a stable landform, consistent with the post closure land use.

5.5.1 SOILS

A total of 0.85 million m^3 of overburden soil is estimated to be generated during initial development and regular mining operation till the end of life of mine in the potential mining area of 1.82 sq km. The soil after scrapping with bulldozer is proposed to be transported after loading by hydraulic excavator/wheel loader to the earmarked overburden soil waste dump yard (OBS-1) located towards northwest of the quarry between N9063640 to N9064085 and E207635 to E208260. The total area earmarked for top soil dumping is 11.85 hectares. The ground elevation of the proposed OBS dump area (OBS-1) is varying from 120 m AMSL to 99 m AMSL and the overburden soil dumping is proposed to be carried out in two stages with 10 m height of each stage. The OBS dump shall achieve 120 m and 110 m AMSL top level at conceptual stage with an average height of 5.73 m. The top soil shall be used in afforestation and plantation during the operation of mines and the remaining soil at the conceptual stage shall be used in spreading over the backfilled area for plantation.

A soil remediation program will also be implemented to ensure that contaminated soils are treated/disposed/re-mediated in-situ progressively through the life of mine, in consultation with the authorities if required, to meet the requirements of the final land use plan, without unduly negatively impacting on the health of surrounding communities or impacting on local ecology, thereby ensuring that the soils do not become a secondary source of contamination to other environmental media.

Specific activities that will be undertaken will include:

- **TLC** shall undertake soil investigations after an accident or incident or at mine decommissioning to characterize the nature of possible contaminants and formulate a site specific soil remediation strategy. **TLC** shall identify appropriate risk based guideline levels against which to assess contamination.

- If contamination is primarily hydrocarbon with soil concentrations exceeding an appropriate risk based guideline, the following will be undertaken:

  - Volumes less than 100 m^3 - On site bio-remediation will be undertaken by collecting the affected soils and transporting them to a dedicated bio-remediation facility.

  - Volumes greater than 100 m^3 – Alternative measures will be investigated which could include disposal at a waste site, micro-encapsulation etc.;

- If contamination is primarily inorganic, a risk based approach will be adopted in determining final soil remediation technology adopted. Options available at present include:

  - Isolation by installation of physical barrier or techniques such as micro-encapsulation;

  - Immobilization by either pH or redox adjustment;

  - Extraction through enhancing solubility and then extracting contaminated solution;

  - Removal and disposal at a suitable alternative site,

- Where risk based assessment indicates that residual contamination is unlikely to present an unacceptable human or ecological risk, contaminated soils will be covered with sufficient fresh soil to provide a suitable plant growth medium and vegetation will be established.

5.5.2 DEMOLITION OF INFRASTRUCTURE

A part of the cement plant premises and the crusher are lying with in the boundary of mineral licence area of Block I-1. It is proposed to refurbish the existing infrastructure like mine office, workshop, stores and other office buildings within the mineral licence area for use of local community at the closure. However, it shall be finalized after consultation with all stakeholders before the closure.

Prior to closure, a water management approach will be undertaken to identify which structures are required at closure and which can be decommissioned. Ditches decommissioned will be closed by backfilling the excavations with the material removed and placed adjacent to the structures, during construction. Embankments not required will be flattened by redistributing the material across the footprint used to borrow the material for construction.

The following will be undertaken for infrastructure, where permission will not be obtained from the statutory body, to leave the buildings for the socio-economic development of the region and where a suitable third party has not been identified for the transference of liability of the structure. This includes infrastructure such as access roads, workshops, offices stores or any other buildings;

- Mining equipment and other machinery with potential resale or scrap value will be removed.

- Remaining equipment will be drained of all lubricants, hydraulic oils, fuels and other process reagents and disposed of as hazardous waste.

- Buildings to be demolished and rubble to be placed into the base of the quarry. Specific demolition requirements include:

- All power and water services to be disconnected and certified as safe prior to commencement of any demolition works;
- All fittings, fixtures and equipment within buildings will be dismantled and removed to designated temporary disposal yards;
- All above ground electrical, water and other service infrastructure and equipment to be removed and placed in disposal pits or the designated temporary salvage yards;
- All pipes and structures deeper than 400 mm need to be sealed to prevent possible ingress and ponding of water;
- All concrete below 400 mm depth will remain underground with the invert of all structures broken/sealed to prevent possible ingress and ponding of water;
- All subsurface cavities such as reinforced concrete tunnels under septic tanks will be backfilled;
- All water tanks not required for closure activity will be demolished and rubble placed at the base of the quarry. Once water is no longer required on site, the remaining tanks will also be demolished.

The yard areas (e.g. platforms created for buildings) will be closed and regraded to control storm water runoff and erosion. The natural topography of the site required the construction of terraces for the working areas using cut or cut-and-fill techniques. Once the structures and foundations are demolished, removed, or buried, the areas will be inspected for any areas of hydrocarbon contamination. Any hydrocarbon contaminated soils will be managed as described above. The yard areas will then be partially regraded to fill in any excavations remaining following the demolition activities utilizing material in berms and highwalls of terraces. Compacted areas will be ripped to mitigate the effects of traffic. Top soil shall be spread over the areas and plantation shall be carried out.

5.5.3 ROADS

Prior to decommissioning and closure, it shall be discussed with all stakeholders including the authorities, government and local community regarding the roads to be required for use and roads to be demolished. In this plan, a part of the road from crusher to the quarry pit has been considered for demolition. Any roads, which will no longer be required, will be rehabilitated by **TLC** as described below:

- Culverts and ducts will be removed where they are no longer required;
- The natural water flow will be restored and any disturbed section of the watercourse will be stabilized and revegetated;

- The road surface, shoulders and embankments will be graded to a slope suitable to prevent erosion. Cuttings will be assessed and where necessary, measures to improve safety and erosion stability measure will be applied.
- Rehabilitated surfaces will be vegetated with a mixture of indigenous species.

5.5.4 QUARRY

The available optimized limestone reserves of 105.71 million ton within the potential mining area of 1.82 sq km in the mineral licence area of Block I-1 shall sustain the 5,000 ton per day (1.65 million ton/annum) clinkerization plant for about 50 years.

The limestone of the area is following the slope of the hill and is dipping about 5^o to 10^o due north. The mining boundary in two dimensions on the surface is guided by mineralization of limestone in the area based on the exploration carried out in the area and which is free from all mining constraints and is economically mineable. The borehole drilled within the potential mining area boundary has proved the limestone mineralization depth till 93.6 m AMSL. Thus based on the exploration data, the ultimate mining limit with the present exploration data has been conceived at 90 m AMSL. Further exploration shall be carried out in remaining unexplored area of Block I-1 in future and the existing benches can be extended accordingly.

Since entire optimized limestone shall be exploited within the potential mining area of 1.82 sq km, thus at this stage of preparation of mine closure plan, a part of the potential mining area shall be reclaimed and rehabilitated by backfilling of inter-burden reject and part area has been considered as storage for water. Fencing is proposed outside the water storage area at conceptual stage to stop inadvertent access and signage will be displayed outside the fencing.

It is planned to keep the bench height of 10 m, sloped at an angle of 80^o from the horizontal keeping a minimum bench width of 35 m during the period of mine operation in limestone and inter-burden. During conceptual stage, it is planned to reduce width of benches to 5 m keeping the height of 10 m in limestone and inter-burden. This will give final pit slope angle of about 56^o to the horizontal as shown in ultimate pit cross sections (**Drg. No. 15113-05-CP-15a)** and is considered to give stable sides. The limestone of the area is hard rock and also sufficient width has been left over the benches, thus no problem is foreseen for the stability of bench slopes during the operations and during the conceptual stage. However slope stability study is proposed to be carried out, if desired for any statutory permission.

The overburden soil generated during the mining operations shall be transported to the overburden soil dump area (OBS-1) and part of it shall also be utilized simultaneously for afforestation purposes during operations. The inter-burden reject which includes conglomeratic limestone, sandy limestone and part of limestone in contact with inter-burden shall be transported to the earmarked waste dumps yard (WD-1). During 21st year and onwards of mine operations, the inter-burden reject shall be used in backfilling over the top benches simultaneously. During conceptual stage entire inter-burden reject stacked in the temporary waste dump yard (WD-1) shall be utilized in reclamation of quarry by backfilling. Further soil shall be spread over the backfilled area and plantation shall be carried out.

With presently available data and mine plan prepared, a part of the quarry area (about 37.8 ha) will fill up with water decanting from rainfall and surface runoff within the quarry. The pit has been considered to be filled up with water maximum up to 126 m AMSL. A spillway is proposed to be constructed towards north of the quarry and will be connected to garland drain for overflow at 126 m AMSL. The benches above 130 m AMSL shall be reclaimed by plantation. The cumulative effect of these inputs is likely to result in the quarry filling to a decant level. The quality of the mixed water in the quarry has not yet been determined and will be the subject of characterization work as the closure plan develops.

There is a risk that the quarry may be attractive as a water source. It is unlikely that it will be possible to prevent access to the users, however the risks associated with inadvertent access will be managed by fencing outside the mining pit or construction of access control embankments.

Closure actions for the quarry will include:

- An engineered spillway will be constructed at an appropriate position to safely convey decant, which may occur as a result of the various water inputs, to the adjacent garland drain which in turn is connected with the nearby stream.
- Inadvertent access to the quarry will be limited by the carrying out fencing around the mining pit or construction of embankment. The embankment will be:
- Constructed from inter-burden reject with a final crest height of 2 m with a crest width of 1m;
- Side slopes that don't exceed 1V:3H;
- Located outside of the quarry break back zone or a minimum of 15 m from the crest, whichever is the greatest;
- Sufficient slope has been considered for the mining benches according to their natural angle of repose and the slope failure on the quarry walls is remote. In case of slope failure, particularly in top benches having overburden soil at places, it may pose a potential risk to people and animals accessing the pits after closure. However, inadvertent access will be restricted by carrying out fencing outside the pit area or by construction of the embankment outside the zone of instability.

5.5.5 OVERBURDEN AND INTER-BURDEN DUMPS

In Block I-1, limestone is exposed on the surface with sporadic occurrences of soil. The overburden soil is reddish brown to brown in color and silty in nature. Its occurrence is only observed in relatively flat to gentle area. The thickness of top soil as encountered in boreholes varies from 1.0 m to 3.8 m.

The mineral licence area is having two bands of limestone. The top band of limestone is exposed on the surface while the lower band of limestone is overlain by bands of conglomeratic limestone and sandy limestone and is overlain by bottom clay. The inter-burden reject comprises of conglomeratic limestone and sandy limestone, which are qualitatively not suitable for use in cement manufacturing due to their high free silica content.

With presently available data, it is estimated that a total of 27.13 million m^3 of waste in the form of top soil (0.85 million m^3) and inter-burden reject (26.28 million m^3) shall be generated till the conceptual stage. Entire top soil shall be utilized only in afforestation and plantation in the area. An area of 11.85 hectare has been identified towards northwest of the quarry for temporary dumping of overburden soil and about 44.75 hectare area towards northeast of the mineral licence area for temporary dumping of inter-burden rejects. The sites have been chosen on the following parameters:

- The overburden soil dumping area lies within the 500 m safety zone of cement plant and no mining activities are proposed to be carried out in the safety zone even in future. The overburden soil shall be dumped in this area temporarily and later it shall be used for afforestation and plantation purposes.

- Based on the geology and structure of the area, the thickness of limestone within the proposed inter-burden dumping area is comparatively less in comparison to the area lying towards south of the potential mining area. In view of this fact, the mining activities are expected to be extended towards south of the existing potential mining area in future. Thus, with the available information, the presently selected site for temporary dumping of inter-burden waste seems to be ideal. Also the site selected is for temporary dumping of inter-burden reject and later entire inter-burden shall be backfilled in exploited area for reclamation and rehabilitation.

The locations of dumps have been marked on the Development plans **Drg. No. 15113-05-CP-08** to **Drg. No. 15113-05-CP-13** and Ultimate Pit Configuration (Conceptual plan) **Drg. No. 15113-05-CP-15** and the coordinates are given in **Table 5.2.**

Dump	Northing	Easting	Total Area (ha)
Overburden Soil (OBS-1)	9063640 - 9064085	207635 - 208260	11.85
Inter-burden (WD-1)	9064055 - 9065020	208900 - 209750	44.75

Table 5.2: Location coordinates of Dump areas

The area selected for the respective waste dump yards is undulating land. The ground elevation of the proposed overburden soil dump area (OBS-1) is varying from 120 m AMSL to 99 m AMSL and the overburden soil dumping is proposed to be carried out in stages with 10 m height of each stage. The OBS dump shall achieve levels of 120 m AMSL and 110 m AMSL at the end of 20th year of operations. The ground elevation of inter-burden dump area WD-1 is also varying from 230 m AMSL to 88 m AMSL and inter-burden dumping is proposed to be carried out in stages with 20 m height for each stage from 230 m AMSL to 110 m AMSL. The height of the dumps is not above the surrounding topography of the area. The dumps are proposed to be built up in almost rectangular shape, shall have flat top.

The dumps are designed to be sloped at the angle of their natural angle of repose, which is likely to be around 30^{o} for inter-burden reject and overburden soil. A berm width of minimum 15 m is proposed to be left between each stage of dumping. The overburden soil and inter-burden dumps at the end of 20th year of operations will have an ultimate slope of about 12^{o}. The dumps are designed to be built up in almost rectangular shape and will have flat top surface. No problem is foreseen in subsidence of dumps due to stability of dump slopes during operations and during conceptual stage.

While dumping of waste in the designated area, water sprinkling shall be carried out over the waste dump yard road and over the dumps to control the air pollution as and when required. Garland drains with de-silting pits are proposed at the toe and crest of the dumps, to channelize the runoff water from dumps. In order to prevent siltation of surface water sources, the garland drains are having siltation pits to arrest the silt and allow flow of clean water only.

The closure activities at the temporary overburden and inter-burden dumps will include loading and transport of inter-burden reject to the quarry for backfilling over the top benches and up to 130 m AMSL and then overburden soil shall be spread over it and plantation shall be carried out. The temporary dump yard area after complete removal of material shall attain its natural condition as it was prior to dumping. Plantation shall be carried out in the temporary waste dump areas during mine closure.

The closure actions over the backfilled area will include:

- Slopes steeper than angle of repose of the material being dumped will be reshaped at or less that the angle of repose.
- Growth medium consisting of top soil will be placed to form an average of 300 mm of cover on the backfilled area;
- Vegetation will be established on the growth medium.

5.5.6 SANITARY FACILITIES

At the commencement of closure activities all sanitary facilities will be decommissioned as follows:

- Septic tanks will be emptied and the sludge used as soil ameliorants where needed on reclaimed land;
- The tanks will be removed and disposed of;
- The excavation will be backfilled and the drain field will remain in-situ;
- Civil infrastructure will then be decommissioned as described above at 5.5.2.

5.5.7 FUEL STORAGE AND DISPENSING

The fuel storage shall be common for cement plant and quarry and is proposed to be located in the plant or jetty premises. The fuel (diesel) shall be carried in a fuel bowser (mounted on a truck chassis) to the quarry for fueling of mining and ancillary machineries. The fuel bowser is proposed to maintained and utilized as per conditions imposed by the licensing authority. Although the main stores will be inside the plant boundary, a mini store may function in the quarry for storage of oils and grease required for the mining equipments.

A portion of the fuel inventory will be used during closure. Thus, near the end of the closure period, after the primary earthwork is complete, the fuel bowser and storage facilities in the quarry like mini store will be decommissioned

The closure of these facilities will focus on physical closure and investigation of potential subsurface contamination from petroleum products. The closure of these facilities will include:

- Removing remaining fuel inventory;
- Removing equipments;
- Sampling soils beneath and surrounding the facility i.e. quarry, crusher and parking areas;
- Classifying and removing any contaminated soils identified and treating them on site to acceptable standards or to a licensed facility if hazardous;
- Re-grading the footprints in line with adjacent yard footprints.

5.5.8 WASTE MANAGEMENT

- During closure, hazardous and non-hazardous waste will be managed in accordance with the procedures established during operation for the management of these types of waste.
- Building rubble will be placed at the base of the quarry and covered by a minimum of 2 m of overburden to limit access to the waste by the local communities. This overburden will then be rehabilitated as done for the overburden waste dump as described in 5.5.5 above.

The Mine Closure Plan for Bucoli limestone deposit showing the actions taken at the closure is enclosed as **Drg. No. 15113-05-CP-17.**

5.6 CARE AND MAINTENANCE DURING TEMPORARY DISCONTINUANCE

When the mine is temporarily discontinued due to any unforeseen circumstances, the following care and maintenance shall be carried out.

- The regulatory bodies will be informed about the reason and expected period of discontinuance.
- The mine employees shall be paid as per the rules laid in the regulation.
- The mining pit area shall be covered by temporary fencing.
- All access roads/ openings to the pit/ face shall be closed by a temporary fencing.
- Warning shall be displayed on the "Notice Board" at appropriate places.
- Security personnel shall be posted at every danger point.
- No unauthorized person shall be allowed to enter into the mine without prior permission of the management.
- All men and machinery shall be withdrawn from the mine and shall be kept in a compact and safe place.
- All safety precautions shall be taken care of as per rule and regulations.

5.7 RELINQUISHMENT CRITERIA

It is necessary to have measurable criteria to assess the effectiveness of the action plan and its implementation. The following criteria will assist **TLC** in identifying when the standard of closure achieved is sufficient to relinquish responsibility for a specific area. The site specific relinquishment criteria for mine are given in **Table 5.3**.

These criteria relate mainly to the biophysical environment and do not at this stage include employee benefit or alternate livelihood criteria. Further relinquishment criteria will be developed prior to final closure of the mine once additional studies and consultations are completed. Also included in the table are the indicators required to demonstrate achievement with the relinquishment criteria and the reporting requirements. The reporting requirements are those that are expected to fulfill the monitoring requirements set out by legislation.

Category	Closure Criteria	Indicators	Reporting Requirements
Ground & Surface Water	Compliance with the in country or IFC EHS Mining Guideline	Downstream water quality monitoring	Monitoring report
Air	Compliance with the in country or WHO Air Quality guidelines as contained in IFC EHS General Guideline	Records of air quality measurements for PM_{10} and $PM_{2.5}$	Monitoring report
Soil quality	Soil quality that does not present an unacceptable residual risk	Soil quality in areas where contamination identified	Results of soil quality and risk assessment
Land productivity	Land capability and productivity similar to that which existed prior to mining	Land capability and productivity	❑ Comparison to analogue areas and pre-mining aerial photographs ❑ Socio-economic survey
Erosion	Implementation or construction of erosion control measures	❑ Engineered structures to control water flow ❑ Natural angle of repose ❑ Establishment of vegetation	❑ Evidence in rehabilitation report that required structures are in place and functioning ❑ Monitoring report
Safety/stability	The site is safe for use by humans and animals, including in the foreseeable future	Geo-technical and hydrological studies of existing structures - outer batter slopes of backfilled area & pit stability	Evidence in rehabilitation report that appropriate risk assessment has been undertaken and control measures are in place
Vegetation	Establishment of self-sustaining vegetation population which stabilizes soils and is not invasive to the region.	Species cover and composition	Monitoring report

Table 5.3: Relinquishment Criteria

5.8 DATA GAPS

Some technical studies are required to improve the information available for closure planning, which ultimately reduces the residual risks associated with the operation. These include:

- Detailed exploration of the balance concession area of Block I-1 to establish the reserves in proved category and economic ultimate pit limit at depth.
- Detailed Hydrological study
- Slope stability study of quarry and for dump yards;
- Long term erosion modeling on the waste dump yards;
- Closure materials characterization including the development of materials balance;
- Vegetation Management;
- Integration of the biophysical plan with the social closure requirements, which includes stakeholder engagement;
- Predictive closure water balance

5.9 POST CLOSURE MONITORING AND MAINTENANCE

“Completion of Production” is the time when the mine has closed down and **TLC** has decided that mine decommissioning should start. Based on the available data, the life of the explored area of 1.82 sq km within the 5.6 sq km Block I-1 area is 50 years and with additional exploration the life of the mine shall further increase substantially for the proposed capacity cement plant.

The post-closure period will begin after complete exploitation of limestone from Block I-1 and will continue over the long term. The major post-closure activities will include:

- Inspection and maintenance of geo-technical structures – Yearly Inspection and if required, maintenance of embankments, garland drains with de-silting pits etc.
- Reclamation monitoring – Yearly monitoring of areas of reclamation.
- Air quality - The operational monitoring network will be rationalized to monitor potential post closure impacts with dust samples being collected routinely from strategic positions;
- Surface Water quality – Strategic water sample position will be identified and samples collected on monthly basis. Analysis to include both chemical as well as suspended load measurements;
- Ground Water - Groundwater levels in boreholes as well as in-pit will be recorded quarterly. Groundwater samples will be collected and analyzed for a suite of chemical parameters;

- Vegetation/Soil – Quarterly visual inspections to be undertaken in re-vegetated areas to assess vegetation establishment and provide early detection of erosion. Suitable plots within each area will be identified where quantitative ecological monitoring can be undertaken.

It is likely that more extensive monitoring in terms of both frequency and sampling location will be undertaken during the closure period. Once closure activities are completed and the operation enters the post-closure phase, it is likely that the monitoring requirements will be revised to include only the key components where further data is required to establish that relinquishment objectives have been achieved.

Reports will be prepared to document the results of the monitoring during the closure and post-closure phases. These reports will provide important information required to manage the on-going closure activities, with the data and reports being used to:

- Provide recommendations for improving subsequent reclamation activities, if required;
- Indicate where reclamation and closure activities have been successful or require some changes in design criteria;
- Provide information about care and maintenance requirements during the post-closure period; and
- Indicate if relinquishment criteria have been achieved.

5.10 ASSUMPTIONS FOR CLOSURE COSTING

The liability assessment can be carried out based on available information including environmental data in EIS, EMP and the Mine plan. Some of the information currently available is preliminary, therefore, assumptions are being considered about general conditions and closure and rehabilitation of the facilities at the quarry in order to estimate the proposed closure liability. The assumptions shall be reviewed and revised as appropriate with generation and collection of more information during the operations of the quarry. The assumptions considered for the assessment are provided below:

- Third party use of mine infrastructure after refurbishment at closure like access roads, office and workshop building etc.;
- Soil with the appropriate geo-chemical and geo-technical characteristics will be available to utilize as growth medium on the exposed footprint, following demolition;
- It is evident from the available exploration data that limestone shall be exploited further to the north, south and west of the potential mining area in future. Thus the existing benches shall be merged with the new benches to be formed outside the potential mining area. Since the potential mining area shall be completely exploited, thus shall be reclaimed by backfilling of

inter-burden rejects and plantation shall be carried out. The slopes of the backfilled area within the pit shall be constructed at its angle of repose and thus would be stable and will not pose any risk. Slope stability study shall be carried out if desired and if, required, slopes will be reshaped for soil spreading and plantation

- The only closure activity in the quarry will be the removal of all mobile equipment and the construction of an embankment and fencing to limit inadvertent access to the workings to the existing pit;

- The materials disposed in the temporary waste dump yards includes overburden soil and inter-burden comprising of conglomeratic limestone, sandy limestone and limestone in contact with inter-burden. The geo-chemical characteristics of these materials indicate that it does not contain any toxic effluents and no leachate is associated with these rocks.

- Entire inter-burden reject shall be backfilled in the exploited pit and overburden soil shall be spread over it and plantation shall be carried out. Thus the area occupied by these temporary dumps will be in its natural state and if with additional exploration this area is not required under mining of limestone economically in future, soil shall be spread over this area and plantation shall be carried out.

- Sufficient erosion control measures like embankment and garland drains with de-silting pits have been constructed around mining area; dump yards during the operations phase as proposed. These structures would be strengthened utilizing cement to sustain for longer periods. Only manpower cost associated for strengthening can be assumed as cement collected from spillage in the captive cement plant will be used, which shall have zero value.

- The quarry area shall be properly fenced and signage shall be placed.

- Mining equipment procurement planning is proposed to be done in a way that all the mining equipments available at the time of closure will be having zero salvage value.

5.11 FINANCIAL ASSURANCE (CLOSURE LIABILITY)

As per the Article 81 of Draft Mining Code, financial guarantee will be provided either in the form of insurance policy, unconditional and irrevocable bank guarantee or deposit in a bank account opened solely for that purpose with a credit institution duly registered and licensed to operate in Timor-Leste, in favor of the member of Government responsible for the mineral resources sector.

The amount of the Environmental Bond will be defined and set forth in the Environmental License by the Government of Timor-Leste, taking into consideration the specific nature and environmental classification of the activities proposed to be carried out, the respective environmental risks, and the cost estimates for the rehabilitation and removal of the site and accordingly the amount estimated for the closure shall be submitted to National Directorate of Minerals by **TLC**.

Presently the Mine Closure Plan has been prepared based on the available exploration data for 1.82 sq km area within Block I-1 (total area 5.76 sq km) and considering mining upto 90 m AMSL for 50 year of mine life.

Based on the geology, structure of the area and exploration proposed to be carried out during the operations phase of the quarry with inflow of more data, the economical ultimate pit limit on the surface and at depth within the mineral licence area of Block I-1 shall be finalized before the presently considered conceptual stage.

The Closure Plan will be reviewed at regular intervals. Since the life of the estimated quarry is 50 years with presently available data, thus a review at every 10 years would ensure that closure plan is reviewed minimum 5 times during the present life of the mine. Any change to or new development associated with the mine as it is currently proposed, would automatically trigger a revision of the Closure Plan and its budget to ensure that sufficient funds are available to cover any additional costs.

Thus the Closure Plan will be reviewed regularly and this will include an assessment of costs and of the adequacy of the rehabilitation fund. This fund will be accrued according to the requirements Mining Regulations.

Annexures

Annexure 1.1

RECOGNIZED QUALIFIED PERSON CERTIFICATE

Names of Sh. K.V. Kher & Sh. Adesh Mishra deleted & following two names have been added.
1. Shri Sandeep Taneja
2. Shri Pradeep Singh

25/3/05
खान नियंत्रक (उत्तर)
CONTROLLER OF MINES (NORTH)
भारतीय खान ब्यूरो
INDIAN BUREAU OF MINES

Renewed /नवीनीकृत up to 01/02/2012

15/2/12
क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

सत्यमेव जयते

CERTIFICATE OF RECOGNITION AS QUALIFIED PERSON TO PREPARE MINING PLANS

(Under Rule 22 (c) of Mineral Concession Rules 1960)

M/s HOLTEC CONSULTING ~~ENGINEERS~~ PRIVATE LIMITED *having registered office at* 45/49 COMMUNITY CENTRE, NARAINA PHASE-I, NEW DELHI, *and having given satisfactory evidence of the qualifications and experience of their key persons is hereby granted recognition under Rule 22 (c) of the Mineral Concession Rules 1960 as a Qualified Person to prepare Mining Plans.*

The registration number is RQP/DDN/009/88/B

This recognition is valid for a period of two years ending JANUARY- 1990

Signature of Authorized Signatory.

28/2/12
खान नियंत्रक (उत्तर)
Controller of Mines (North)
भारतीय खान ब्यूरो
Indian Bureau of Mines

Place: DEHRADUN.

Date: 2-2-1988

Regional Controller of Mines
Indian Bureau of Mines
DEHRADUN.

भारत सरकार भारतीय खान ब्यूरो
सत्यमेव जयते
Indian Bureau of Mines

Renewed /नवीनीकृत up to January -1992

10/4/90
क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

01 फरवरी 2022 तक के लिए नवीनीकृत
Renewed up to 1st Feb.2022

Renewed/नवीनीकृत up to 1-2-1994

28/2/12
खान नियंत्रक (उत्तर)
Controller of Mines (North)
भारतीय खान ब्यूरो
Indian Bureau of Mines

क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

S.No.	Name of Key Person	Qualification
1.	Shri K.K. Misra	M. Sc. (Geology)
~~2.~~	~~Shri P.K. Srivastava~~	~~B. Sc. (Hon) Mining Eng.~~
~~3.~~	~~Sh. Biprajit Chakravarity~~	~~B. Tech. (Mining Eng.)~~
~~4~~ 2	~~Sh. P.D. Chaudhari~~ Deleted on 10/9/2021	~~(Mining)~~
~~5~~ 3	Sh. S. S. Rawat	M.Sc. (Geology).
	~~Sh. Sandeep Biswas~~	~~M.Sc. App. Geology~~
4.	Sh. Anand Kumar Jain	M.Sc. (Geology)

* Name added at the time of first renewal.

24/6/96

Renewed/नवीनीकृत up to 1-2-1996

* Name included on 1/11/2000

क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

Renewed/नवीनीकृत up to 1-2-1998

The following 3 names added on 20/11/2003

~~4. Shri K.V. Khar~~ Deleted as per request

5. Dr. Puneet Nigam

~~6. Shri Adish Mishra~~ Deleted as per request

क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

20/11/03
क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

Renewed up to 1-2-2000

15.5.98

खान नियंत्रक (उत्तर)
Controller of Mines (N)
भा.खा.ब्यू खान ब्यूरो
Indian Bureau of Mines

दि. 28.2.2012 को निम्नलिखित व्यक्तियों को मुख्य व्यक्ति (key person) के रूप में मान्यता प्रदान की गई।
1. श्री एस.एस. रावत
2. श्री ए.के. जैन
3. डा. पुनीत निगम
4. श्री संदीप तनेजा
5. श्री प्रदीप सिंह

Renewed/नवीनीकृत up to 1/2/2002

28/2/12
खान नियंत्रक (उत्तर)
Controller of Mines (North)
भारतीय खान ब्यूरो
Indian Bureau of Mines

क्षेत्रीय खान नियंत्रक
Regional Controller of Mines
भारतीय खान ब्यूरो
Indian Bureau of Mines

Annexure 2.1

MINERAL LICENCE

DEMOCRATIC REPUBLIC OF TIMOR-LESTE
MINISTRY OF PETROLEUM AND MINERAL RESOURCES

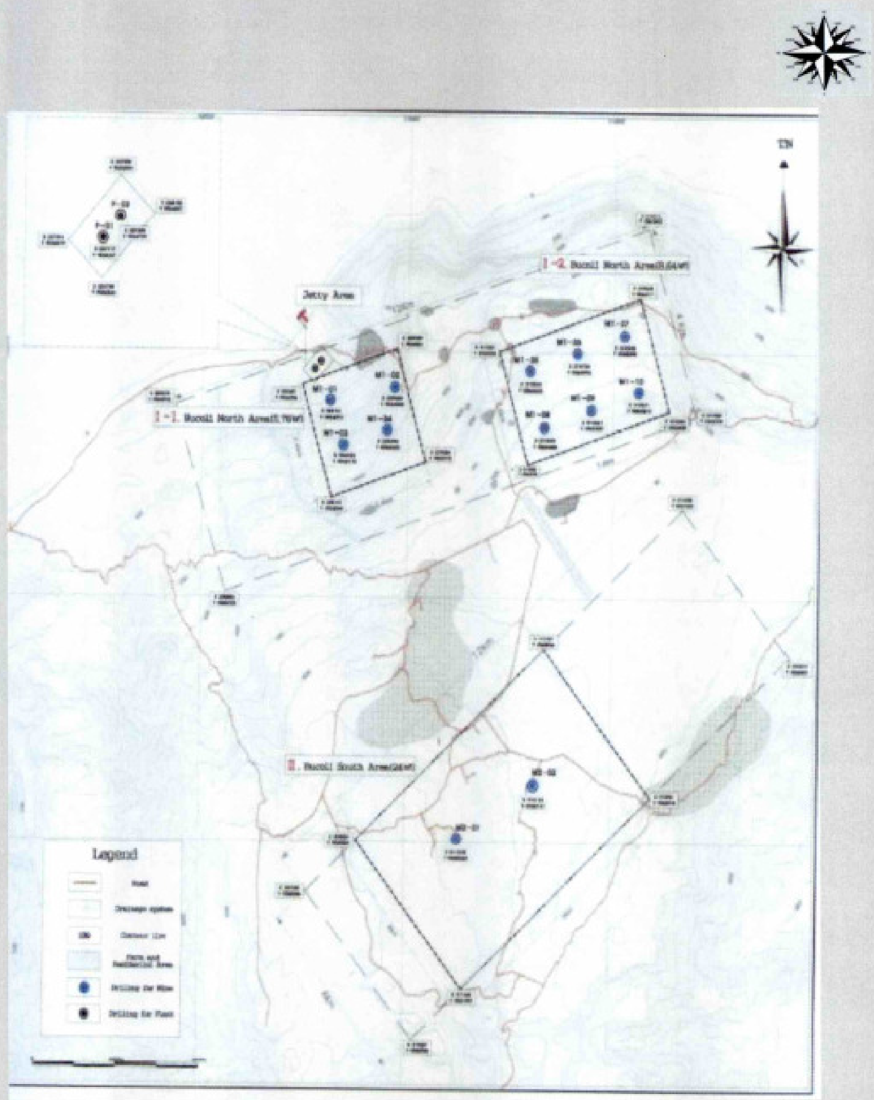
MINERAL LICENSE

No. 1/2014

COMPANY / INDIVIDUAL IDENTIFICATION		
Name or Company Designation: TL Cement, LDA		
Voter Registration No. / Registration No. 1184223A/MCIA/I/2014	Share Capital: USD 100,000	
Taxpayer Identification No.: 1184223		
Representative: James Rhee		
Address: Rua Complexo Ramelau, Aimutin, Comoro, Dom Aleixo, Dili		
District: Dili	Sub-District: Dom Aleixo	Suco: Comoro Aldeia:
Telephone: 3311206	E-mail: james@tlcement.net	

LICENSE TYPE Please check where applicable	
☒ New ☐ Renewal	Duration: 12 (twelve) months
☐ Small Scale ☒ Large Scale	Fee amount and periodicity: USD 1,000 (one-time payment)
Construction Minerals covered: Limestone	
Special conditions, duties or limits of the License: Prospecting Activities only. The use of explosives is not allowed. Company must prove it has taken out adequate insurance to cover the risks arising from prospecting activities, and provide the additional documents/information listed in the application form within 30 days.	

MAP



Geographic reference:

Please refer to DNTP plant No. 410-69/II/2014 attached

Description of the Area covered by the Mineral License:

Suco Tirilolo, Bahu, Caibada, Triloca, Bucoli, Wailili, Fatumaca

Sub Distrito Baucau, Vemasse, Venilale, Distrito Baucau

Signature of ~~Legal~~ Representative	To be completed by NDNR
	Fees paid: USD 1,000
	Receipt No. 01/MPRM-NDMR/2014
Signature:	Signature of the individual in charge
Place: Dili Date: 26/02/2014	Alfredo Pires

HOLTEC Consulting Private Limited

‘**Holtec Centre**’
A Block, Sushant Lok,
Gurgaon - 122 001, Haryana, India
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Naraina Vihar, New Delhi-110028
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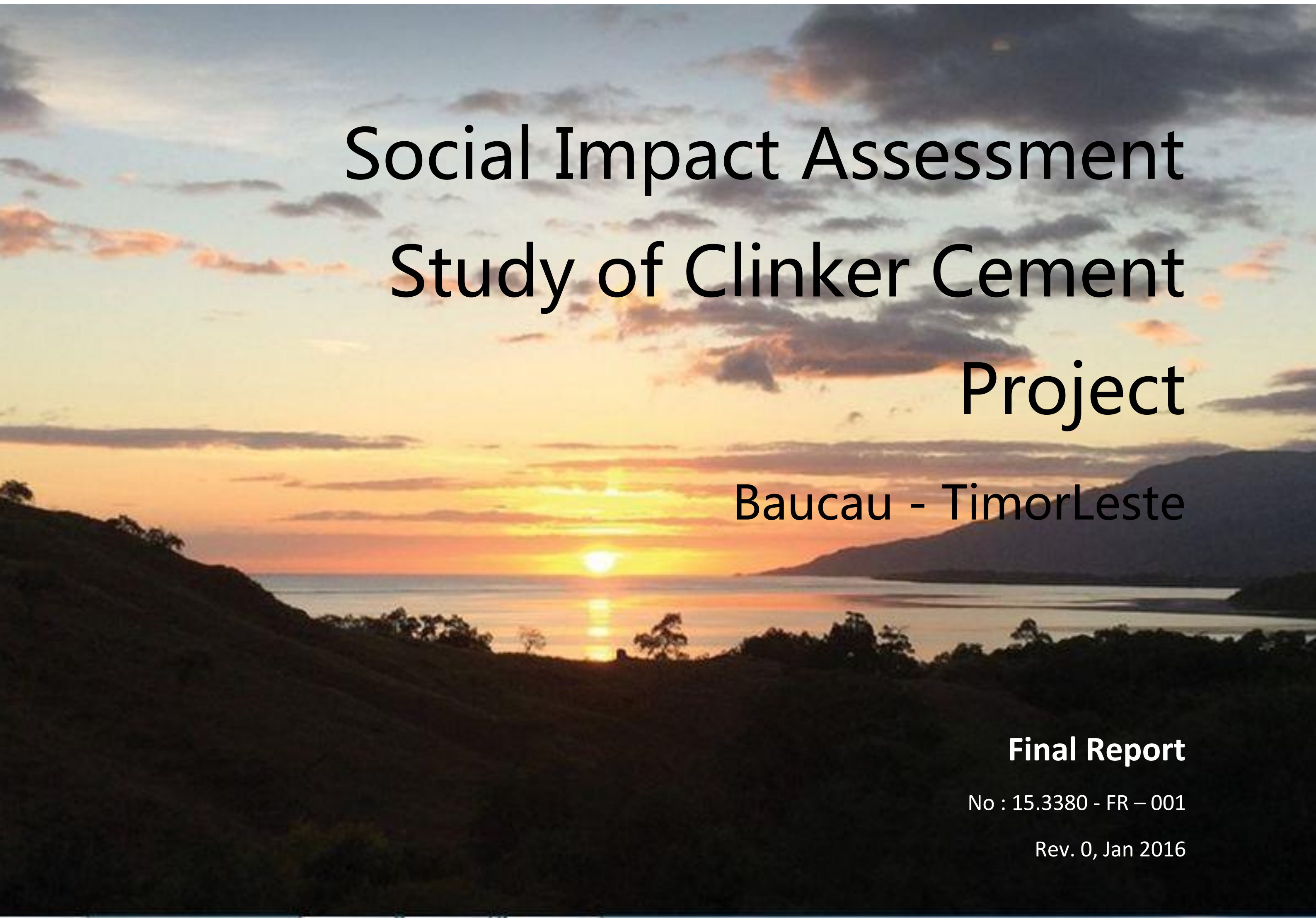
Email : info@holtecnet.com; Web : www.holtecnet.com

Appendix 8 Social Impact Assessment Study

TL CEMENT Lda.



Social Impact Assessment Study of Clinker Cement Project

Baucau - TimorLeste

Final Report

No : 15.3380 - FR – 001

Rev. 0, Jan 2016

Prepared by:

PT. BITA BINA SEMESTA

CONTENTS

EXECUTIVE SUMMARY

The clinker cement factory plan is located in Suco Tirilolo, Baucau Subdistrict and Suco Vemasse, Vemasse Subdistrict; both sucos are located within the Baucau District.

This project would have to acquire land for the mine and plant sites, a jetty, and a hauling road in Aldeia Osso-Ua, Suco Tirilolo, as well as for a clay area in the Aldeia Wailacama, Suco Vemasse.

Socio-Cultural Baseline

The Wailacama region was historically situated within Suco Ostico's customary territory. During the Indonesian occupation, the Aldeia was administratively moved into Suco Vemasse. However, this change in administrative status did not change Wailacama's customary status with respect to its original region. The population of the Wailacama Aldeia was 15 households at the time of the administrative move, which has grown to 27 households at present. These households are regarded as the 'native residents' of their customary territory since their baptismal surnames mark them as custodians of the customary area. This baptismal surname identity (as the custodians of the local customary area) plays a very important part in defining their social, economic, and political rights and responsibilities as residents of the customary territory.

Apart from these 'native' households, there are also 44 'immigrant' households that live with their woman-receiving lineages. As women-givers, they have the right to demand a livelihood from the respective woman-receiving lineage; but, as 'non-native' groups in the Ostico customary area, they have no rights of possession over the resources in the customary area (suco), except for the resources granted to them by their women-receiving lineages. These households have no right in decisions about various issues in the Aldeia or Suco where they live.

The Ostico settlers in Wailacama used to rely on rice cultivation in their original habitations. Now, the lack of water resources has prompted them to move to non-farming sectors.

In the Wailacama aldeia, the heads of the 16 migrant households from Ostico work as either drivers (10) or merchants (6). Others who still have some kin relationship to the women receiver of the Wailacama natives (44 households) work as firewood collectors in Ostico forests.

Unlike the clay extraction site, the mine and plant sites and the jetty are located in Aldeia Osso-ua, suco Tirilolo. Suco Trilolo generally consists of two principal regions: an 'urban' area made up of two Aldeia, and the 'rural' Caisido area with 4 Aldeia (Parlemento, Caisido, Lialaileso, and Osso-ua).

Although the 'rural' areas are no more than 4 to 7 km away from Baucau City, they have experienced a profound physical, socio-economic, and political isolation throughout the Portuguese era, the Indonesian occupation, and all the way into the independence period. The last 5 years saw the establishment of a dirt road leading from the main road to the Aldeia Osso-Ua along with the construction of public facilities such as clean water distribution networks, electricity grids, and health and educational facilities. The prolonged isolation, the lack of attention from external authorities, and the adverse soil and weather situation have led the Caisido communities to construct their social and cultural organizations in a distinctly 'rural' or 'parochial' manner, as described by Appdurai : '…. *place imprudence through the interaction of social relation, expression of identity and the practice of Culture*'.

With reference to these facts, the analysis of the social and economic impacts from the plans to build a clinker cement factory in the Caisido region would be based upon the results of ethnographic research.

The analysis of social impacts is focused upon the Caisido community since this area would see the largest extent of land acquisition, population resettlement, and road construction activities that may lead to the growth of local transportation enterprises, increased noise levels, and the concentration of industrial activities. In this way, the impacts and their characteristics – extent and magnitude, direct or indirect, accumulation, reversible or irreversible, manageable or unmanageable – would be related to and affected by the characteristics of the Caisido community.

The population of nearby sucos would inevitably react to the project's impacts, especially the creation of employment opportunities outside the traditional sector. Therefore, the impact analysis would include potential impacts to the population of other sucos within the same subdistrict.

Suco Tirilolo is one of the three oldest sucos in the Baucau Subdistrict. The Tirilolo residents were originally immigrants from the Waiweko region. Their ethnic identity is generally displayed through the baptismal surnames of Da Costa, Belo dan Flores. Most residents identify with these baptismal surnames as their tribal identity. However, it would be more anthropologically accurate to view these baptismal names as signifiers of customary territorial identity. The use of certain baptismal names (Da Costa and Belo) as identities for the entire population of the Caisido territorial community originated with the names of the leaders of the traditional elites acknowledged by the Portuguese colonial administration. Anthropologically speaking, these surnames were intended to flatten out the traditional social hierarchy and organisation that prevailed among the local population at the time. This constructed identity has lasted into the modern age through its use to signify the residential identity of the population of local sucos.

From the anthropological viewpoint, the use of the same baptismal surnames (or only a few surnames) for the entire population of a suco has both positive and negative consequences. On the plus side, all individual residents have the same status in terms of resource possession and political rights, and 'foreign' parties (not bearing the same surname) can be strictly limited in their ability to exploit the resources within the customary territory. This territorial demarcation can be seen as way to manage the environmental carrying capacity through customary means.

On the negative side, individuals and households are rendered unable to develop their livelihoods outside their customary territories. This limitation is one of the factors that have shaped the Caisido residents' subsistence situation in establishing their livelihoods for the sake of mutual survival.

Another negative consequence is the lack of a leadership structure that can represent the entire population. Most present residents in Caisido are third-generation settlers who can no longer identify the direct descendants of the first Belo immigrants in the region. Leadership usually falls upon the oldest male member in the household who can trace descents to a recognisable ancestor (lineage). The lineage group identifies with a particular customary/traditional ritual house (*rumah adat*). The identity centred upon the customary house makes up the basic structure of Caisido's traditional community.

Customary houses are usually built together in a centralised location in each Aldeia. However, ceremonies are performed separately in each customary house by the corresponding lineage. The lack of joint ceremonies held by multiple lineages in one customary house indicates that there are no traditional figures seen as the most prominent elder among all lineages.

A number of customary houses in Osso-ua stand apart from the main cluster of customary houses in the hamlet. The local residents offer no explanation for this separation. It is possible that these segregated customary houses originally belonged to the families of lepers. Osso-ua was historically designated as a leper colony for the entirety of Timor Leste in 1945. However, curative services were only provided by the Church from 1988 onwards. Administrative records in Suco Tirilolo show that there are only 2 remaining leprosy patients in the area.

No sites or artifacts of historical significance have been discovered at the mine and plant sites or the future jetty, with the exception of some graves and customary houses. Customary houses are used to affirm and symbolize the identity of lineage groups, while graves are meant not only as body disposal sites but also '....to remove the souls of the dead from the living world and fit them firmly into the sacrewd word of the afterlife, and to serve the living members of the lineage. These living members benefit from the tie they form to the sacred world (through the intermediation of the spirits of the dead) and the ability to find closure that allows them to return to the normal rhythm of day-to-day life'.

The population of Suco Tirilolo is 6441, approximately 2% of the Baucau Subdistrict's total population (37613). Its population growth rate over the last five years is 18%, while the growth rates among other sucos in the subdistrict vary from 0.3% to 28%. The total population of the Caisido region (the Project Site) is 2387 or 38% of the Suco Tirilolo population (6441).

There are 532 households with Osso-ua having 123 households or 23% of the total in Caisido. The average size of households is 5 people.

The total number of men and women of productive age in the Caisido region is 1225. The number of productive-age males in the Caisido region is 613, or approximately 18% of the total number of productive-age males in Suco Tirilolo (3364).

The population of the Baucau Subdistrict is 37613, spread among 7523 households. This means that the average household has approximately 5 people in it. Number of male productive age is 8811 or 23% of total Baucau Subdistrict population.

Most heads of households and their wives work for their families' livelihoods, but relatively few other members of the family are gainfully employed.

According to the family card records, 34 – 56% of the heads of households in the 'urban' areas (Tirilolo) work in the traditional (agricultural) sector, while the remaining 44 – 66% work in non-agricultural sectors. There are 17 – 20 occupations listed, with schoolteachers, private sector employees, police officers, merchants, drivers, and public servants being the most prominent. Most wives tend to be stay-at-home housewives (38 – 81%), but a number work in the traditional farming sector (3 – 45%), and even in non-traditional sectors (17 – 18%). There are 9 – 11 kinds of occupations open to such women, the most prominent being schoolteachers, public servants, and public functionaries.

Among the children, 8 – 10% of boys and 2 – 6% of girls are employed. Most (92-98%) are still at school. The most common occupation, both for working age for boys and girls, is that of private sector employees. There are 6 – 9 other occupations found among these children.

In rural (Caisido) communities, 69 – 95% are heads of households and 70 – 95% are wives working in the traditional (agricultural) sector. The rest work in non-agricultural sectors. There are 2 – 11 kinds of occupations recorded among the heads of households with the most important being drivers, private sector employees, merchants, brick makers, and public servants. Meanwhile, the most common occupation among the women is as merchants/traders. There are 1 – 2 other occupations such as teachers and public servants.

Their children, consisting of 14 – 38 working age and 15 – 40 girls, also work mostly in the traditional (agricultural) sector. Not many kinds of occupations outside the traditional sector have been successfully developed whether for boys or for girls (2 – 6 types in each case), some of the most important being merchants, drivers (for boys), public servants, teachers, and NGOs.

The tabulation of the data from Tirilolo shows that employment opportunities in urban areas are more diverse than those in rural areas. In rural regions, traditional (agricultural) occupations still dominate, both for wives and their children. The most common employment opportunities are as public functionaries, merchants, private sector employees, teachers, and public servants. This picture is likely to hold for other sucos in the Baucau and Vemasse Subdistricts.

The Caisido region has a number of vulnerable groups including disabled people, widows, and infants; they number 540 people or 22% of the total Caisido population. These vulnerable groups (except the infants) are eligible for a government allowance of 30/month/person. This amount is enough to buy three 25-kg sacks of rice.

The remaining vulnerable group – the 370 infants (15% of the total population) in Caisido – are likely potential to be affected by project activities. The local medical clinic's record of visits and health complaints show the following data:

From the opening of the clinic (2011) to the present (first three months of 2015), nearly the entire Caisido population has visited the clinic; the total number of visits is 108% – 144% of the Caisido population. The proportion of people with actual diseases or medical complaints is 56% - 98% of all visitors.

Patients came from all age groups. Among children under 1 year old who visited in 2011 – 2015, 9%-13% had actual medical complaints; so did 16% - 26% of the visitors aged 1 – 4 years, 4% - 19% of visitors aged 5 – 14, and 54 – 67% of visitors aged 15 years and above. This seems to indicate an increasing incidence of disease as people age. The number of medical complaints from infants under 1 year old is relatively low. As children enter the 1-4 years age bracket, the number of medical complaints begins to increase. The next age bracket (5 – 14 years) sees further reduction. In the final age bracket (15 years and over), the predominant complaints are those of old age; the large number of anemia, rheumatism, bronchitis, and gratitis cases hints that the local people's physical condition tend to deteriorate as they enter advanced age.

The most common types of diseases among all age groups are the big three (Upper Respiratory Tract Infections/URI/*ISPA*), other skin diseases, and other diseases not classified in the table before. There is an increased incidence of diarhea among children 1 – 4 years old. This may be due to difficulties with the weaning process. Similarly, the prevalence of URI can be attributed to the dry and dusty environment. Another observation is the prevalence of diseases and disorders associated with dehydration due to the limited supply of clean water.

Data from the 2010 census gives a general breakdown of education levels among people aged 5 and up, but it does not give a clear picture of the level of education for every single family members.

Data from family card records in Suco Tirilolo is used to develop a better picture of the educational status within local families. The degree of education found in this suco is deemed fairly representative of other sucos in Baucau sub district.

Recent data for the two *aldeia* in Tirilolo's urban segment (Baucau sub district) shows that 6% - 9% of the heads of local households had junior highschool education, compared to 11% - 14% of housewives. 27% - 31% of the heads of households had senior highschool education, and so did 37% - 39% of their wives; 11% - 15% of the heads of households and 11% - 16% of wives had college diplomas or university edcucation. Among the younger segments of the population, 10% - 23% of boys and 12% - 16% of girls had junior highschool education; 19% - 24% of boys and 22% of girls had senior highschool education; and 9% - 12% of boys and 8% - 10% of girls had college/university-level education.

Meanwhile, the general picture of education in the four inland (Caisido) *aldeia* of Tirilolo is: 10% - 20% of boys and 12% - 21% of girls had junior highschool education; 5% - 17% of boys and 12% - 25% of girls had senior highschool education; and 13% - 31% of boys and 13% - 24% of girls had bachelors' degrees.

Therefore, the level education throughout the family (father/head of household, mother, son, and daughter), both in urban areas (Lutumutu and Betulale *Aldeia*) and in rural ones (Caisido: Caisido, Parlemento, Lialaileso, and Osso-Ua) has seen a considerable improvement.

Caisido residents recognize 4 types of land utilization patterns, namely forests, rice fields, gardens/orchards, and bush. The forests in the Osso-ua hamlet are mostly secondary forests and are regarded as government land. The local residents harvest wood from these forests for firewood and construction materials. Some rice fields are found in the Osso-ua hamlet, mostly dry fields that depend on rain for watering the crop. The rice field plots are generally quite small except for those on the clay extraction site in the Wailacama, Ostico, and Vemasse hamlets. The scarcity of water and labor means that these rice fields are not cultivated in a particularly intensive or extensive manner.

The bush in Caisido largely functions as reserve or fallow horticultural lands. Garden/orchard plots throughout the bush are cultivated under a three- to four-year crop rotation system. These plots are demarcated with piled stone fences; however, it is even more important for individual owners to remember and keep track of the boundaries of their plots.

Virtually the entire Caisido region outside the forests is in the possession of local community members. People from outside the aldeia or suco are not allowed to own or possess land outside the territories of their “tribe” (baptismal surname group). The alienation of land ownership rights through the sale of the land would deprive the seller of his/her social, economic, and political rights within the aldeia or suco. Distribution of ownership and possession rights is conducted through inheritance mechanisms. Only male family members have the right to inherit; the women do not. Although the inheritance proceedings distribute the family’s lands, the oldest male member in the household remains responsible for the overall management of the inherited lands. Every hamlet resident knows the limits and boundaries of their neighbour’s land possession rights. In this way, local landowners mark their identity as “native” residents of the hamlet, but this native resident status lacks official corroboration in the form of title deeds or ownership certificates for customary houses.

The main source of livelihood for Caisido households is the traditional agricultural and horticultural sector. Traditional fisheries remain relatively undeveloped beyond a few residents’ activities in catching fish with simple methods and tools. Animal husbandry functions as a system for the accumulation of surplus, providing residents with a form of savings that allows them to fulfill their cash income needs as well as the demands of traditional ceremonies such as weddings and circumcision.

The extent of individual possession over horticultural lands is calculated according to the number and extent of boundary fences built. The size of each individual fenced plot is tailored to each household’s estimated subsistence needs and production optimisation strategies for the development of the household economy. There are three available strategies for the optimisation of horticultural productivity. The first divides a single plot of land into several sections, each of which would be planted with a particular kind of cash or subsistence crop. The second model, particularly preferred by households with large amounts of land, relies on the availability of multiple different plots of fenced-out land. Each plot is planted with one type of subsistence and cash crop. The third model has a single plot of land planted with various kinds of both cash and subsistence crops interspersed among each other (rather than separated into distinct sub-plots).

An important factor in the development of these three strategies is the influence of traditional norms and personal adherence to Protestant ethics. Traditional customs discourage individuals from showing off any excess fortune they may have. On the other hand, religious ethics call for the individual to try and work as hard as their capabilities would allow (and as their needs dictate). Even when the individual is motivated by the Protestant ethic, traditional norms prevent them from displaying the prosperity they have thereby gained.

Case studies reveal that households that rely on horticultural resources still face considerable uncertainty in the fulfillment of their subsistence needs. The households that are better-off or more certain in the fulfillment of their subsistence needs are generally the ones that possess sources of income outside the traditional sector. It is very difficult to find out the exact number of both well-off and at-risk households since the marketing of garden/orchard produce is done on a haphazard basis whenever the need for cash arises. Monthly social security allowances from the government have helped people who are struggling to fulfill their subsistence needs, such as vulnerable groups and former independence fighters.

The social organization structure in the Caisido community recognises both formal and informal authorities. Formal authority is held by (on a descending scale) the District Administrator, the Subdistrict Administrator, the Chefe Suco, and finally the Chefe Aldeia. The District and Subdistrict Administrators are appointed by the central government as its local representatives while the Chefe Suco and Chefe Aldeia are elected by the local residents. Although the Chefes are elected by the people, their mandate does not confer the power to make binding decisions about rights of ownership and possession over the resources of the Suco community. Meanwhile, the highest political authority (with the power to make decisions in the public interest) lies in the District Administrator's hands.

Informal political authority is wielded by local churches with their baptismal institutions and the corresponding civil register powers. This informal authority accommodates the interest of both the flock and the formal government. The church's social and political authority mostly manifests in the conduct of daily social life among the villagers (such as in thanksgiving and life-cycle ceremonies).

Other forms of social organization that play a major part in the mutual survival process are territorial groupings, customary ritual house-based groupings, and marriage bonds.

Baptismal surname groups are an important form of territorial social organization in the Baucau region. Identification with a particular baptismal surname (Belo in Caisido) guarantees an individual's rights to obtain a livelihood within the corresponding Suco. Individuals with baptismal surnames that are not identified with the local customary/traditional territory are generally not allowed to reside and work in a different baptismal surname grouping's territory. Exceptions are made through intermarriage, particularly as a member of a woman-giving lineage, but even then the migrant's rights are limited by the customary rights of the woman-receiving lineage. Immigrants of this type do not have a right in decisions about their village of residence or even about their own individual interests. Their individual interests are subsumed and represented by the *lia nain* of the woman-receiving lineage. Although the immigrant becomes a member of the customary house in his new locale, his original group identity remains and limits his rights and responsibilities relative to other villagers who are regarded as native residents.

Another form of social organization that underpins the social structure of Caisido is lineage groups (consisting of individuals who claim descent from the same ancestor). The members of such a group band together in an extended customary household. The customary ritual house (*rumah adat*) provides a physical symbol for the unity of the members' kinship-based identity. Customary/traditional name identities were introduced to allow a finer distinction between members of the same hamlet community who share the same baptismal surname. The customary house also hosts important life-cycle ceremonies for its group members, especially marriage and mourning/funerary rituals.

One more form of social organization that contributes to group survival is the bond between woman-giving and woman-receiving groups. This bond extends well beyond the individual relationship between husband and wife, and involves entire lineages on both sides. The woman-giving lineage has the stronger right to demand social and economic aid since it also bears great responsibility in taking care of deceased members from the woman-receiving lineage. The involvement of the woman-giving lineage is crucial in helping the soul of the deceased settle down in the afterlife and providing comfort for the bereaved family members.

Women play an important part in group survival within the entire social organization framework. However, their position within their own lineage groups is essentially that of second-class citizens (subordinate of of her lineage). Women are the most economically important asset for acquiring guarantees of aid from receiving lineages. The woman is a key figure in the effort to provide *belis* (dowry from the men's side) when any of her male relatives are about to get married. In funerary rituals, the woman also holds a principal role in making sure that her husband's family would provide the funeral shroud.

Paradoxically, women remain somewhat marginalized within their own lineages since they do not have inheritance rights to their ancestral land resources. The only way they have to guarantee their livelihood if their husbands left or passed away would be to rely upon the generosity of their children and/or their brothers (due to the strength of brother-sister bonds)..

It can generally be concluded that, as stated by Appdurai, social organizations form or are formed within a space where the community has to develop a complex of institutions (culture) in order to manage the needs of mutual survival. Changes to any single element in any single institution have the potential of causing further significant social and/or cultural changes.

Social Impacts Assessment

The two project activities that can lead to significant primary potential negative impacts are :

- Land acquisition
- Relocation of people, graves, and customary/traditional ritual houses

Another activity that can potentially cause not only significant primary and secondary negative impacts but also significant primary positive impacts is :

- Employment opportunities

These potential impacts are expected to remain within manageable bounds. Compared to the situation in the project's absence, the advent of the project in the Caisido region in particular -- and in the Baucau subdistrict in general -- would result in the creation of potential social and economic benefits to the residents of the surrounding areas. The project would be stimulate the growth of new employment opportunities and business opportunities outside the stagnant traditional sector.

Land Acquisition

The potential significant primary impact of land acquisition largely takes the form of the degradation of the local subsistence situation. This degradation stems from the local residents' weak bargaining position over the legal status of land possession and ownership, the small amount of land owned by each individual landowner, and the inability to utilize the compensation money in productive pursuits.

The degradation of the subsistence situation is attributed to the fact that land ownership status is usually assessed according to whether the land is being actively cultivated or not at the moment, which means that fallow fields in the bush may end up being assessed as public lands with no private ownership rights attached. This considerably reduces the amount of land attributed to each landowner for compensation purposes -- and weakens local landowners' bargaining position in the determination of the appropriate value, system, and form of compensation for their land. In the end, land acquisition under the abovementioned criteria would reduce the amount of replacement land that the former landowners would be able to buy with the compensation funds. Another complicating factor is that the sale and purchase of land in Caisido rarely takes place openly since the sale of lands would deprive the seller of their status as a native resident of the local village, which in turn means that they stand to lose their social, economic, and political rights rights in the village community.

Land acquisition through the payment of cash compensation to people who have only had experience with subsistence living also carries the risk of trapping these people in a consumptive behavior pattern, and it wouldn't be easy to prevent or mitigate this risk in the face of merchants' efforts to take advantage of the situation by offering incentives and inducements for more consumption.

Unlike the Caisido case, land acquisition in the Wailacama area is not expected to greatly affect the local landowners' social and economic situation since they are no longer so exclusively dependent upon the traditional sector for their livelihoods.

The potential secondary negative impacts from land acquisition in this hamlet are disputes over the administrative predicament of the lands to be acquired and disagreements over the desired land acquisition model or system. The land needed for the clay extraction site is administratively located within Suco Vemasse, but from the traditional/customary viewpoint it still belongs to Suco Ostico. This situation can lead to a conflict of interest over the expected benefits; these benefits can take the form of administrative fees or royalties paid to the village, or specific allocations out of the economic opportunities expected to arise from the project such as employment opportunities and CSR programmes.

These potential secondary negative impacts are expected to be somewhat simpler to manage than the primary negative impacts upon the Caisido community.

Relocation of People, Graves, and Customary Houses

The number of residential sites, graves, and customary houses that would have to be relocated is relatively small (between 5 and 15 in total), but the management of the move can be quite complicated and it might affect not only the social and economic condition of the households undergoing the move but also shape the project's image and viability in the future.

Population relocation is also inextricably linked to the chosen amount and system of compensation payments, the acknowledgement of fallow plots as privately owned land, the search for and establishment of a resettlement site that remains within the bounds of the same customary/traditional territorial unit, the restoration of the resettled households' economic livelihoods, and the revitalization of the areas surrounding the resettlement site to prevent the growth of social envy and discontent among neighbouring settlements. The management of this impact demands a long-term approach since the project needs to ensure the restoration of the resettled households' ability to sustain an independent social and economic livelihood.

The acknowledgement of customary rights over reserve/fallow fields is very important to the management of population resettlement, the choice of resettlement site, the restoration of household economies, and the resettled people's quality of life due to the guarantee that the resettled households would not be removed from their traditional/customary territory. This acknowledgement would also help in the negotiation of a suitable form of compensation, which should preferably not be made in cash; possible alternatives are the construction of new houses and social facilities for the resettled populations, along with the guarantee that each household would receive an allocation of permanent employment opportunity in the project environment. The relocation of gravesites and customary ritual houses raises certain psychological issues related to the resettlement project. Graves are not seen as mere disposal sites for the bodies of the deceased, but also as places for the maintenance of a spiritual connection between the spirits of the dead and the living family members. Maintaining this connection provides closure and reassurance to the living family members who need to move on and resume their daily lives.

Meanwhile, customary ritual houses serve to symbolize the identity of lineage groups in contradistinction to other lineages within the same territorial (baptismal surname) group. As with graves, customary houses are sites for mediation with ancestral spirits, and also a gathering place for the entire lineage as a social, economic, and political unit led by the oldest male member (*lia nain*). The presence of customary ritual houses affirms the lineage members' identity as "native" residents. This affirmation guarantees their rights and obligations as members of the hamlet community. As such, the relocation of family sites (*i.e.* graves and customary houses) requires consultation with both customary stakeholders and all male heads of households within the relevant lineage.

Employment Opportunities

Employment opportunities present a potentially significant primary positive impact to the household economic situation of local workers; however, it may also lead to a significant secondary negative impact through conflicts over the limited amount of opportunities available and the mass layoff of workers upon the conclusion of construction activities.

Additionally, the employment opportunities would mostly be made available to men, which may cause a significant negative secondary impact upon gender dynamics and women's bargaining position.

The availability of employment opportunities for 1000 workers during the construction phase would absorb about 11% of the productive workforce in the Baucau and Vemasse Subdistricts. Later on, during the operational phase, the project would require 700 workers and thus absorb around 8% of the productive workforce in the Baucau and Vemasse Subdistricts.

Amidst the dearth of employment and economic opportunities outside the traditional farming sector, these jobs – especially the ones in the operational phase, with the promise of long-term employment and a number of desirable perks – may lead to a negative secondary impact in the form of tensions and jealousies or even open conflict between individuals and sucos over the limited number of available jobs.

Even the positive social and economic impacts can lead to a negative secondary impact, especially during the lay-off of construction workers. Workers who have grown used to a steady cash income would then face potential difficulties in re-adapting to a life without cash after the termination of their employment. Whatever cash incomes they may derive from the traditional sector would seem quite small and highly uncertain compared to their construction wages

The introduction of a cash wage system into a subsistence economy (that has hitherto been rather unfamiliar with it) can have both expected and unexpected consequences that demand the project's involvement in managing social and economic development in the local area.

The overwhelmingly male composition of the workforce absorbed into the project may weaken women's position in the household economy. The traditional economic structure has relied so far on a cooperative effort between husband and wife; the availability of employment opportunities outside the traditional sector for male members of the household would change this by making the household economy structure more dependent upon the men's income. This shift would change the cooperative relationship pattern between husband and wife in the development of the household economy. This potential dependence should be counterbalanced with the reinforcement of women's role in the traditional farming sector. These efforts would take the form of the empowerment of a regional economy based on local resources with women as the principal actors.

All of these potential impactscan be managed with the prevention and mitigation measures outlined in the Table below. The Table also lays out the monitoring scheme needed to supervise those management efforts.

A more detailed description of mitigation and monitoring efforts is presented in the full report.

Table 1 Summary of Proposed Impact Mitigation Measures

Potential Impact	Proposed Mitigation Measures
Land acquisition: • Loss of subsistence resources • Loss of bargaining power over land status, value, and compensation system	Intense negotiation with landowner, chefe aldeia, chefe suco, and *lia nain*
Population displacement/resettlement Relocation of ancestral cultural sites: graves and customary ritual houses (*rumah adat*)	Comprehensive resettlement program
Recruitment of workers and distribution of employment opportunities	Establishment of a labor recruitment institution
Loss of women's bargaining power Dependence upon cash income in household economic subsistence systems Transformation of traditional agriculture and the promotion of regional development	Composition of an agricultural development and market integration plan Establishment of a regional development board Empowerment of women's role in agricultural and horticultural production

Table 2 Monitoring Parameters and Schedules

Potential Impact	Mitigation	Parameter to be monitored	Monitoring schedule
Loss of subsistence resources	Integrate part of resettlement plan	The number of landowners and the size of plots outside the affected area	Once after the direct identification of affected households
Loss of bargaining position over the status and value of land and the compensation system	Intensive negotiation with landowners	• Trends in complaints and requests from the landowners • Negotiation deadlocks • The effectiveness of an independent third party's involvement in negotiation	Once within three months after negotiation
Dissatifaction/ conflict over the relocation of gravesites and customary/ traditional ritual houses	Integral part of the resettlement plan	• Trends in the numbers and intensity of rites of integration (where the body is incorporated in the world of ancestral ghosts, giving it a sacred status in the cosmos)	Duration of the adjustment period (1-3 years after relocation)
Resettlement	Comprehensive resettlement plan	• The performance and effectiveness of the resettlement plan and the implementation of	Every 3-6 months during the 3-year adjustment process

Potential Impact	Mitigation	Parameter to be monitored	Monitoring schedule
		resettlement schedules • Trends in the effectiveness of household economic restoration • Trends in the number of disease and malnutrition cases • Trends in rites/ceremonies of integration (see explanation above) • Integration with neighboring people (host communities)	
Potential conflict over worker recruitment and the distribution of employment opportunities	Establishment of a labor recruitment institution	• Trends in the effectiveness of the labor management institution • Trends in the number of complaints and conflict incidents • The development of recruitment schedules • Transparency and fairness in worker registration and recruitment criteria	Every three months since the establishment of worker accommodations in the first year; then every 6 months for the duration of construction and operational activities
The loss of women's bargaining power Dependence of the household economy upon cash income Transformation of traditional agricultural practices	The creation of an agricultural development and market integration plan	• Establishment of a regional economic development board • Trends in the development of agricultural market plans • Trends in the empowerment of women's role in the agricultural sector • Trends in the improvements made by agricultural extension workers	Every years for the 5-year plan; or upon every review of the programs

1. INTRODUCTION

1.1. Brief Project Description

TL Cement LDA, a privately-owned company, proposes to construct a Greenfield cement manufacturing project in Baucau Municipality, Timor-Leste. The project will produce approximately 1.65 million tons per annum (Mtpa) of Portland cement clinker.

Clinker refers to small lumps (3.0-25.0 mm diameter), produced by heating limestone and other materials such as clay and sand in a cement kiln. Clinker, if stored in dry conditions, can be kept for several months without appreciable loss of quality. Because of this, it can easily be handled by ordinary mineral handling equipment, clinker is traded internationally in large quantities. Clinker is then ground to a fine powder, along with gypsum and other substances to produce useable cement.

The proposed project will provide cement for both domestic use and international sale. A feasibility study is currently being undertaken to demonstrate the commercial viability of the project.

The proposed project represents a significant investment of approximately $350 million and the largest industrial project undertaken in Timor-Leste to date. It is anticipated to create 1000 jobs at the peak of the construction. It will then continue to have 700 permanent employees during operation. The project aims to develop local capacity and will develop a training center.

The spin off benefit would be indirect employment to local community members, through the multiplier effect due to downstream socio-economic benefits and consequent improvement in the living conditions of local population in the project area.

A. <u>Cement Clinker Plant</u>

The plant includes clinkerisation and cement grinding facilities with a rated capacity of 5,000 tons per day (tpd) of clinker and 100 tons per hour (tph) of cement. The plant also includes a waste heat recovery (WHR) power plant.

Up to 60% of 0.53 Mtpa of cement will be sold in the local markets and balance 40% will be shipped to Australia in 8,000 Deadweight-Ton (DWT) ships. Balance clinker of 1.15 Mtpa will be shipped in vessels of 40,000 DWT ships to Australia.

The project involves developing a green field plant including, but not limited, to the engineering, design, manufacturing and supply of new equipment for cement plant, a waste heat recovery based power plant, a captive thermal power plant of approx. 30 MW and Port (Double wharf jetties) about 1.5-2 Km from the plant site.

B. <u>Thermal Power Plant Bottom and Fly Ash Utilization</u>

The waste from the thermal power plant will be fly ash and bottom ash. The total ash will be utilised in the cement grinding for producing PPC based on the coal data and ash in the coal the fly/bottom ash generation will be approximately 50 t/day i.e approx 16500 t/annum. This will produce around 66000 t/a of PPC based on 25% ash in PPC. All ash from the thermal power plant will be transported pneumatically to the cement grinding section.

C. Mines and Raw Materials

The raw and fuel material requirements for the proposed plant are to be met from different sources as given in Table below.

Table 1.1 Raw Materials

No.	Material	Source	Source Locality	Remarks
1.	Limestone	Local	SucoTirilolo, Triloca, Bucoli , Baucau Municipality	Primary raw material. Transported from mine site to crusher by trucks.
2.	Clay	Local	Suco Wailacama, Baucau administrative post in Baucau municipality	A corrective material. Transported from quarry to plant by road.
3.	Iron Ore	Import	Australia	A corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.
4.	Gypsum	Import	Australia or other	A corrective material. Transported to Timor-Leste by ship or barge, off loaded at jetty, and transported to plant by belt and pipe conveyor.
5.	Coal	Import	Australia/ Indonesia	Fuel source and corrective material. Transported to Timor-Leste by ship or barge, offloaded at jetty, and transported to plant by belt and Pipe conveyor.

D. Limestone Deposit

The limestone deposit is accessible from Baucau by a tar road. The mine is located about 1 km from the main road and Bucoli village. The mining area is located around 0.5 km from the coastline where a jetty is proposed to be constructed. The limestone concession area (I-1) which shall meet the initial limestone requirement of the plant covers an area of 576 ha. The deposit area is generally undulating and hilly. As observation result, the limestone bearing area is covered by thick or scattered trees, thorny bushes and tall grass.

E. Clay Deposit

Clay is found to occur close to the plant site in Suco Wailacama in Baucau administrative post, less than 10 km west of the plant site. Clay shall be used as corrective to compensate for silica and alumina deficiency in the raw mix. Clay is proposed to be transported to the plant site by trucks.

F. Jetty

A dedicated jetty is proposed at a distance of 2 km from the plant site. Inbound material, (e.g., coal, gypsum, iron ore) and outbound clinker shall be transported between the plant and the jetty by a 0.5 km long conveyor belt ±1.5 km Pipe Conveyor (fully enclosed). The maximum load during unloading is estimated as 1000 tons per hour and during loading is estimated as 1000 tons per hour.

G. Utilities

a. Power

Power will be supplied by captive thermal power plant of approximately 30 mega-watts (MW) capacity and Waste Heat Recovery power plant.

Power for initial phase of plant operation when cement grinding is commissioned will be from grid power. Tapping from the nearby grid line of 20 KV will be tapped and step down to 11 KV at the plant substation. Generator sets will be utilized for construction power.

Emergency power requirement for initial commissioning of cement grinding is not required. For full plant 1.5 MW genset will be required. Thermal power plant shall include black start power requirement separately.

b. Water Supply

The water requirement for the cement project shall be met from groundwater by drilling bore wells. A makeup water supply of approximately 3,150 m^3/day is required for operations including requirement of mines, colony and green belt which may be possible to obtain this from one or two boreholes.

An underground aquifer is reported to occur below the mining blocks. As there is no industry in the area, the exploitation of water resources during the operation is not expected to adversely affect the water availability in the area for other competing users.

A detailed hydrogeological study is proposed to be carried out to assess the availability of groundwater in the area. Water shall be required for:

- Process Water Circuit;
- Cooling water (required for machine cooling);
- Make-up water shall be provided while re-circulating water shall be in a close loop;
- Water required for township;
- Water for on-site facilities;
- Construction and operations (dust suppression).

c. Waste Water

The cement plant is being designed as a Zero Discharge facility and there shall be no discharge of waste water outside the plant premises. All the process waste water shall be treated in Water Treatment Plant and reused for plantation purposes. The waste water generated from domestic activities shall also be treated and reused for dust suppression, green belt development to the extent possible.

d. Solid Waste

Domestic solid waste generated from plant and jetty area shall be segregated and will be sent to waste disposal site as allocated by the local administrative authorities.

1.2. Location Study

The proposed cement plant and marine jetty are located in Suco Tirilolo, Aldeia Osso-ua, in the Baucau administrative post of Baucau municipality, Timor-Leste. The location is about 120 km east of Dili and approximately 16 km west of Baucau.

The Proponent has been granted a Prospecting License for limestone over three blocks, including, Block I-1 (Bucoli North Area-1), covering areas of 576 ha. The prospecting blocks are spread over Sucos Tirilolo, Bahu, Caibada, Triloca, Bucoli, and Wailili in administrative posts of Baucau, Vemasse and Venilele in Baucau municipality.

Sources of clay are located at Suco Wailacama within 10 km from proposed plant site. Corrective iron ore and additive gypsum are proposed to be procured from Australia. Coal will be used as a fuel for the kiln and power supply at the cement plant and is proposed to be procured from either Indonesia or Australia. The location of plant, mines (Block I-1) and jetty are shown in figure below.

Source : *https://commons.wikimedia.org/wiki/File:Sucos_Baucau.png*
https://www.mof.gov.tl/about-the-ministry/statistics-indicators/sensus-fo-fila-fali/download-suco-reports/baucau-suco-reports/

Figure 1.1 Location of TL Cement Development Project

1.3. Scope of Works

According to scope of works from WorleyParsons, the social impact assessment study will assess the following task :

- Identifying the condition of social economic culture of the communities in the study area;
- Predicting potential impacts from the proposed project related to the communities;
- Preparation of recommendation the mitigation measures to avoid adverse impacts and to enhance the project benefits to the communities;
- Conduct social economic and cultural survey using appropriate methodology.

2. METHODOLOGY

2.1 Data Collection

This study relied upon the ethnographic strategy. The original plan was to conduct questionnaire-based surveys and in-depth interviews to fill the gaps in the survey results, and then collect secondary data to obtain a general picture of the demographics. After the initial visit to identify the research area and the feasibility of a questionnaire survey, the plan was modified to account for the following issues:

1. The settlement patterns consists of hamlets (*aldeia*) widely dispersed according to the local availability of staple resources, so a questionnaire survey would take an unfeasibly long time; it is feared that interviewers might try to artificially speed up the process by writing subjective and biased reports.
2. Household units within residential territories are based upon patrilineal and patrilocal lineages, so the choice of a nuclear family unit might not produce representative results for the entire lineage unit, it is supposed to represent, especially with regard to questions about views/response towards the project and about decision-making processes over acquisition or the sale of land;
3. Despite the use of money for trade, the local population is still anthropologically categorized as subsistence households;
4. The local topography and availability of natural resources play an important part in shaping the local population's agricultural patterns and subsistence strategies, creating a relatively homogeneous pattern of life; this kind of situation can only be captured through in-depth interviews;
5. The local population's isolation and external parties' (*i.e.* the government's) lack of attention towards their welfare, anthropologically speaking, has caused them to rely on their own resources and show little interest in cooperating with people outside their lineage group; this tendency can only be captured with an ethnographic approach, especially in comprehending the surplus accumulation strategies permitted by customary law and the importance of ancestral land in signifying identity (and rights) as a member of the village community.

The ethnographic survey was performed through observation, in-depth interviews, and secondary data collection at the village level, especially in areas likely to suffer direct impact from the project. This is based on the assumption that the people in such areas are the most likely to suffer significant impact (in terms of changes to their subsistence livelihoods). The people elsewhere are expected to be less significantly affected since the potential benefits provided by the project in the form of employment opportunities are not likely to dramatically change their resource exploitation habits, except under intense empowerment to increase the productivity of existing resources.

The study were undertaken on the following activities:

- Preliminary observation on 5th – 9th May 2015
- Ethnographic study 20th May – 2nd June 2015 (This ethnographic study was conducted by two anthropologist)

Observation was performed to understand land use patterns and the resource situation, crop types and planting schemes, cooperation in the exploitation of subsistence resources, the location of residential areas relative to the project site, the location of cultural identity sites (such as cemeteries and traditional/customary houses) relative to the project site, and resource exploitation activities (agriculture and fisheries) in order to understand subsistence patterns.

In-depth interviews were intended to understand the production systems and patterns needed for the survival of the nuclear family and the lineage group; distribution arrangements between woman-giving and woman-receiveing lineage groups in the context of group reproduction and the development of intergroup networks, and customary norms in the exchange between woman-givers and woman-receivers as social capital in the social security context; accumulation strategies in accord with customary norms to manipulate the demands of obligations as a member of the lineage group; types of crops and planting (production) strategies to fulfill subsistence needs; and modes and processes for acquiring cash income from produce in order to fulfill consumption needs and accumulate surplus.

Apart from these three livelihood factors, the in-depth interview also sought to develop an understanding of customary and religious rituals with regards to the affirmation of lineage membership after the introduction of new indentity paradigms by the church. The focus lies upon the importance of these two identities to the individual as a member of the village community, as well as to land and the attached rights for the community member.

Secondary data was extracted from two different sources. The first is the data from the 2010 population census. This data was compared to the latest demographic data from 2015, which was available in the village. This comparison was meant to figure out the population growth rate in the villages around the project site, namely the villages (Suco) of the Baucau and Vemasse Subdistricts. Not all villages around the project site had a complete suite of demographic data that included levels of education, occupations of family members, vulnerable groups, and age groups (especially productive age groups). For the purpose of analyzing impacts upon the villages that may incur indirect impacts from the project, the old but easily available data from the 2010 census can still be used to obtain a general idea of the number of working-age residents, levels of education among family members, the numbers of employed and unemployed residents, the number of vulnerable households, and other relevant data.

Other important secondary data include demographic records at the hamlet or *aldeia* level, which was obtained from family cards. These cards contained data about the names, age, education, and occupation of all family members, whether male or female. Unfortunately, most hamlets within the project's likely impact area did not have such an extensive record of family cards as the one found in the Tirilolo Village. Although complete demographic records in the form of family cards were only available in Tirilolo, it is possible to describe the pattern of occupation and education levels among village households in the project's likely impact area with the use of the demographic picture obtained from the two *aldeia* groups of Tirilolo Vilage (two *aldeia* at the center of Baucau City) and four *aldeia* in rural areas (Caisido).

Another secondary data source that provides information similar to the demographic data in family cards was monthly reports from the auxiliary clinic in the Caisido *Aldeia*, Tirilolo Village. This auxiliary clinic provided medical services for the people in four *aldeia*. The clinic lies within the area likely to incur direct impacts from the project. The monthly reports recorded the number of visits and the number and type of medical complaints reported by the visitors, categorized by age group. This data is very important since it correlates with the socio-economic condition of the local population's residential environment.

2.2 Data Analysis and Impact Assessment

Secondary/quantitative data was analyzed to find out tendencies and patterns. This data is particularly useful for finding out the reasons and considerations behind the villagers' behavior, especially those within the indirect impact area. Meanwhile, quantitative data for villages in the direct-impact area is used to forecast the spread, magnitude, and accumulation of reversible and irreversible impacts.

Quantitative data from medical reports was analyzed for patterns in the diseases commonly found among the local population and their relationship to sanitation conditions, the scarcity of clean water, and the local population's socioeconomic well-being.

Ethnographic data is analyzed to comprehend the rationality of individual behavior in developing and nurturing mutual survival interests. Customary systems and mechanisms for member reproduction, as well marriage institutions and related customs, provide opportunities to develop social networks for the purpose of enhancing social security; meanwhile, customary laws and institutions provide an opportunity for individual economic development through the accumulation of surplus under the constraints of limited resources, customary obligations to maintain communal unity, and the lack of attention from external parties. The project will directly and indirectly cause positive changes to behavioral (cultural) patterns in terms of more rational surplus accumulation with fewer customary and ritual constraints; or the strengthening of member reproduction systems and mechanism and customary economy in response to ongoing changes, especially among people who haven't derived any benefits from the project. These two possibilities aside, traditional/customary houses would probably remain an important element in group identity, particularly in the context of how social lineage groups respond to attempts to merge their traditional group identity into religion-based communities through the baptismal names of past traditional elite figures. Theoretically speaking, the contrivance of setting up customary territories on the basis of baptismal names is deemed acceptable since it provides benefits to both sides.

Impact assessment is based upon the following guidelines:

1. IFC's Performance Standard on Environment and Social Sustainability 2012.

2. Riki Therivel, John Glasson, and Andre Chadwick. 2010. Introduction to Environmental Impact Assessment. 3rd Edition. Routledge. London and New York.

3. The main subjects of analysis are:

    a. Direct and indirect impacts;

    b. Extent and magnitude;

    c. Cumulative Impact;

    d. Reversible or irreversible;

    e. Manageable or unmanageable;

    f. Impact consequences with and without the project;

2.3 Study Area

Intensive ethnographic research was performed at the mine site and plant site – traditionally known as the Caisido region, consisting of the Parlemento, Caisido, Lialaileso, and Osso-ua *Aldeia* in the Suco

Tirilolo. In the Wailacama *aldeia*, Suco Vemasse is the closest site to the clay area. The Wailacama *aldeia* community currently resides on the clay site. The fields in the area are currently being left fallow while the owners reside elsewhere. Beyond these five *aldeia*, observation was also made upon several sucos in the Baucau subdistrict as well as Suco Vemasse, which exhibit certain similarities and peculiarities in terms of ecology, ricefield cultivation, perennial gardens, etc. Apart from this direct observation, secondary data collection was conducted in suco administrative centers, and also interviews with *chefe suco* to find out their knowledge, response, and hopes about the planned project.

3. ENVIRONMENTAL BASELINE

3.1 Administrative Boundaries of the Project Area

3.1.1 Administrative Boundaries

The planned site for the clinker cement project is administratively located in Suco Tirilolo, Baucau Subdistrict, and Suco Vemasse, Vemasse Subdistrict. The mine site and plant site are located within the Osso-ua *aldeia*. Access roads to the Osso-ua *aldeia* pass through the Parlemento, Caisido, and Lialaileso *aldeia*. All four *aldeia* comprise a region within Suco Tirilolo historically known as Caisido. The mine and plant sites are located approximately 7 km away from the Baucau – Dili main road. The four *aldeia* are still relatively isolated, particularly in the case of Osso-Ua. Roads that allow access to four-wheeled vehicles were built approximately 3 years ago. With the establishment of the road, public transportation cars now make 2 trips per day from Baucau City to the Parlemento *aldeia*, but the route does not extend into Osso-ua. Passengers going to Osso-ua must stop at the Caisido T-junction and walk the remaining 4 km. Most Osso-ua residents who wish to travel to or from Baucau City prefer to walk approx. 7 km to an intersection on the Baucau-Dili road, where they then take a ride on local transport to the city. About 10 motorcycles for hire park at the end of this road to serve trips to the four abovementioned *aldeia*. However, most local residents prefer to walk the distance since the cost of a motorcycle trip ($2 - $3) is deemed too steep.

These four *aldeia* were settled around two or three generations ago. Several interview subjects stated that the *aldeia* Parlemento, Caisido, and Lialaileso have been inhabited for a long while, while the *aldeia* Osso-ua was settled around 1945. This a*ldeia* was settled by (or designated as a settlement for) lepers from throughout Timor Leste. The history of this leper colony will be described later.

The clay mining site in Wailacama was located within Suco Ostico up to 1975. Local settlements of the *aldeia*'s population around the clay mining site are relatively isolated. At the time of the Indonesian invasion in 1975, the hamlet consisted of 15 households, which were relocated to their current habitations along the Baucau – Dili main road. The new settlement still uses the name of the Wailacama *aldeia* but it is administratively located in Suco Vemasse. However, land resources at both the new and the old site are part of the Ostico customary lands, especially those under the possession of the Wailacama residents. As such, the current population of the Wailacama village resides within their traditional customary resource areas. The identification of customary areas is very important to individuals and their descendants since it bears upon the descendants' inheritance rights and limits external parties' ability to claim possession over resources outside their own ancestral lands. The importance of customary land rights will be more fully explained later on. Access from the new settlement site to Suco Ostico is available through a 3 km dirt road through secondary forest, traversable with four-wheel-drive vehicles.

Although the planned clinker cement project will only cause direct impacts upon the abovementioned five *aldeia*, the overall influence may extend to other sucos within the subdistrict, especially by raising hopes for employment and business opportunities for the younger generations in two subdistricts. These hopes were reinforced when Suco leaders from the Baucau and Vemasse Subdistricts were brought to review the central site of the cement industry plant in Australia. During the visit, they were given information about potential benefits for the local population, especially in terms of employment opportunities and the development of social facilities in the area.

Apart from the abovementioned explanation, the arrival of a large manufacturing project in the Baucau region's subsistence farming landscape inevitably brings about hopes for benefits from the project. The fulfillment of these hopes constitutes the indirect impact of the project. In other words, the construction of the clinker cement plant is expected to cause direct impacts to five *aldeia* in two sucos as well as indirect impacts to other villages around the project site **(Table 3.1).**

Table 3.1 Village Boundary, Direct, and Indirect Impact

Subdistrict	***Direct Impact Sucos***	***Indirect Impact Sucos***
	Mine, Clay site, and plan site.	
Baucau	Tirilolo	Bahu
	-	Bucoli
	-	Baruma
	-	Wailili
	-	Samalari
	-	Gariuai
	-	Triloca
	-	Seical
	-	Caibada
Vemasse	Vemasse	Ostico
	-	Ossoala
	-	Luilubu
	-	Uaigae
	-	Uatu-Lari
	-	Caicua

Source: Survey Inventarisation, May 2015.

3.1.2 The History of Adat Identity and Territory

One of the informers explained that Baucau was settled by people from the western region of **Waiweko/Waihaloi** who initially migrated to the east (Manatuke) to the area between Dili and Baucau, followed by a further migration to Waikeke (west) and finally to Baucau. Immigrants from **Waihaloi** are dominated by the Da Costa group. The first destination at Waikeke was already occupied by the Amaral, Soares, Ximenes and Sausagroups, which prompted them to remigrate westwards or 'upwards' to what is now Baucau. These clan names were based upon the baptismal names of leaders among the territorial elite at the time. These names were then adopted by community members born and residing within the territory of particular sucos.

At the moment, certain baptismal names signify a person's origins or residence in a suco. The Baucau Subdistrict is traditionally dominated by three surnames, namely *Da Costa, Belo,* and *Flores.* Local legend holds that these three surnames originated from three brothers who owned/controlled resource in their respective territories (sucos). Each lineage owns an *adat*/customary house used for communal rituals with their ancestors. This *adat* building is located in Suco Bahu. Ceremonies are held on an irregular schedule, depending on whether the house requires repairs or not. Ceremonies are led by the oldest male member of the groups. This leadership is not passed down to a late leader's son but is transferred according to seniority.

All the sucos, whether in the Baucau or in the Vemasse Subdistrict, are dominated by particular baptismal surnames (**Appendix 1**). All residents of the village/suco identify with or are identified with the historical baptismal name of their traditional elites. Although the village/suco residents use the same baptismal name throughout the entire suco, they usually do not share the close blood ties that such a shared surname would normally imply. Theoretically, all communities have elite and follower components. To affirm the power of the traditional elites, the power is institutionalized in certain rituals. The ritual site and mechanism are chosen to reinforce the power of the traditional elite over their territory. This traditional power is performed through rituals, along with the organizational apparatus needed to arrange and conduct the rituals.

No such ritual activities have been found in the project area apart from that performed by lineage groups in their customary houses. In this respect, the baptismal surname cannot be accurately seen as clan names, but rather as territorial groupings. The possible goals for the use of these baptismal surnames as markers of territorial identity will be discussed later.

3.1.3 The History of Osso-Ua's Leper Colony

Suco Tirilolo is the oldest suco along with Bahu and Caiboda. These three Suco were the origin of a social group based upon a baptismal surname, namely Belo. This Suco was historically divided into two regions: the inland Caisido region (now the Aldeia Caisido) and the upper region (Old Market, Baucau Subdistrict). The inland (Caisido) region is made up of 4 Aldeia: Caisido, Parlemento, Lialaileso, and Osso-Ua. All these four Caisido had been settled prior to 1945 except for Osso-Ua. Osso-Ua is located approximately 4 km away from the other three aldeia towards the north, an isolated site that can only be reached over a footpath.

Informers state that, around the year 1945, the Portuguese government (Portu) designated Osso-Ua as a quarantine area for lepers from all over East Timor. The lepers were left to fend for themselves with no amenities provided by the government – no housing, arable land, nor healthcare. The lepers were managed solely through restrictions on the use of the clean water sources passing through the village. The lepers were directed to use the smaller water source (*Uai Mata Anna*) while the larger water source (*Uai Mata Uli*) was reserved for the general public. This separation was intended to prevent contagion. Attempts to approach and treat the lepers began under Indonesian rule (1988). Medical care was provided by church sisters. Intensive care only began in 2008 and has continued to this day. Reports from village family cards and church records indicate that only 2 lepers remain in the area. Recent information hints that the leper colony will eventually be moved to Bondura, a coastal site to the west of Osso-Ua.

3.1.4 A Chance of Community Empowerment

Over 400 years of Portuguese colonization, 29 years of Indonesian occupation, and 16 years of independence, the people of Caisido (four *aldeia* around the mine and plant sites) have received scarcely any attention from the outside. External attention only began to manifest itself during the Indonesian occupation in the form of:

1. The construction of clean water conduits from the army base at the Baucau-Tirilolo road junction, utilizing a water source originally tapped to serve the military base. The clean water supply went all the way to Caisido with a flow rate of 1000 l/second in the 1980s.
2. 2011 saw the electrification of four villages (including Tirilolo) with the construction of 18 km of power lines from Caibada Village to Caisido by the State Secretariate on Electricity (*Secretario Du Estado Elektrisidade*)
3. The isolation of the area and the lack of medical care has motivated the Australian Red Cross foundation to widen the 3 km access road from the Baucau main street (in front of the military /*Falintil Forcas de Defesa de Timor Leste*/FFDTL base) to Caisido – Caibada and a 4-km stretch on the Caisido – Osso-ua route, and to build clean water reservoirs in Caisido. This was done three years ago on the initiative of Baucau community figures who contacted the Australian nonprofit.
4. 2013 saw an expansion of the electrical network from Carabela (Vemasse) to Osso-Ua;
5. Food aid and improvement of the road from the T-junction on the main street to the four *aldeia* by the US NGO CARE International (*Cooperative for Asisstance and Relief Everywhere*).
6. In 2002-2003 the WHO (World Health Organization) brought in food aid for pregnant and lactating mothers and children under five years old, as well as treatment for malaria; this was done in cooperation with the ministry of integrated community healthcare (SISCA / *Servico, Integrado, Saude Comunitario*).
7. In 2004, existing clean water conduits underwent maintenance in the form of the replacement of old pipes with new pipes of the same diameter (2 inches);
8. In 2014, the clean water distribution network was expanded to Osso-Ua from the existing pipeline (Caisido);
9. 2015 saw the construction of new clean water pipes parallel to the old pipes. The new pipes wil fill 10,000 l water storage reservoirs in several locations (**Appendix 2**) with water taken from Garuwai.
10. In 2013, the World Vision foundation provided aid for the construction of an elementary school in Parlemento and healthcare clinics. The new clinics began to operate in June 2014. This aid was directed towards the fulfillment of education and healthcare needs, while the local population's hopes for agricultural empowerment have not yet been addressed.

3.1.5 Cultural and Historical Sites

Neither interviews with the *Chefe Aldeia* (*Aldeia* Chief) nor field observations at the mine and plan sites and the clay area has revealed any signs of historical artifacts. According to Senor Januario, the District Director of Environment of Baucau, there is a sacred location (*lulik*) on the Tirilolo coast. The place is said to be guarded by a sea guardian spirit (*Na'in Ba Tasi*). Januario could not point out the exact location, but Palmer's 2011 report (*Water Selection: Customary System and the Management of Baucau Citiy's Water*) identified the sacred location at the beach below Baucau City (Wotabo), or more precisely the site of a spring that discharges from Bucoli to Wailili and then straight to Wotabo Beach. This site is quite distant from the Osso-Ua beach.

There are two cultural sites that figure prominently in lineage group identity around the mine and plant site, namely the cemetery and the *adat* (customary/traditional) house or *rumah adat*. These two places serve as venues to pay respects and pray to deceased ancestors (the cemetery) while and to maintain the integrity of lineage group identity. Memorial and bereavement rituals for the death of a family member (*ikat bunga*) are performed at the cemetery with the sprinkling of flowers and the recitation of prayers for the dead. The ceremony is conducted a year after the death and is repeated afterwards on a yearly basis. This ceremony involves prayers led by the pastor. The prayers can be said at the site or during Mass at the church without the need to take the priest to the gravesite. All family members are involved in the ceremony. Apart from praying for and remembering the dead, the ritual also serves the function of strengthening social bonds among living family members.

There are two distinct opinions about the possibility of relocating the cemetery. The first opinion states that graves cannot be relocated since such an action would bring bad consequences upon the living members of the family, such as local disasters. The second opinion holds that graves can be relocated in times of great need with a ceremony similar to the original funeral ceremony and presided by a priest.

An informer – the village *Lia nain*—said that it is difficult to find an appropriate site for a cemetery complex. The difficulties in bringing the graves together into a central location are mostly due to the lack of sites with at least 2 meters of soil without any large rocks.

At the jetty site on the coast of Osso-Ua *Aldeia*, there are 7 graves spread between two sites. These graves are expected to be directly affected by the jetty construction plans.

Another institution that plays an important role in the maintenance of lineage group identity is the customary house (*rumah adat*). The customary house is a simple building quite similar to other local houses. The house is mostly made up of bamboo and roofed with thatch made out of palm leaves. The customary house provides a place to store the clothes left by a deceased person; these clothes are stored in a basket (*toah*) made out of fronds harvested from the palm trees growing nearby. Outside the basket storage area, a number of seats are placed around the house. Customary or cultural ceremonies are performed at the same time as repairs to the building when it is deemed necessary. The ceremony is led by the oldest male member of the lineage group and the male heads of nuclear families. During the ceremony, the names of lineage ancestors and the original (pre-baptismal) names of lineage members are recited. The order in which the names of lineage members are recited is based on memory. To maintain lineage identity, all members of the lineage adopt the name of the ancestor who resided in the customary house (the name of the customary house). This name allows members of the lineage to identify their kinship to each other.

There are 17-37 *rumah adat* (customary houses) in the four *aldeia* closest to the project site. These houses are generally grouped together at the same site as the original customary houses built by the ancestors. In the Osso-Ua *Aldeia* there are a number of customary houses (around 3-4) situated apart from the complex of customary houses built by the rest of the population. Instead, these segregated customary houses are located much closer to the residential hoises of their lineage groups. The reason for this remains unknown. Their owners and everybody else generally answer that it was done to facilitate maintenance of the customary houses. Our conjecture is that these families were descended from lepers who deliberately sited their customary houses apart from the others'.

The importance of the *rumah adat* as a symbol of core cultural identity for the kin/lineage groups make them even more difficult to relocate than graves. The graves themselves are not merely body disposal sites, but also a place where the living family members undertake '*... to remove the corpse and dead soul from the secular world and fix them firmly in the sacred, and to serve the lineage kin. From their tie with the sacred world and restore them to secular life*' (Hicks, 1976:114). The funeral process involves the woman-giving party as 'givers of life' along with the lineage group of the deceased.

Table 3.2 Number of Adat Houses in Project Area

Suco/Aldeia	***Number of Household***	***Number of Adat House***	***Number of Lineage***
Tirilolo			
Aldeia Parlemento	99	17	17
Aldeia Caisido	184	37	37
Aldeia Lialaileso	101	27	27
Vemasse			
Aldeia Wailacama	27	1	1

Source: Survey Inventarisation, May 2015.

3.2 Demography

3.2.1 Population Numbers in the Subdistrict and Affected Suco

The population of the sub-districts around project activity sites is 41,895 for the Baucau Subdistrict and 9605 for the Vemasse Subdistrict. Compared to the census figures from 2010, the Baucau population has experienced a 4% decline while Vemasse saw a 12% growth. Prior, all the datas related to population number were calculated by population growth rate formula. Datas required from census 2010 and monography suco 2015.

$$r = (Pt - Po)^{\frac{1}{t}} - 1)*100$$

r= Population growth rate formula

Pt= Total population on last year

Po= Total population on basic year

t= year differences between Pt and Po.

Nearly all sucos in the Baucau Subdistrict exhibited population growth within the last five years, varying between 0.3% - 7% per year with the highest figure being found in Tirilolo (as the directly affected area) at 18%/year, followed by Salamari at 7%/per year and Buibau at 5%/year. Meanwhile, Baruna saw a sharp population decline (-28%/year).

Table 3.3 Population Growth in Suco, Direct, and Indirect Affected Areas for 2010 – 2015

Subdistrict	Suco	Direct Area			Rounding	Indirect Area			Rounding
		Number of Pop.		Population	Off	Number of Pop.		Population	Off
		2010	2015	Growth (%)		2010	2015	Growth (%)	
Baucau									
	Tirilolo	2815	6441	18.003525	18				
	Bahu					5188	6727	5.33	5
	Bucoli					2179	2711	4.46	4
	Buruma					15664	3063	-27.85	-28
	Buibau					3708	4705	4.88	4.9
	Wailili					3519	3573	0.31	0.3
	Samalari					1534	2183	7.31	7.3
	Garuai					4518	4663	0.63	0.6
	Triloca					2442	2193	-2.13	-2.1
	Saical					1876	2231	3.53	3.5
	Caibada					3057	3549	3.03	3
Total						**45695**	**37613**	**-3.82**	**-4%**
Vemasse									
	Vemasse	4679	3132	-7.714442	-8				
	Ostico					1240	1612	5.39	5.4
	Ossoala					665	1578	18.87	18.9
	Luilubu					1146	1255	1.83	1.8
	Uaigai					366	744	15.24	15.2
	Uatu-Lari					858	1192	6.8	6.8
	Caicua					54	1083	82.16	82.1

Subdistrict	Suco	Direct Area			Rounding	Indirect Area			Rounding
		Number of Pop.		Population	Off	Number of Pop.		Population	Off
		2010	2015	Growth (%)		2010	2015	Growth (%)	
Total						**4329**	**7464**	**11.51**	**12%**

Source: Census 2010 and Monography Suco, 2015.

Similarly, almost all sucos in the Vemasse subdistrict experienced population growth. The growth varied between 2% - 19% over the population figures from five years ago, with the most extreme growth happening in Suco Caicula (82%) or 8 times the initial calculations from the 2010 census, with Ossoala coming a distant second at 19% and Uiegea at 15% (**Table 3.3**) Suco Vemasse alone experienced an 8% decline over the last five years.

What caused these population changes? Our experience in the field suggests that the population records in most sucos are poorly kept, with the exception of Tirilolo where the suco administration keeps family card records for the population in its *aldeia*. The village secretary explained that the population numbers cited in village monography is recapitulated from these family card records.

The family card provides a complete record of each family member's age, level of education, and occupation. Other sucos have not undertaken such a complete recording of family cards as in Tirilolo. As such, social assessment of the general picture of the subdistrict's working-age population, educational status, and occupations has to rely on data from the 2010 census. A recapitulation of the family card data from Tirilolo is used as reference material for detailed description and comparison.

3.2.2 Number of People and Houshold Likely to be Directly Affected by the Project

As explained elsewhere, the mine and plant site are located in Suco Tirilolo, especially in the Osso-Ua *Aldeia*, while transportation activities during construction will affect the Caisido, Parlemento, and Lialaileso *Aldeia*. The population of Osso-Ua is approximately 598 (93 households) or about 9% of Tirilolo's population and a quarter (25%) of the Caisido population.

The local population growth rate is 1 – 2%/year, lower than in large cities where the growth rate may reach 2 – 3%/year. The dependency ratio in Caisido averages around 1 – 2 people, or in other words the productive-age population/workforce must support 1-2 unproductive people on average although they have 4-6 family member/houshold.

Table 3.4 Population by Age Group Suco Tirilolo by 2011

Aldeia	Total Family	Age Groups	Total	Productive (16-59)	Non Productive (0-15 & 60+)	Ratio
Betulale	382	0-5	147	1390	540	2.57
		6-15	227			

Aldeia	Total Family	Age Groups	Total	Productive (16-59)	Non Productive (0-15 & 60+)	Ratio
		16-35	766			
		35-45	317			
		46-59	307			
		60+	166			
Lutumuto	541	0-5	1107	4112	2457	1.67
		6-15	1242			
		16-35	1282			
		35-45	1392			
		46-59	1438			
		60+	108			
Caisido	150	0-5	58	381	320	1.19
		6-15	181			
		16-35	247			
		35-45	70			
		46-59	64			
		60+	81			
Lialaileso	126	0-5	145	299	317	0.94
		6-15	130			
		16-35	209			
		35-45	53			
		46-59	37			
		60+	42			
Parlemento	113	0-5	84	245	208	1.18
		6-15	82			
		16-35	84			
		35-45	91			
		46-59	70			
		60+	42			

Aldeia	Total Family	Age Groups	Total	Productive (16-59)	Non Productive (0-15 & 60+)	Ratio
Osso-Ua	127	0-5	83	300	281	1.07
		6-15	146			
		16-35	175			
		35-45	62			
		46-59	63			
		60+	52			
		46-59	70			

Source: Secondary Data from Suco 2015

Table 3.5 Number of Family Member

Suco	Aldeia	Total	Household	Fam. member/house
Tirilolo	Betulale	1937	383	5.06
	Caisido	719	174	4.13
	Lialaileso	583	119	4.9
	Lutu-Muto	2081	434	4.79
	Osso-Ua	606	123	4.93
	Parlamento	470	116	4.05
Subtotal		**6333**	**1349**	**4.69**
Triloca		2193	444	4.94
Ostico		1612	293	5.5
Vemasse		3075	700	4.39

Source: The Latest Suco Statistic, 2015

Observations in the field indicate that the number of households that will be directly impacted or may end up being located inside the cement plant's activity area is approx. 10 households at the mine site, 15 households in the nearest settlement to the mine site, and 7 households near the jetty. The rest of the households are within the activity influence area but would not need to be relocated.

There are no people known to reside at the planned clay site in Wailacama customary land. In the past, 15 households were known to have lived close to the planned clay site, but these families were moved next to the Baucau-Dili road during the Indonesian occupation. This relocation changed their administrative status from being residents of Suco Ostico to residents of Suco Vemasse. However, the customary land and resources remain in the ownership of the relocated families. Due to the relocation, their customary land around the clay site has not been cultivated except for the lands owned by one person who uses it as rice fields. Their displacement to the new location has not completely severed their connections to their original suco.

There is a trail passable by four-wheeled vehicles from the Wailacama site to suco Ostico, so the people do not feel physically or socially dissociated. The new settlement site is occupied by 71 households, consisting of 15 native Ostico households, 12 households of their descendants, and 44 immigrant households. These include the household of the customary chieftain’s wife, 7 households of the Waturo group and 10 households of the Watanaru baptismal group. They follow a patrilocal (woman-receiving) dwelling pattern. As immigrants, they have no customary right to local resources. They currently work as firewood collectors in Ostico’s forests.

3.2.3 Potential Labor Force in Suco and Subdistricts near the Project Area

The working-age population (ages 16-50) in the Baucau subdistrict numbers 20,597 with 11,586 men or 25% of the total population and 9011 women or 19% of the total population. The numbers in the Vemasse subdistrict are 2088 in total with 1077 men (25%) and 1011 women or 22% of the total population.

Nearly all suco in the Baucau Subdistrict have experienced 0.3% - 7% of population growth in the last five years, but the subdistrict as a whole has seen a population decline of -4%/year. The two extremes are Tirilolo with a growth rate of 25%/year and Suco Baruma with a steep decline of 28%/year. In the Vemasse Subdistrict, all suco experienced 2% - 19% population growth with particularly high rates of growth in Ossoala (19%/year) and Uaigae (15%/year) (see **Table 3.3 in sub chapter 3.2**). On average, each suco had a population growth rate of 12%/year, with the exception of suco Caicua where the population nearly doubles every year.

In suco Tirilolo, the recapitulation of family card data shows a total population of 6441, 3869 of whom live in the two urban *aldeia* while the remaining 2572 reside in the rural Caisido region. The potential workforce, especially in Caisido, is made up of 45% (1157) men and 55% (1415) women.

The numbers of men and women in the workforce are relatively balanced. In traditional sectors, employment opportunities for women mostly exist in gardening, farming, and firewood harvesting activities, while employment opportunities in the mining sector are more likely to attract the male segment of the workforce.

3.2.4 Employment Opportunities and Occupational Structure

The working-age population of 11,586 men (25%) and 9011 women (19%) in Baucau sub district plus 1077 men (25%) and 1011 women (22%) in Vemasse sub district is quite large for a region that ostensibly depends on subsistence farming in difficult conditions, both topographically and hydrologically, and with underdeveloped market activity. According to census 2010**,** only 50% of productive-age men and 26% of the women in Baucau subdistrict are employed, and only 60% of the men and 29% of the women in Vemasse subdistrict. However, there is no detailed breakdown available of their occupations.

This detailed picture of employment status and occupation among the local population (especially of the Baucau Subdistrict) had to be extrapolated from the recapitulation of family card data in suco Tirilolo. The recapitulation distinguishes between urban and rural *aldeia* (see **tables in the Appendix 3 for Suco Tirilolo Family Card Record, 2015**).

According to the family card records, 34 – 56% of the heads of households in the 'urban' areas (Baucau subdistrict) work in the traditional (agricultural) sector, while the remaining 44 – 66% work in non-agricultural sectors. There are 17 – 20 occupations listed, with schoolteachers, private sector employees, police officers, merchants, drivers, and public servants being the most prominent. Most wives tend to be stay-at-home housewives (38 – 81%), but a number work in the traditional farming sector (3 – 45%), and even in non-traditional sectors (17 – 18%). There are 9 – 11 kinds of occupations open to such women, the most prominent being schoolteachers, public servants, and public functionaries.

Among the children, 8 – 10% of boys and 2 – 6% of girls are employed. Most (92-98%) are still at school. The most common occupation, both for working age for boys and girls, is that of private sector employees. There are 6 – 9 other occupations found among these children (see **tables in the Appendix 3 for Suco Tirilolo Family Card Record, 2015).**

In inland (Caisido) communities, 69 – 95% are heads of households and 70 – 95% are wives working in the traditional (agricultural) sector. The rest of the community work in non-agricultural sectors. There are 2 – 11 kinds of occupations recorded among the heads of households with the most important being drivers, private sector employees, merchants, brickmakers, and public servants. Meanwhile, the most common occupation among the women is as merchants/traders. There are 1 – 2 other occupations such as teachers and public servants.

Their children, consisting of 14 – 38 working age and 15 – 40 girls, also work mostly in the traditional (agricultural) sector. Not many kinds of occupations outside the traditional sector have been successfully developed whether for boys or for girls (2 – 6 types in each case), some of the most important being merchants, drivers (for boys), public servants, teachers, and NGOs (see **table in Appendix 3**)

The tabulation of the data from Tirilolo shows that employment opportunities in urban areas are more diverse than those in rural areas. In rural regions, traditional (agricultural) occupations still dominate, both for wives and their children. The most common employment opportunities are as public functionaries, merchants, private sector employees, teachers, and public servants. This picture is likely to hold for other sucos in the Baucau and Vemasse Subdistricts. The planned construction of industries in the inland/rural regions would probably lead to a greater variety of employment and business opportunities. The plant is also likely to intensify transportation activities in the rural areas.

In the Wailacama aldeia, the heads of the 16 migrant households from Ostico work as either drivers (10) or merchants (6). Others who still have some kin relationship to the wives of the Wailacama natives (44 households) work as firewood collectors in Ostico forests.

The Ostico settlers in Wailacama used to rely on rice cultivation in their original habitations. Now, the lack of water resources has prompted them to move to non-farming sectors. In our opinion, the main factor in the abandonment of rice cultivation is the low productivity of the land and the difficulty of finding capable workers, while on the other hand working as drivers or shop/kiosk-owners offer a larger and certain income.

Meanwhile, although the immigrant families come from woman-giving groups, they weren't given the chance to cultivate rice fields or farms except for subsidiary food i.e. cassavas and sweet potatoes due to concerns that it might cause conflict (especially with regards to land possession issues in the future).

3.2.5 Level of Education

According to the 2010 census, the level of education among people over 5 years old in the two subdistricts closest to the project site varies between primary, pre-secondary, and secondary education. This census data gives a general breakdown of education among people aged 5 and up, especially by gender (male and female); but it does not give a clear picture of the level of education for every single family members, particularly the head of the family and his wife.

Once again, data from family card records in Suco Tirilolo is used to develop a better picture of the educational status within local families. The degree of education found in this suco is deemed fairly representative of other sucos in Baucau sub district.

The 2010 census shows that most people (68%) aged 5 and up in Tirilolo had primary school education, while 13% had preschool education and the same percentage had secondary education. Only 1% had any higher (college/university) education. Meanwhile, recent data for the two *aldeia* in Tirilolo's urban segment (Baucau sub district) shows that 6% - 9% of the heads of local households had junior highschool education, compared to 11% - 14% of housewives. 27% - 31% of the heads of households had senior highschool education, and so did 37% - 39% of their wives; 11% - 15% of the heads of households and 11% - 16% of wives had college diplomas or university edcucation. Among the younger segments of the population, 10% - 23% of boys and 12% - 16% of girls had junior highschool education; 19% - 24% of boys and 22% of girls had senior highschool education; and 9% - 12% of boys and 8% - 10% of girls had college/university-level education (**see tables in Appendix 4).**

Meanwhile, the general picture of education in the four inland (Caisido) *aldeia* of Tirilolo is: 10% - 20% of boys and 12% - 21% of girls had junior highschool education; 5% - 17% of boys and 12% - 25% of girls had senior highschool education; and 13% - 31% of boys and 13% - 24% of girls had bachelors' degrees **(see tables in Appendix 4).**

Therefore, the level education throughout the family (father/head of household, mother, son, and daughter), both in urban areas (Lutumutu and Betulale *Aldeia*) and in rural ones (Caisido: Caisido, Parlemento, Lialaileso, and Osso-Ua) has seen a considerable improvement. Unfortunately, there are no complete records about the level of education among heads of households and their wives in this region (unlike the records from the urban *aldeia*), so it is difficult to see whether there has been any improvement. All the same, the data on the education level of family members in the Caisido region above will play an important part with regards to job opportunities for the local youth.

Heads of households in the Caisido region appear to be highly motivated to put their children in school. This can be seen in the fact that 5 out of 7 case respondents have children who are undergoing higher education, whether in Dili or in Indonesia. They generally hope that their children will be able to have a better life without being limited by their origins in Caisido.

3.2.6 Vulnerable Groups near the Project Site

The number of vulnerable people (including elder women, elder men, elder men's spouses, invalids, and widows) in the *aldeia* closest to the project site is relatively low, being around 6% - 11% of the total population. The highest number is found in the Osso-Ua *aldeia* at 11% of the total, while the lowest is in the Parlemento *Aldeia* at 6%. However, these numbers are relatively high when compared to other *aldeia* in suco Tirilolo, being twice the proportion of vulnerable groups in urban areas (3% - 5% of the total population).

Table 3.6 Number and Category of Vulnerable Group

Category	***Aldeia***				***Total***
	Parlemento	**Lialaileso**	**Caisido**	**Osso-Ua**	
Elder Women	6	10	8	17	31
Elder Men	6	13	20	17	56
Elder Men's Spouse	5	8	10	10	33
Invalid	0	4	2	1	7
Widow/Women Housewive	7	3	11	12	32
Infant	84	145	58	83	370
Sub-Total	108	183	109	140	540
Total Population/*Aldeia*	416	594	823	598	2431
Percentage (%) of Vulnerable Group	23	31	13	23	22
Number of household in *Aldeia* Wailacama	71				
Ummane Group: Number of households	44 (61%)				

Source: Elaborated from Suco Family Card Tabulation, May 2014

In the context of the planned project, residents aged 0-6 years (toddlers and small children) can be categorized as a vulnerable group due to the likelihood of dust and noise exposure.

The Timor Leste government provides vulnerable groups with a $30/month allowance on a quarterly basis through its department of social affairs. This sum is deemed sufficient to fulfill these individuals' subsistence need. The price of moderate-quality rice is around $10 for every 25kg sack. With 4-5 family members per household, the average family takes 7-10 days to consume that much rice. This shows that a vulnerable household's rice requirements can be fulfilled out of the welfare allowance. The only constraint is that the quarterly payment of the allowance may make it difficult to maintain a steady subsistence. However, nearly all households in the four *aldeia* cultivate gardens and orchards for their own private needs, so the quarterly distribution of the allowance can be seen as a helpful addition to the family's own produce towards the fulfillment of their subsistence demands.

About 44 households *ummane* group (women-giving group) are all stay in *aldeia* Wailacama following the *fetosaun* (women-receiving group). However, they dont have any access to main resource (land). Their livelihood depend on collecting firewood in suco's secondary forest (common property).

After East Timor's independence, the government decided to provide welfare funds for veterans and guerrilla supporters ("clandestines"). The "clandestines" are people who provided non-combat support to Timorese guerrillas, such as by supplying them with food. The high degree of secrecy about their identity means that the number of people in this category (whether in Ostico or in Tirilolo) is relatively small. Guerrilla fighters are similarly few and far between. As an expression of gratitude, the government offers varying allowances that depend on the beneficiary's time in service. There are three known categories of allowances:

a. 4-7 years in service: $1,000 one-time payment

b. 8-14 years: $275/month, with an initial one-time payment of $6,000

c. 15-19 years: $375, with an unknown initial payment

The stipends/allowances for the third category remains unknown since there are very few beneficiaries in this category in Baucau and none were encountered during the study. Neither did we manage to find a detailed numerical breakdown of how many people are eligible for these allowances in total, which is unfortunate since the information would be important in assessing the people's ability or opportunity to develop the fulfillment of their subsistence needs. In Ostico, one of the beneficiaries of the "clandestine" stipends stated that he used the funds to rebuild his brick/stone house. In Caisido, a veteran we managed to interview said that the initial payment he received was saved for his son's education in a college in Dili, while the monthly allowances were used to help him fulfill his everyday needs. He had not thought of improving his house with the money. The reason for this will be explained in another sub-chapter on the farmers' economic morality.

3.2.7 Community Health Situation in Caisido

Since the establishment of an auxiliary community health clinic in Caisido, the number of visits by local people to the clinic has been relatively high. There has been an average of 3000 visits per year to the clinic; the proportion of genuine medical complaints is also high, ranging from 50% to 98% of the total number of visitors (**see Table 3.7 and Figure 3.1 & 3.2 below**). The clinic is staffed by a doctor (educated in Cuba) and three nurses. The clinic serves the community's health needs except for the lepers, who are specifically under the care and custodianship of church sisters. The clinic's doctor stated that he would have liked to keep tabs on the lepers' medical situation and development but the information has been hard to get. He believes that he needs the information to plan the health service program for other residents due to the small possibility of contagion to other community members who may visit the clinic. The information is deemed necessary for early warning and prevention against such contagion.

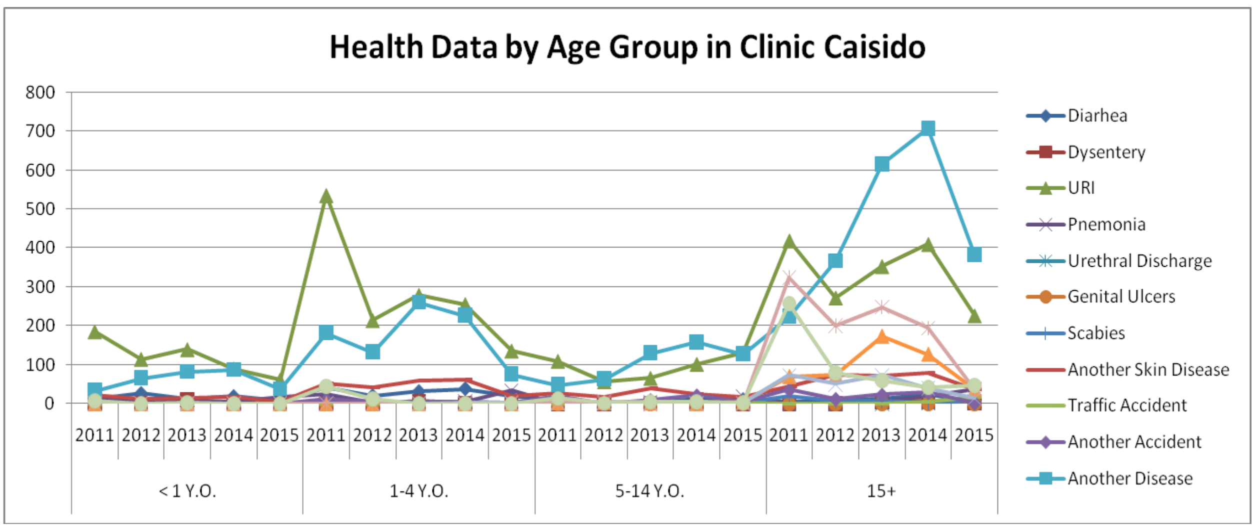
Amidst such difficulties, the government is planning to conduct a census on family health. This census will probably be very useful in informing disease prevention, education, and treatment efforts along with the provision of adequate and appropriate medical supplies to the clinic.

Table 3.7 Health Table by Age Group per Years

Health Table By Age Group per Year

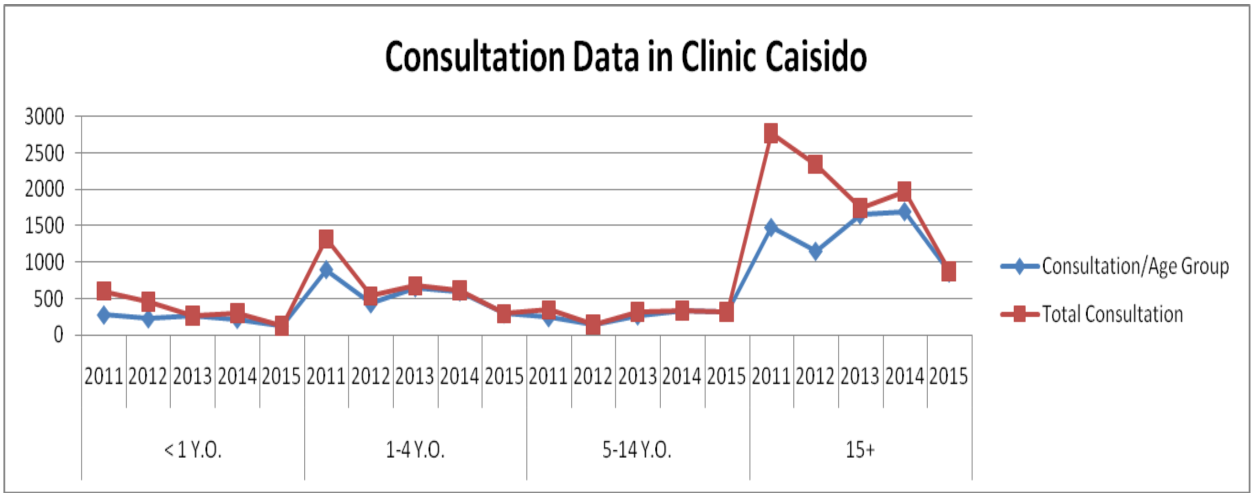
Disease	< 1 Y.O.					1-4 Y.O.					5-14 Y.O.					15+				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Diarhea	12	27	11	19	6	43	21	32	39	19	6	2	3	13	11	4	10	12	25	2
Dysentery	0	0	11	0	1	2	0	6	2	2	0	0	2	2	1	1	0	5	6	2
URI	185	114	139	89	60	536	214	279	255	135	109	56	65	101	131	419	272	353	410	226
Pnemonia	18	6	4	4	17	23	3	5	6	34	0	0	3	0	18	1	0	4	20	36
Urethral Discharge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5
Genital Ulcers	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0
Scabies	1	0	0	1	0	4	0	5	0	0	7	0	3	0	2	19	8	7	2	6
Another Skin Disease	21	12	15	18	5	52	42	59	60	20	27	16	40	24	18	44	73	70	78	37
Traffic Accident	0	0	0	0	0	0	0	0	0	2	0	0	1	4	2	0	0	1	4	17
Another Accident	0	1	0	0	0	11	4	2	4	2	19	1	9	21	5	36	12	23	29	2
Another Disease	33	66	82	87	37	182	133	260	227	76	48	63	130	158	127	224	367	616	708	383
Gastritis	0	0	0	0	0	0	0	1	0	0	3	4	2	1	5	70	74	173	127	37
Bronchitis	0	0	1	0	0	0	0	1	2	3	4	5	2	2	2	72	50	73	40	14
Rheumatism	0	0	0	0	0	0	0	1	0	0	3	2	0	1	0	325	201	249	195	38
Anemia	8	0	3	0	0	44	12	0	1	0	14	2	6	6	3	257	79	59	43	47
Consultation/Age Group	278	226	266	218	126	897	430	651	596	293	241	151	267	333	325	1472	1148	1646	1689	852
Total Consultation	607	465	269	301	129	1323	542	681	619	298	351	153	321	346	323	2775	2344	1747	1971	877

Source:Tabulation from Clinic Caisido Statistical Report 2015



Source: Tabulation from Clinic Caisido Statistical Report 2015

Figure 3.1 Graphic of Health Data by Age Group



Source: Tabulation from Clinic Caisido Statistical Report 2015

Figure 3.2 Graphic of Consultation Data

The information about plans for a cement industry raised the doctor's hopes that he would be able to map the health status and disease patterns in his area of responsibility. This data will be important not only for the doctor's disease management efforts but also for the project in developing healthcare aid programs for the local population around the project. Therefore, it would be a good idea to develop cooperation by offering aid in the form of improvements/reinforcements to the human resources available to the clinic and the provision of technological apparatus (especially computers) for database storage.

Reports from the clinic indicate that, since the opening of the clinic (2011) to the present (first three months of 2015), nearly the entire Caisido population has visited the clinic and there are probably even some visits by outsiders (since the total is 108% – 144% of the Caisido population). The proportion of people with actual diseases or medical complains is 56% - 98% of all visitors.

Patients came from all age groups. Among children under 1 year old who visited in 2011 – 2015, 9%-13% had actual medical complaints; so did 16% - 26% of the visitors aged 1 – 4 years, 4% - 19% of visitors aged 5 – 14, and 54 – 67% of visitors aged 15 years and above. This seems to indicate an increasing incidence of disease as people age. The number of medical complaints from infants under 1 year old is relatively low, probably since they still consume breast milk and thus their health is relatively well-maintained. As children enter the 1-4 years age bracket, the number of medical complaints begins to increase while they are being weaned and converted to solid food. The next age bracket (5 – 14 years) sees further reduction in adaptive capability. In the final age bracket (15 years and over), the predominant complaints are those of old age; the large number of anemia, rheumatism, bronchitis, and gratitis cases hints that the local people's physical condition tend to deteriorate as they enter advanced age.

The most common types of diseases among all age groups are the big three (Upper Respiratory Tract Infections/URI/*ISPA*), other skin diseases, and other diseases not classified in the table before. There is an increased incidence of diarrhea among children 1 – 4 years old. This may be due to difficulties with the weaning process. Similarly, the prevalence of URI can be attributed to the dry and dusty environment. Another observation is the prevalence of diseases and disorders associated with dehydration due to the limited supply of clean water. It is interesting to note that there are no indications of malnutrition despite the uncertain state of the local population's subsistence. Is it possible that some of the other diseases recorded in the clinic can be attributed to malnutrition? However, people living in subsistence economic conditions are not necessarily poor households. The subsistence category essentially means that the people are able to fulfill their calorific needs, but not to excess. However, the situation as a whole still seems quite risky, since natural disasters or disturbances may render the local population vulnerable to mass famine.

Table 3.8 Number of Visits and Patients at the Caisido Auxiliary Clinic

Year	Total Population (Caisido)	Total Visitors	(%)	Total Patients	(%)
	2431[1]				
2011		5056	208%[4]	2888	57%[2]
2012		3504	144%	1966	56%
2013		3018	124%	2825	94%
2014		3237	133%	2849	88%
2015[3]		1627	67%	1594	98%

Source: Elaborated from clinic report

[1]) Number of visitors in 2015 but only in the first quartal (3 months)

[2]) % Calculated from total visitors

[3]) Total of population as asumed in the settle condition (relatively fixed), due population growth in Caisido are 1%/year.

[4]) % Total visitor calculated according to total population

Table 3.9 Number of Visitors and Patients by Age Group

Year	***Total Visitors***	***Total population/age group***							
		<1 year old		1 – 4 year old		5 – 14 year old		15+	
		Total	%	Total	%	Total	%	Total	%
2011	5056	607	12%	1323	26%	351	7%	2775	55%
2012	3504	465	13%	542	15,5%	153	4,4%	2344	66,9%
2013	3020	269	8,9%	681	22,5%	321	10,6%	1749	57,9%
2014	3237	301	9,3%	619	19,1%	346	10,7%	1971	60,8%
2015	1627	129	7,9%	298	17,9%	323	19,9%	877	53,9%

Source: Elaborated from clinic report
% calculated from total visitors by age group

3.3 Economic Activity

3.3.1 Ecological Condition

The ecological and geographical situation of Timor is marked by environmental destruction and degradation, which creates serious problems for Timor Leste. Another description of the situation in

Timor is: *'An island-wide ecological crisis, caused by swidden agriculture systems and population pressure..'* Pannel also states the *'characterisation of subsistence systems as a voracious slash and burn agricultural regime', with 'low agrarian production'* (Pannell, 2011:217).

Pannel's opinion is meant to describe Timor as a whole, but some of these characteristics are also visible in the Caisido (inland) region of Tirilolo. Informer's statements on the migration of the Da Costa and Flores groups to the Baucau region and the use of Osso-Ua as a leper colony around 1945 indicates a substantial history of settlement in the area. The signs of environmental degradation and destruction can be seen in the form of empty uncultivated fields overrun with bushes and shrubs. Osso-Ua still has some secondary forests area that experiences constant deforestation under the pressure of logging for building materials and firewood. The agricultural land is cultivated under a slash-and-burn cultivation system that rotates from one farming plot to the next on a 3-year cycle (fallow system). The soil is riddled with limestone boulders which limits local subsistence patterns to low-productivity agrarian production. This situation leads to considerable population pressure. This population pressure is attributable not to a large population but to the low productivity of arable land (especially dry orchards) in fulfilling subsistence needs.

Agricultural water sources are relatively rare, except in Osso-Ua where water is largely limited to domestic uses. The exploitation of natural resources depends heavily on the availability of rain, so the types of crops that can be cultivated are relatively limited and cannot respond to market demands. Even when the locals sell their produce on the market, it is merely to obtain cash for the fulfillment of other needs. This pattern is theoretically categorized as subsistence farming. The longstanding isolation and lack of attention from the outside has led the Caisido (inland) peoples in Tirilolo to develop their social and cultural organizations in a 'rural' or 'parochial' manner, as described by Appdurai: *"… place is produce through the interaction of social relation, expression of identity and the practice of culture."* (cited from Pannel, 2011:220).

3.3.2 Land Use and Land Status

The Caisido people in Tirilolo (*Aldeia* Parlemento, Caisido, Lialaileso and Osso-Ua) distinguish various types of land according to their status and usage.

A. Land Status

Land in Caisido is divided into two categories according to status, namely private land/property and government property. Government property generally covers all land not cultivated by local residents. This category has unclear boundaries since there are many fields that have been left fallow and become scrublands but are still claimed as private property. Some land around Osso-Ua is full of perennial plants and not cultivated but claimed as private property. One exception is the mine site, where the secondary forest is categorized as government property. This land is not claimed or cultivated but the local residents harvest the trees for building materials. The key difference is supposed to be about whether the land is cultivated or not but the difference between the two remains ill-defined except when private owners have a clear idea of the boundaries of their property. Some issues have surfaced with regards to the scrublands on either side of the access road from the Baucau –Parlemento *aldeia* main road. The land is generally uncultivated but claimed as private property. This claim is understandable since the local cultivation pattern follows a 3-year cycle of land clearance and crop rotation. The rocky soil and lack of knowledge about fertilizers means that landowners have to restore their lands' fertility by leaving them fallow for a certain interval prior to recultivation. Humus for the land is obtained from the ashes of the burned bushes and scrubs.

Land ownership status is generally not supported by official documentation. Claims to possession of land are corroborated only by the statement of neighboring landowners. The Suco administration does not make much fuss about formal land ownership in any case since there is currently no taxation system for privately owned land. The village doesn't have detailed land registers that record the type, extent, and ownership of private land for tax collection purposes.

Field boundaries take the form of piled stone fences. The owners seldom know the exact area of land they have in numerical terms. Land is commonly measured by means of the stone fence boundaries, and the local residents usually quote how many fenced plots they have. 24 years of Indonesian occupation in Timor Leste had not successfully introduced the concept of quantitative land measurement. This can be explained by the local system of slash-and-burn cultivation, where land clearance mostly depends on the availability of labor to process and estimate the amount of produce needed to fulfill subsistence requirements.

B. Land Use

In terms of land use, the local population distinguishes between four categories, namely paddies/rice fields, forests, gardens/orchards, and bushes/scrubland.

Paddy Fields. Information from the Chefe Suco in Tirilolo and Vemasse state the existence of rice fields in the local area but not the areal extent in each suco and the fields' geographic location. In the Caisido area near the planned project site, there is an approximately 0.5 ha rice plot in the *Aldeia* Osso-Ua. This field draws water from a local water source so that the owner can plant upland rice. Due to the cultivation of paddies on the land, the owner categorizes the plot as a rice field.

Statements from the chefe suco and our own field observations indicate that the rice fields in the area depend heavily on rain. Once the land has been used to grow rice, it cannot be reused for other crops due to the lack of water for further cultivation. Some sucos have ricefield plots watered from springs in Bucoli (Palmer, 2011:145) and in the Wailacama *aldeia* (the planned location of the clay source) but the lack of farm labor means that the field only produces one crop per year or is left completely fallow.

Land cultivation is done in a very simple manner; once the land has been watered, a water buffalo is used to churn up the soil until it is suitable for planting. The government has provided aid in the form of tractors for rice cultivation, but the local population seems unable to use the machines effectively so their use remains very limited. Ricefield owners who do not own buffaloes may cooperate with the owner of a buffalo in cultivating his land. In this arrangement, the owner of the buffalo gets the same share as the owner of the field. The owner of the buffalo becomes responsible for the cultivation of the land all the way to the harvest. This system has not seen much development since landowners are often reluctant to share their produce.

For the most part, ricefield owners also own a buffalo (or more), so their land cultivation work is done with the use of their own buffalo by the head of the family (male). The next phase is to plant cultivated rice seedlings with the aid of several workers. Most of the workers in this phase are women, and are generally relatives or neighbors of the owners. Non-related workers are paid about $5/day while relatives only receive food during the planting work and a discretionary amount of the produce later on based on their contribution during planting and their economic condition. Once the rice has been planted, it is generally left without any further care or fertilizers until it is ready for harvest. This simple rice cultivation regime results in very low productivity. Calculations during the field study indicate that a 0.5 ha field planted with three sacks' worth of rice seeds would produce 60 sacks of rice of the same quality. After the rice has been dried, the end result is 30 sacks weighing 25 kg each.

This low production rate and scarcity of labor has prevented rice cultivation from becoming a major factor in economic development. Garden/orchard cultivation has a better potential for surplus accumulation than rice cultivation. One of the problems is that rice fields (especially in the Vemasse subdistrict) cannot be used to cultivate other crops. The land gets waterlogged during the rainy season, making rice the only option available. The rice produce is generally not sold but kept for the farmer's own consumption.

The lands claimed as rice fields in the Osso-Ua *aldeia* are planted with dry (upland) rice. These lands do not generally receive much excess water so the owner retains the choice of planting them with other crops.

Ricefield owners, especially in the sucos of the Baucau and Vemasse districts, are likely to be the oldest settlers in each suco in a similar fashion to the villages in West Timor (NTT, Indonesia). Rice fields are owned by traditional elites since rice represents a more certain means of subsistence compared to other traditional sources like coffee (Achmad, 2002). In Timor Leste, especially in Baucau and Vemasse, the merging of lineage groups into baptismal name groups (as explained earlier) makes it difficult to decide (for example) which Belo or which Freitas is directly descended from the founder group in the tribe. However, land clearance and cultivation for rice fields tends to demand considerable amounts of labor, so only local elites are capable of mobilizing the necessary workforce. Our meetings with ricefield owners in Vemasse and Ostico tend to support the notion that they are usually some of the oldest residents in their suco. The limited availability of labor and water has prevented these ricefield owners from developing much better subsistence conditions, except when they also have orchard lands that can be used to plant cash crops.

Forest. Forests around the cement plant site are mostly located in the Osso-Ua *Aldeia* of suco Tirilolo, as we have mentioned before. Other forested areas are found in the Wailacama *aldeia* (formerly part of suco Ostico) and the buffer zone of the planned clay site inside Suco Ostico. The secondary forests in these two areas are fairly thick. Both areas are currently exploited by the residents of Ostico and the Wailacama *aldeia*. They see the forest as a place to hunt and to harvest wood for building materials (whether for their own use or for sale) or for firewood. The *chefe* of Wailacama *aldeia* stated that virtually all immigrant families (44 households) in his jurisdiction collect firewood as their primary livelihood. There is no definite information about how many trees have been cut down for their wood, but he said that most locals pick firewood from already fallen trees. There is no clear information about the average income of firewood collectors either, but each collector can probably earn \$10-\$15 per harvesting trip at a price of \$0.5 per firewood bundle. One Wailacama resident can be regarded as an entrepreneur for his success in earning \$200 - \$300/month by selling firewood to the city. For this purpose he hires large trucks at a price of \$40/ trip.

Some Ostico residents engage in similar activities, but they only fell trees to find building materials for their own houses. One of the things that may cause some ambiguity over land ownership in this suco is the presence of candlenut plants growing in local settlements and nearby forests. Lands where these trees grow may be claimed as private property even though the land would otherwise be seen as public forests when judged by the variety of other plants growing in the vicinity. This Ostico forest is located outside the clay mining site. Almost all the land in the projected clay mining site are rice fields, both those presently cultivated by their owners and those that have been abandoned by owners who moved to a different area, namely the Wailacama *aldeia* as we have described in a previous section.

Since the introduction of white teak trees by the Indonesian government, a number of Wailacama residents have begun to plant these trees near their settlements. The tree takes 5 years to grow before it is ready to harvest. The white teak is generally used as house construction material.

Local residents in the two *aldeia* closest to the forest have not mentioned the existence of any forbidden or sacred ground inside. Neither do they view the forest as the location of dead ancestral spirits that must not be disturbed. Their belief system holds that their ancestral spirts reside in the customary house (*rumah adat*) and tomb.

Gardens and Orchards. Horticultural lands (gardens and orchards) are the main source of subsistence for the Caisido people (Parlemento, Caisido, Lialaileso, and Osso-Ua). This land is mostly dry lands planted during the rainy season. Gardens are orchards are normally located close to the owners' houses or settlements. Cultivated orchards are usually protected with stone fences to prevent interference by livestock. Most residents own more than one fenced orchard located close to each other, or alternatively a single large orchard (about 1 ha) divided into smaller plots with stone fences. The division into multiple sub-plots usually correlates with the planting and cultivation strategy. Most gardens/orchards are worked for 2-3 years and then moved to a different location for the same interval. This rotation is meant to restore soil fertility since the orchards are given no fertilizers whatsoever. The only measure for increasing soil fertility is burning the brush growing on the land. There is no effort to use livestock manure as fertilizers either since most livestock are not kept in pens but rather left to roam free in the scrublands around the village.

The cultivation of the orchards begins in August-October or November. Planting should be accomplished by December or January at the latest. In the event that the rains begin in December, the planting process is likely to fail. The work from August to November mostly consists of land clearance and the burning of the cut-down vegetation. The clearance can be done with the aid of unpaid labor from close relatives in return for help in clearing these relatives' land in turn. Despite this extra labor, the amount of land opened is still limited according to how much land the owner can realistically manage by himself. The tending of the orchards is generally performed only by members of the nuclear family since each family is fully occupied with tending its own land and there's not much opportunity to enlist help from others. Every person/household has an associated garden or orchard so there are no landless laborers to hire either. Neither are there any rent or sharecropping arrangements apart from the lending of some land to the husband of a sister who lives with his wife's kin group. Despite this lease of land, the lender does not incur any obligation to help in the management of the oldest male relative's orchards from the wife's side (a form of corvee labor). This is due to the fact that every single farmer must devote full attention to tending his/her land in the face of their dependence upon the whims of the weather. Climate change or early rains inevitably influence the choice of crops to plant and how much land should be cultivated.

After the land has been burned, it is tilled with hoes. Garden/orchard lands usually have stones strewn randomly across them, so plants are normally placed in an irregular manner to make use of the available non-rocky patches of soil. The most important crops are maize and groundnuts. The maize is normally consumed by the family and livestock, while the groundnuts are primarily used as a cash crop. Other crops commonly planted in the area tubers like cassava and sweer potatoes and vegetables such as green tomatoes and chili peppers. The tubers are primarily meant for subsistence while the vegetables are usually intended for both subsistence and cash.

There are two main planting strategies used by garden/orchard owners. Those who own large numbers of plots may plant a single type of crop in every fenced plot to maximize production, especially for cash crops such as chili or shallots. People who use this strategy usually intend to sell all their produce.

Although each plot is designated for only one specific kind of crop, usually the larger plots are still reserved for subsistence staple crops. The amount of land planted depends on estimations of subsistence requirements. More focused monoculture of cash crops is likely to be more profitable for the fulfillment of subsistence needs, but this strategy is very uncommon except among people who have enough land to be worth dividing into a number odf monoculture plots. This strategy is usually adopted when there is considerable need for a cash income, for example by a respondent with four children who are undergoing higher education in Indonesian universities (in Surabaya, Malang, and Jakarta).

The second strategy is most prevalent among farmers who have a relatively large amount of land concentrated in a single contiguous expanse. This expanse is then fenced up into several smaller plots and each plot is used for a single type of crop. In this case the largest plots also tend to be reserved for staple crops like maize and groundnuts. In this case the owner errs on the side of safety by prioritizing self-subsistence needs over cash income.

These first two strategies depend on the farmer's diligence and the availability of labor. One example is a case respondent who chose the first strategy. The respondent is a Muslim man, and despite his advanced age he continues to put a great deal of work into his orchards for his children's sake. Any surpluses are stored in the form of livestock or sent directly to one of his children. Thus, these surpluses do not go into improving his wood-and-bamboo house as in the case of most other villagers. His reluctance to renovate his house is based upon his reluctance to show off his material wealth. This relates to the local standards of morality, which will be discussed in a later section. Despite his Islamic beliefs, he uses a baptismal surname (Belo) to affirm his status as a native resident of Parlemento, and as a member of the lineage he continues to contribute livestock for ceremonies in his lineage's customary house (*rumah adat*).

The second case respondent is a horticultural farmer who also owns a simple mom-and-pop store. He has the motivation to maximize the productivity of his orchards, but the demands of running the store prevent him from devoting his entire attention to farming. He divides his land into a dedicated plot for staple crops such as maize and groundnuts, while secondary crops such as green tomatoes, cassava, and sweet potatoes are planted haphazardly in the spaces between the main crops.

The first respondent tends to sell his produce immediately at harvest-time, but the second respondent prefers to hold on to his groundnut harvest until the price rises. For the vegetable crops, the second respondents harvests them in stages according to their differing harvest times and then sells them directly in the old market. The proceeds from the sale are used to buy goods to resell in his shop. This allows him to fulfill his subsistence needs at the same time he replenishes the stock in his shop. His profits and/or surpluses are saved up by buying livestock such as pigs, chicken, and goats.

The planting and sale strategies utilized by those two farmers are not common among other gardeners/orchard-owners. Most of them have rather small plots (topping out around 50 x 50 m or 50 x 75 m), so they lack the capability to adopt the strategies used by larger landowners. They mostly plant a variety of crops such as maize, groundnuts, shallots, and chili peppers with some sort of intercropping or random planting pattern. The main consideration in choosing which crops to concentrate on is the demands of subsistence (maize) and for cash (groundnuts, shallots, and chilis). However, the small amount planted for each type of crops means that the yield (especially for cash crop) tends to fluctuate. Sales are made in stages as each crop ripens for harvest. The lack of traders who visit the farmers to collect produce means that the farmers must go to the market to sell their produce by themselves. There are merchants in the market who would buy up the entire groundnut crop for resale, but none for the vegetable products so the farmers have to sell them directly to individual shopkeepers in the market or even to customers in the street.

The horticultural situation in Osso-ua is relatively better than in Parlemento, Caisido, dan Lialaileso. The gardens and orchards in Osso-Ua are quite suitable for vegetable crops such as shallots, upland rice, and chili peppers. All of these are regarded as cash crops. The relative remoteness of the area from the closest public transportation facility (around 4 km from the closest point served by public transportation cars going to Caisido) means that the farmers tend to be reluctant to sell their produce directly in the market. The produce is normally sold to buyers who travel from the city (the old market) to pick up the commodities at Osso-Ua.

It is not easy to calculate the productivity of local gardens/orchards since the harvest is normally performed in several stages, except by the owners of particularly large plots. Most owners do not know how much horticultural land they have and use, and for the most part they only count how many fenced plots they have. Therefore, the calculation of horticultural income is done by fenced plots.

The *Lia nain* of the suco describe a set of ritual strictures for the management of gardens and orchards from the land clearance phase, to the burn, the tilling, the planting, the harvest, and all the way to the storage of the harvested produce. We do not study this matter in detail in this study since it is deemed irrelevant for a social assessment. The main objective in understanding the local population's economic activities is to figure out whether they are already capable of fulfilling their subsistence needs with their main sources of livelihood, how they regulate their production and consumption, distribution systems (especially within kin groups), how they accumulate surplus, and how they invest surplus to guarantee the household's future economic sustainability (especially in the context of women's needs) as we will explain in a later section.

Bushes and scrubland. The bush and scrublands are usually regarded as reserve lands for the 3-year plot rotation system. These lands are covered in long grasses and bushy growths (especially *Imperata cylindrical, Cromolaena adorata, and Lantana camara L*). These sites are also used as pastures for buffaloes, oxen, and goats. The parts where the grasses and shrubs grow densely are ecologically regarded as a normal part in the succession towards secondary forest. The bushes and scrub do not cover the land in a fully continous manner, so external parties are prone to categorize the land as uncultivated wastes or government property. However, further exploration will reveal linear piles of stones that mark out field boundaries. Each farmer knows the boundaries of their plots. Most of the bushes and scrubland in Caisido are located outside the projected mine and plant sites, except in the Wailacama *aldeia* where some is found in the planned clay extraction site.

3.3.3 Tenure System

The land as the main resource for the fulfillment of the local population's subsistence needs is usually obtained through ancestors from the people's forebears. There is no clear indication of when the ancestral settlers began to reside in the Caisido region. Theoretically speaking, given the lineage-based social structures, it is likely that the ancestors only go two generations back (current residents' fathers and grandfathers). As such, the Caisido region was probably settled around 75-100 years ago.

Those estimations aside, the local residents' assertions that their land ownership proceeds from ancestral rights shows that they feel that they have the rights of possession. This possession usually comes without any form of written or formal proof. The local population generally does not feel any pressing need to obtain formal acknowledgement of their land ownership since the legal status of their claim to the land has never been seriously disputed before. Only with the plans for the construction of a cement factory does the issue of ownership come to the fore. This is particularly relevant to the bushes and scrublands since there is some concern that the lands being left fallow might be claimed as government property despite the existence of ownership markers in the form of stone fences or boundaries.

Apart from these individual ownership claims, the local population would also like to stake out their communal rights as members of the Belo group. The Belo group is a territorial control identity for all the people acknowledged as members of the Belo group. Other baptismal surnames will find difficulties or may even be barred from claiming possession of lands within Belo territories even if they choose to marry a woman from the Belo territory. The only kind of opportunity that may be made available is as a temporary borrower in lands owned by the wife's family.

Ownership and possession of land is passed down through inheritance. Only sons receive inheritance rights while daughters do not, although the latter remain the ward of the oldest son in the family (*lia nain*). All sons have a claim to the inheritance but the control of the land is given to the oldest son, who will then arrange for the distribution of workable land; if any son is a minor or is uninterested in faming (such as if they have already a job in the city), the right to manage the land is handled by the *lia nain* who also takes responsibility for the distribution of subsistence needs. In this case the wife usually regulates the management and fulfillment of common subsistence needs.

When a son relinquishes possession rights to the land, such as by selling off his share, his economic and political status as a lineage member is no longer under the *lia nain*'s responsibility and he loses the right to participate in decision-making at the kinship and hamlet/*aldeia* level. Therefore, the relinquishment of land possession rights is a decision that cannot be taken unilaterally and must involve both the *lia nain* in the kinship group and the *lia nain* for the village as a whole.

Daughters do not get inheritance rights since they will eventually fall under their husbands' custody. If the husband dies without descendant, the husband's property will fall under the management of the oldest male in the husband's kin group. However, if the property comes in the form of land, the widow may still have rights to make use of the land. In this regard, interview results indicate that most wives and mothers would invest the property of a deceased husband towards their children's education. These children represent the mother's principal hope for future livelihood.

If the widow wishes to return to her parents' kin group, she becomes a ward of her group's *lia nain*. If she wishes to remarry and the new husband would like to move in with the wife's kin group/family, he must seek the approval of the woman's *lia nain* (the oldest male in the lineage elder).

In any case, no matter who dies in the relationship, customary exchanges between woman-giving and woman-receiving parties remain in force. Indeed, if the widow chooses the remarry, it merely creates a larger network of exchange relationships. Local informers state that it is very difficult to avoid the customary burden brought about by these obligations.

3.3.4 Animal Husbandary

Animal husbandry is one of the traditional sectors in the livelihood of the Caicido population (in Parlemento, Caicido, Lialaileso, and Osso-Ua). However, not all families own livestock. Livestock are mostly treated as a way to invest the surplus obtained from agriculture, especially gardening/orchard farming. The most common types of livestock are horses, water buffaloes, oxen, goats, pigs, and chicken. It is not easy to find out the exact number of livestock and the number of households that keep them since the Suco administration has never performed any census on livestock ownership. The following **Table 3.10** is based upon estimations offered by the Village Secretary and *Chefe Aldeia*, though neither of them could give precise estimates of the combination of livestock types and how many of each type are owned by individual families. Even so, this data may prove useful since it still contributes towards the main research objective of observing the forms and functions of traditional investment in communities that still struggle with subsistence needs. The functions of livestock will be explained in the following sections, while surplus strategies will be described elsewhere.

Table 3.10 Livestock table and ownership

Livestock	Caicido		Lialaileso		Parlemento		Osso-Ua	
	Total Family: 184		Total Family: 127		Total Family: 99		Total Family: 184	
	Total Owner	Total Animal	Total Owner	Total Animal	Total Owner	Total Animal	Total Owner	Total Animal
Goat	120	200	110	250	90	100	127	200
Sheep	100	250	115	230	90	120	130	150
Horse	15	25	11	36	15	30	16	30
Cow/Buffa	8	40	17	60	18	30	15	30
Pig	180	250	129	160	118	230	127	260
Chicken	182	400	180	360	118	230	238	260

Source: Tabulation From Suco Tirilolo 2015

Chicken. Buffaloes, pigs, and chicken are symbols of wealth that carry not only economic value but also considerable social and ritual significance. Chicken are regarded as livestock with the lowest value. Despite this low economic value, chicken provide a way to fulfill emergency demands at very short notice. These demands include offering food to important guests, providing aid to neighbors in distress, making contributions to celebrations of life-cycle events, and obtaining cash to cover unexpected needs.

Goat and Sheep. Sheep and goats are important livestock for *belis* contributions. They also provide a source of quick cash, being the next most easily sold type of livestock after chicken. Sheep and goats are usually not bought for household consumption but rather become the first choice for surplus investment. Their relatively affordable price compared to pigs makes them some of the most intensely traded livestock in the market.

Pigs. Pigs have a substantially higher economic value relative to chicken and goats; they also play an important part in various individual and group rituals, in addition to being acceptable gifts or dowery given by the wife's family to the husband's or vice versa on ceremonial occasions. A gift deemed inappropriate or inadequate may be taken to signify a lack of respect that may lead to friction in the relationship between the two parties. Pigs are also an important component in sealing deals or agreements to resolve past disputes.

Buffalo. Are the most valuable type of livestock and also very important in traditional religious rituals as well as *belis* contributions. Buffaloes are used in death rituals, rituals in the customary house (*rumah adat*), and bonding activities when the entire lineage gathers at the end of the year (for Christmas and New Year).

3.3.5 Traditional Fisheries

The planned jetty site on the Osso-Ua coast is currently used by some Osso-Ua villagers for fishing activities. They go out to fish when the waves are not too high. Their fishing activities are conducted with very simple equipment such as fishing poles with lines and bait as well as rowboats.

The fishing methods are also quite simple; one of the boat's crewman takes the fishing tackle a short distance out to sea, about 50-75 m from the coast. After the line is released, the boat does not return straight away to the beach but waits for some time while moving the fishing tackle around in several directions to attract attention to the bait. Once a fish has taken the bait, somebody on the beach would alternately draw and play out the line until the fish tires out. When the fish's resistance has subsided, the line would be fastened to a bamboo pole sunk into the beach. This procedure is repeated until some or all of the fishing lines have caught enough fish.

This activity may provide up to $10 - $20 per fishing trip. Larger fishes are usually sold to buyers in Baucau, who can be contacted over a cellular phone. Fish that are not (or cannot be) sold are not preserved in the form of salted fish but used for housed consumption.

Everyone can engage in fishing but a boat provides the owner with an important productive asset in this regard. Relatives may borrow the boat; so can non-relatives, but seldom more than once before they acquire their own boats.

3.3.6 Non Farming Activities

Caisido's isolation and the difficult circumstances for agriculture has not prompted the development of non-farming activities. There is only 1 small shop/kiosk owned by the chief *Lia nain* in the Suco, 2 canned drink sellers, and 1 greengrocer. The *lia nain*'s shop sells several types of canned and packaged drinks, children's snacks, light dry snacks, and rice. Due to the shop's location right across a school, it receives a great deal of patronage from the children during the school's break times. The owner stated that he opened the shop to help the local people obtain basic necessities, especially during long dry seasons and drought periods when there's not much chance to farm productively and the local people have to come and buy rice on credit. The payment is deferred until the next harvest. The shop only provides credit for the purchase of rice, while other commodities have to be paid for in cash. The owner believes that credits for non-essential items (other than rice and baby supplies) would saddle the borrowers with an unbearable burden; indeed, even the rice credits are only given on a limited basis.

Shop inventory is acquired from the old market in Baucau and transported with the use of public transportation cars passing by the shop. The shop owner does not buy produce from the locals or accept loan payments in kind. Such transactions may in fact be profitable, but the owner believes that groundnuts are the only produce with considerable market value and its price tends to be quite low at harvest time. Farmers may hold on to their nuts until the price rices, and indeed the shop-owner does so for his own produce, but he does not feel comfortable doing so with his customers' produce since he fears that he may be accused of being selfish and lose his respectability as the *lia nain*. By encouraging fellow villagers to sell their produce on their own, he tries to avoid becoming a subject of gossip and resentment.

Capital for the store was obtained from his own savings. The original capital was acquired by buying livestock like goats, pigs, and chicken, or by strategically timing the sale of his groundnut harvest. The groundnuts are not sold immediately at harvest time but kept until the price has risen by a reasonable extent; for example, the price of groundnuts at harvest may go as low as $10 for every 25 kg rice sack, but during scarcer times it may rise as high as $20 - $30/sack. The significance and mechanism of this surplus accumulation system will be explained later.

The two sellers of drinks and children's snacks in Parlemento and Osso-Ua cannot be properly called food/beverage merchants since their stock of merchandise is very limited, consisting of a few cans of drinks, several instant noodle packages, and some snacks.

A Parlemento resident can be categorized as a greengrocer. His inventory comes from a combination of purchases from his neighbor, produce from his own garden, and purchases in the old market of Baucau. He then ties together the vegetables in certain amounts to be sold in retail. He actively pursues his commerce activities since he needs a great deal of cash to provide food and milk for an infant child. He also feeds nieces and nephews playing at his house dring mealtimes, so he needs some money to buy extra rice. At the same time, he also works as a lottery brokers, but neglected to mention it for unknown reasons.

Apart from these mercantile activites, there are also 10 two-wheeled vehicles operated by Caisido residents to serve trips to and from far-flung local settlements. These motorcycle taxis usually gather beside the main road at the junction with the road towards Caisido. The fares vary between $1 and $3 depending on the distance. There are not many passengers for these motorcycles aside from outsiders who wish to travel into the area, such as the research team. One of the motorcyclists explained that he usually earns no more than $5/day.

Handicraft and food industries remain underdeveloped. For the most part, it is limited to old women weaving baskets for their own use from the leaves of *lontar* palms growing around the *aldeia*.

Informers state that there have been no empowerment initiatives for the development of household industries. Such empowerment remains a difficult proposition due to the absence of a substantial market.

3.3.7 Economic Morality Among Kin Groups and Neighborhoods

Economic activities in Caisido cannot be equated with rural economic activity in Java, where money economy and the accumulation of surplus by individual households have become long-established fundamental features. In most parts of Caicido, the village community is made up of members of the same lineage. The lineage's social unity is affirmed through kinship and marriage relationships that involve special reunification/reaffirmation ceremonies involving all lineage members in the customary house (*rumah adat*). These ways mark the local population's identity as native residents.

Land as a livelihood resource is only possessed for the fulfillment of life's necessities. Private possession rights are transferred through an inheritance system. The nuclear family as the smallest unit in the local community's economy is given some latitude in choosing how to fulfill its subsistence needs. However, as part of a larger kinship or lineage group, these families have the obligation to share their subsistence resources with members of the same kin/lineage groups before they share with the rest of the village. These differences underlie a mutual aid system based upon a morality of exchange within the community. This is particularly visible in the marriage system, which regulates the types of goods to be exchanged and the moral values of the exchange. These institutional arrangements provide direct and indirect social guarantees for mutual subsistence while at the same time presenting obstacles to the development or improvement of an individual household's socioeconomic condition. In this context, limited resources, the ecology of the land, and the lack of empowerment initiatieves have limited the village economy to the fulfillment of subsistence needs under mutual uncertainty.

Morality of Exchange. There are several important details that must be observed to understand the economic system of the Caisido community. Firstly, most of the local population manages to survive in social and physical terms amidst resource limitations on land that can only support the cultivation of a few types of food crops. Access to the market economy is also rather limited, except for livestock. Similarly, there are relatively few opportunities to acquire cash. These circumstances prompted the development of mutual sustenance patterns, especially with regards to how social and moral systems can guarantee the formation of social institutions. The social structures and organizations thus formed, although united by kinship ties, still leave room for a considerable degree of inter-lineage social competition where the groups openly profess their kinship to each other but privately prefer to attend to their own interests.

Amidst these resource limitations, the society needs an institution that can guarantee the mutual fulfillment of subsistence needs, namely an exchange institution. The exchange institution is also developed to provide social security and fulfill individual sustenance needs as well as group reproduction needs. The exchanges in Caisido partake of both reciprocity and redistribution. Reciprocal exchanges play an important part in forming livelihoods and maintaining social insitutions.

The social norms contained in reciprocal giving imply that the gift is made to bind the recipient with an obligation to reciprocate, especially when the gift takes the form of a marriageable woman. This obligation perpetuates itself indefinitely as long as the parties are bound in a well-maintained social bond. No calculations are made on the basis of economics (money) or the types of goods exchanged. Valuation stresses the idea of 'need' and the social relationship between the two actors, such as between a woman-giving lineage and a woman-receiving lineage; this exchange pervades all livelihood, social, economic, and ritual aspects. Reciprocity with members of the same village is based upon religious norms, common congregations, or baptismal brotherhoods. This reciprocity happens on a much more limited level.

The variety of choices in terms of exchanged goods remains bound to the exchange morality or rules that provide a common ground for the actors in the exchange. Generally speaking, the reciprocal exchange system has an important role in establishing and maintaining social relationships between woman-giving and woman-receiving groups.

Owing a *belis* debt is not seen as a shameful or disgraceful thing. Indeed, the pervasiveness of the reciprocal indebtedness indicates the extent of a person's social network and the degree of trust in his ability to reciprocate. This reciprocal indebtedness pays no heed to the value of the exchanged goods or any fixed timeframe for the reciprocation expected from relatives by marriage.

The rules that regulate requests for loans are determined by the group's status as either the woman-giver or the woman-receiver. The gift of a dowry in the form of ceremonial items by the groom's side to the bride's family places the woman-receiving group as the first group who will be approached for a loan or aid by relatives from the woman-giving side. The borrower is not required to repay the loan with the exact same quantity and kind of goods; for example, the loan of a buffalo may be repaid with women's ceremonial items of unequal value with the item originally borrowed. Repayment with the exact same type and value of goods is seen as a breach of tradition. Such a violation would affect the relationships that have been so painstakingly established.

The Accumulation of Wealth. Amidst the complexity of the reciprocal indebtedness morality, the poor ecological resource situation, and the underdeveloped market economy, it is quite difficult to accumulate considerable amounts of wealth. However, this does not mean that the exchange institution does not provide any opportunities to accumulate surplus, only that not all individuals are capable of doing it.

The traditional morality allows group members the chance to acquire livestock as a way to accommodate surplus. Livestock is commonly kept as a form of savings to finance the future education of the owner's children. These savings are seldom used to buy more land or to increase the added value of the owner's house since there is hardly any purchaseable land to begin with. In the last few years, farmers with large orchards have begun to invest their surplus by buying motorcycles that are then hired out to help fulfill local transportation demands. This initial investment outside traditional sectors may signify a change of paradigm in material investment. The notion of 'helping' serves as a convenient excuse for the investment. Theoretically, a change in the preferred type of investment asset may be the initial signs of the more widespread introduction of money economy that will create opportunities for socioeconomic stratification that have been absent thus far.

Money. In a society that still depends on a subsistence cycle where transaction systems provide the main principle for the exchange and redistribution of goods and labor, the definition of money is that of a device that serves as a medium of payment, a way to measure the value of goods, a calculation apparatus, and the means to accumulate savings.

In Caisido, certain kinds of livestock such as buffaloes, pigs, and chicken can be seen as money from the perspective of local value standards, with buffaloes having the greatest nominal value. People in Caisido are already familiar with money but have not yet begun to use it extensively except to obtain education and healthcare services and to transact with outsiders in purchasing everyday necessities that are not produced within the village.

Giving transactions usually involve the transfer of goods according to need. Ritual goods are deemed unsuitable for monetary reimbursement or even valuation. This does not mean that people do not keep money at home, but rather that keeping significant amounts of money at home is unprofitable since it would invite others to request loans and thus prevent the owner from effectively saving the money.

As with more traditional means of exchange, the use of money is also categorized into several levels from the highest to the lowest priority. The payment of education/tuition fees take first priority, and the higher the level of education the more important it becomes. Other high-priority items include the conduct of important rituals and healthcare expenses. Home improvements occupy the lowest priority.

In a community that relies upon a traditional exchange economy, the introduction of money does not always result in the immediate spread of market economy as long as the use of the 'new' means of exchange (*i.e.* money) does not nullify or interfere with existing priorities among actors and categories of goods. In Caisido, the use of money occupies its own distinct scale of priorities, while more traditional means of exchange such as buffaloes and pigs are used to fulfill needs on an altogether different scale of priorities. The institutions of exchange transaction remain relatively unchanged. With regards to the unique properties of money as it is commonly understood, traditional commodities such as buffaloes remain irreplaceable since they are regarded as more than mere 'assets' but also as living creatures with a symbolic value that figures into the transaction process. In the context of traditional customs and values, the functions of these alternative means of exchange are integrated with other socio-cultural elements into an inseparable whole.

New material symbols of wealth (motorcycles) have not displaced more traditional symbols. This can be seen in how exchanges to repay *belis* debts do not utilize money as the unit of value. The fulfillment of material needs has not caused the emergence of social stratification based on conditional hierarchies since everyone is regarded as members of the same group. The only available opportunities rely on the cultivation and maintenance of relationships that establish social networks with woman-giving and woman-receiving families and brother-sister relations as a way to guarantee livelihood through a number of mechanisms, especially in times of crisis. Examples include the customary demand to always provide food for people in need and social institutions that require people to accumulate wealth in the form of ritually significant goods (such as livestock).

Social Stratification. The Caisido community does not exhibit significant disparities in wealth. Although certain persons and families may own more land or livestock, they generally do not flaunt this wealth in everyday life, as exemplified by the Muslim informer mentioned in a previous section. There are no rules against displays of surplus, but most people apparently do not wish to openly display excess wealth. Many of the respondents in our in-depth interviews expressed a preference to invest their surplus in the education of their children and the purchase of livestock as savings assets. These kinds of surplus investments are deemed traditionally respectable since the improvement of children's human resource value can help counteract the image of the home village as an underdeveloped area.

Unlike in Caisido, the people in Ostico are less reluctant to show off their wealth by improving the visible condition of their houses, *e.g.* by replacing a wood and bamboo-mat construction with wooden walls and corrugated metal roofs. This ostentation is motivated not only by the lifting of resource constraints; we have been informed that such improvements are partially driven by neighbors' success in improving their houses from wooden to stone constructions and also by the success of relatives who have moved to the city. These urbanized relatives may return in brand-new vehicles and smart clothes during Christmas and New Year Holidays to show off their success in the cities, such as in becoming a ranking government functionary.

These differences may be attributed to the ecologically critical resource situation and the limited opportunities for expansion, which leads to the notion that ostentatious displays of superior wealth should be regarded as 'deviations' against traditional norms and as cause for suspicion, especially when the ostentatious party is prone to ignoring local norms of the communal economy.

3.3.8 Income and Expenditure

With the extreme ecological conditions, the rarity of water, and the poorly developed market economy (lacking traders to collect the local population's produce), it is difficult to see why the Caisido residents persist with their subsistence patterns and strategies. The main exceptions are people who have enough land to develop market-oriented cultivation strategies, such as by devoting each particular plot of fenced land to a single type of market or subsistence crop. This makes it easier to quantify the collected harvest. On the other hand, in the more usual paradigm where horticultural farmers only own and open as much land as they think they need and the available labor, the harvest is more difficult to measure quantitatively except for main staples like maize and groundnuts. Other crops are planted in an intercropped/interspersed manner, haphazardly maintained, and harvested as they ripen. These methods make it very difficult to count or estimate the total size and value of the harvest.

Some case respondents have willingly provided information on their produce, categorized by the type of main staple crop:

Table 3.11 Garden and Orchard Production for Subsistence Needs in Caisido

	Case Studies				
	1	**2**	**3**	**4**	**5**
Total Garden (*pagar*)	**1**	**5**	**2**	**3**	**1**
Estimated Area (m²/*pagar*)	100 x 100	50 x 50	50 x 75	50 x 50	50 x 100
Crops					
Corn	5 sacks	5 sacks	2 sacks	5 sack/s@10 Kg	5 sack/s@10 Kg
Peanut	10 sacks	23 sacks/@ 10 Kg	4 sacks/@ 10 Kg	20 sacks/ @10 Kg	10 sacks/@ Kg
Tomato	1 sack/@10 Kg	-	1 sack/@ 10 Kg	1 sacks/@ 10 Kg	1 sack/@ 10 Kg
Kale/Kangkung	-	-	-	-	-
Red Chili	1 sack/@10 kg	-	-	1 sack/ @10 Kg	1 sack/@ 10 Kg
Cayenne Pepper/Cabe rawit	-	-	1 sacks/@ 10 Kg	-	-
Red Onion	-	-	-	-	-
Cassava	-	-	-	-	-
Tuber/Ubi jalar	-	-	-	-	-
Rice Needs					
Total Family Member	4	2	8	4	4
Rice needs/week	1 sacks @25 Kg/week	2 sacks @25 Kg/week	5 sacks @ 25 Kg/ week	1 sack @25 Kg/week	1 sack @25 Kg/week

Source: Case Study of household income

Note: (-) cannot be calculated

Table 3.12 Income from Non-Agricultural Sectors in Wailacama

Activity	Case Study		
	1	2	3
Driver	$500/month		
Small shop		$100/week (gross)	
Forest/firewood			$10 - $15/week
Total Family Member	3	5	4
Rice needs/week	2 sacks @25kg/ month	1 sack @25kg/ month	2 sacks @25 kg/month

Source: Survey result/case study.

The case studies show that case respondents 1, 2, and 4 are capable of fulfilling their subsistence needs. This is correlated not only to how much horticultural land they own and farm, but also two other supporting factors. One is lower subsistence needs, where a 25-kg sack of rice can be made to last for a week and 2 sacks for a month. Another is that respondents 1 or 2 successfully engineered the sale of their produce, not selling them immediately after the harvest but holding on to them for several months to get better prices.

Both respondents could utilize this measure since they have built subsistence fulfillment reserves from their shop profits and personal savings. On the other hand, respondent 4 managed to fulfill his subsistence needs because his family could obtain additional income from fishing. The remaining case respondents – 3 and 5 – could not resort to these measures since they lacked alternative sources to help fulfill their needs and to adopt a more sophisticated produce-selling strategy, so they were forced to sell when prices were still low. The price of groundnuts can fall as low as $10 – $15 per 10kg can depending on whether the nuts have been peeled or not, meanwhile, in scarcer times groundnuts can sell for as much as $30 - $40 per 10kg can in peeled condition. The difference in these sale prices is not as dramatic as it seems since freshly harvested groundnuts are volumetrically larger and thus fewer of them will fit the can than when the nuts have been peeled and dried for several months. The discrepancy between freshly harvested volume and the dried volume after 2-3 months of storage can be quite dramatic; the freshly harvested nuts may be half again as large as the dried ones. This results in a price difference of only around $5 – $10 /can. The problem is how would a subsistence farmer fufill his family's needs and his own for the 2-3 month it would take to wait for favorable prices? It is only possible when the farmer has substantial surplus or an alternative source of income that can help fulfill his household's needs. It is quite difficult to find out how many households in Caisido fall into this category.

These case studies lead to the conclusion that a household's ability to fulfill its subsistence needs cannot be judged according to the amount of land it cultivates, but rather by how many alternative livelihoods are available to fulfill subsistence needs so that the household would have the freedom to develop more optimal subsistence strategies. In many cases the gardens/orchards are the only sources available for the fulfillment of all family members' sustenance demands.

The results of in-depth interviews provide a general picture of the daily consumption patterns commonly found among Caisido households. All case respondents state that they always eat breakfast made out of whatever produce they have at hand, such as nuts, corn, and tubers. Lunch should ideally include rice, especially for children. Adults may eat other carbohydrate sources instead (such as tubers) and defer their consumption of rice to dinnertime. Dinner (usually in the evening) serves rice as the principal carbohydrate source for all family members. Issues may arise when there are infants or toddlers that still require milk. For example, respondent 3's wife gave birth to twins but could not produce breast milk, so he had to buy canned milk for the twins. Infant malnutrition and survival rates should ideally be deduced from fertility and mortality data. Unfortunately, the data is not available in the local clinic so it is very difficult to figure out the infant survival rate. Still, the low population growth rate of around 1% per year can be taken as an indication of the local population's lack of subsistence capacity.

A different picture emerges in the Wailacama aldeia, where the availability of income from outside the farming sector has doubtlessly helped the residents in fulfilling their subsistence needs. The main exceptions are the households that rely on firewood harvesting. The main opportunity to ensure the fulfillment of subsistence needs lies in the chance to work land owned by the woman-giving side; this chance is relatively small since land is not considered an integral part of the *belis* dower, so the woman-giving lineage is not saddled with the obligation to 'give' as part of the exchange. The provision of cultivable land may lead to worries about the future.

The largest expenditure for all households in Caisido and Wailacama is the purchase of rice. Rice is generally not produced locally but rather purchased in the market. Although the price of rice has remained within reasonable bounds at $10 - $15 per 25kg sack, the subsistence pattern carries considerable risks if the market fails to meet the demand (such as if production or distribution was disturbed by a natural disaster) or if the price of agricultural produce experiences dramatic fluctuations. All of these circumstances can affect the local population's subsistence/survival capabilities.

Table 3.13 Livestock and Crop Prices

Unit Name	Price	Unit	Note
Brick	$0,45 -$0,65 cent	1 Piece	-
Brick	45 cent	1 Piece	-
Chicken	$5 - $20	1 Chicken	Depends on size
Chili	$25	1 Sack 25 kg	-
Cow/Buffalo	$600	1 Big Cow	-
Firewood	50 cent	1 bundle	-
Firewood	$0,5	1 bundle	-
Fish	$15	12 Fishes/ kg	-

Unit Name	Price	Unit	Note
Goat	$60-$200	1 Goat	Depends on size
Guava	50 cent	4 Fruits	-
Jati wood	$600 - $700	1 m^3 or 40 pieces firewood with 2 x 30 cm size	In condition you have to share the profit with somebody who have saw/chainsaw to cut the wood. In Addition before you cut the wood you have to gain permit from authority then you have 3 days estimation as clausal.
Kale (Kangkung)	25-50 cent	1 Bundle	-
Peanut	$15 - $45	1 Sack 25 kg	Depends on size Sells by urge or not already/not already peels out.
Pig	$30 - $50	1 Pig	Depends on size
Tomato	$3	1 *kuncimas*/large bucket 10 kg	-
White Jati/ Philiphina's Jati	$100	1 m^3	-

Source: Survey Inventaritation, May 2015.

Note: Rice's price for 1 sack (25kg) equal $12-$15.

3.4 Social Organization

3.4.1 Hierarchies of Authority

The Baucau District is subject to two main spheres of authority, one being the government's (Formal) and the other being the church's (informal). Although their authorities differ, they both have the ability to mobilize the masses and the need to support each other.

A. *Formal Authority*

i. Regent/District Administrator in Baucau

The formal government hierarchy in Baucau proceeds from the Regent (district administrator) to the subdistrict, then to the suco, the *aldeia*, and finally to the *bairo* (citizen). The Regent and the Subdistrict Administrator are appointed by the central government in Dili while the head of the Suco is generally elected by the local population. Although the Regent and the Subdistrict Administrator are not elected, their power and authority to lead the *bairo* are widely acknowledged. They act on behalf of the government through the suco administration. In case of any deadlock related to the project (such as with land issues), they have the final say within their respective spheres of authority and can compel obedience from the *bairo.*

The present emergency in Baucau has given the Police Department wide-ranging powers in the interest of maintaining law and order, especially in the suppression of the MM (Maut Muru) 'rebellion.' Any activities by external parties must obtain the approval of both the civil government and police authorities. This approval must be obtained through the proper bureaucratic procedures. The procedures are largely vertical to signify the respect/acknowledgement given by the leader(s) of the requesting institution to the local government authorities. According to these procedures, all the bureaucratic staff at the central (district), subdistrict, and suco level will obey their orders and carry out their duty in serving the interests of the external party (investor, researcher, community empowerment initiative, or the like).

ii. Subdistrict Office and the Roles of the Camat/Baucau Sub-District Administrator

The subdistrict is the level of government immediately below the district and is further divided into several suco. As the intermediate institution between the district and the suco, the sub-district is responsible for implementing decisions and policies from the district level down to its subordinate sucos. Conversely, it forwards inputs, performance reports, and complaints from the sucos up to the district level. The subdistrict office contains a number of services/specialties that handle specific aspects of government, the economy, economic and social development, security, the youth, women, and traditional/customary (*adat*) issues. These services' activities depend heavily on the Subdistrict Administrator's performance. The agencies may implement top-down programs from the central government or bottom-up programs initiated at the suco level. The program to gather inputs and initiatives from the suco level has been in the works at the suco level but has not proceeded to the final implementation stage. Empowerment initiatives are usually made by third parties cooperating with the appropriate agency under the central government. The District, Subdistrict, and Suco administration merely get notified of the program. Some numbers are adjusted to be more in line with the programs already planned by the Subdistrict.

However, there are programs initiated at the suggestion of local NGOs to foreign donor institutions outside the Subdistrict's lineup of programs. The unilateral implementation of empowerment actions by external parties has become a major issue for Subdistrict and Suco administrators since such initiatives may invite dissatisfaction from other sucos or groups. However, Subdistrict or Suco administrators can only refuse such programs (initiated by foreign donors through local NGOs) with great difficulty since the programs are intended to benefit the region's people in the first place.

Subdistrict institutions and the administrator are meant to play a central role in planning and implementing various citizen empowerment programs, but this role has not been satisfactorily implemented. Still, the success or failure of local development is closely tied with the Subdistrict Administrator's performance in the eyes of the *aldeia* citizens. According to the informer (*Chefe Aldeia*), the average citizen has virtually no power to change the prevailing conditions no matter what. For this reason, the arrival of a major project in the form of a cement plan is hoped to change life in Baucau for the better.

iii. Role and Authority of the Suco

The Chefe Suco is the lowest representative of the central government's authority at the local level. The Suco's role is to serve the citizens' interests and implement the central government's programs to the citizens at the suco level. For this purpose, the chefe suco is aided by an administrative staff that includes the suco secretary, aides/representatives for specific issues (youth, women, healthcare, religion, education, economy), and the customary chieftain at the suco level (*lia nain*) (**see Appendix 5).** All of these suco staff members are appointed by the Chefe Suco, except for the *lia nain* in Tirilolo who is chosen through a popular election process. This particular office is usually given to a person deemed to have the most extensive knowledge of traditional laws and customs. This person does not have to be of advanced age or a descendant of the previous *Lia nain*. The Chefe Suco is directly elected by the people. In some of the villages we visited, the Chefe Suco were common people who had managed to prevail over rivals coming from the local elite (the rich). According to these Chefe Suco, they were elected since the people wanted an accessible leader hailing from among the common people so that the Chefe Suco can be more easily met or contacted without having to navigate too much bureaucracy.

The Chefe Suco's role and authority are respected due to his position as a government representative. The Chefe has the power to make decisions in dealing with outsiders. In matters that solely involve local citizens, the Chefe Suco frequently delegates authority to the *Chefe Aldeia* at the hamlet/*aldeia* level or to the specialist staff. The principal staff member who has the greatest effect upon the strengths and weaknesses of the suco administration as the whole is the suco secretary. Although the secretary is appointed by the chefe, he/she wields considerable influence upon the leader. The Suco Secretary in Tirilolo seems to have an even more important role in the suco's administration than in the other villages we visited.

Although the organization chart of the village names many of the staff members we have previously mentioned, in none of the villages (Tirilolo, Triloca, Ostio, and Vemasse) do these staff perform their office at the suco's administrative center? Most of them usually handle their duties from their homes and occasionally visit the village center to obtain information related to their duties. If the Chefe Suco needs them, they can be summoned through telecommunication apparatus such as cellular phones.

An important village-level institution that handles conflicts between village people or among the youth is the KPK (*Konsellu Polisia Komunitaria/Community Police Councils*). This agency has two co-leaders, one appointed by the police (*community police*) and one community representative. This institution also includes representatives from youth, women's, religious, *aldeia*, and business interest groups **(see Appendix 6).** In practice the KPK leadership and the Chefe Suco act to handle local issues and disputes so that they don't have to be taken to the police.

iv. The Final Level in The Hierarchy of Authority: The Aldeia.

The *Aldeia* is the furthermost extension of the Suco organization. This lowest level of village administration is led by a *Chefe Aldeia* elected by the hamlet's residents. The Chefe's role and responsibility as a local leader is to serve the needs of the people. As a normal citizen in the hamlet, he should be quite familiar with all aspects of the hamlet's life, from whether certain villagers are native to the village to their employment status, the education of their children, and their places of residence. Despite the status of the Chefe *Aldeia*, his power or authority in certain matters (such as the acknowledgement of land boundaries and the making of deals with external parties) can only be exercised in consultation with the local citizens, as otherwise the decision is likely to face considerable resistance. Such important decisions are normally made through a citizen's meeting to obtain a local consensus.

At the projected mine and plant site, the *aldeia* official is elected by the villagers, but he is not fully interested in becoming the *Chefe Aldeia.* He was elected at the behest of the local population, but he sometimes objects to the burden of the office since it does not provide him with any stipends or allowances for travel to the village's administrative center. The obligation to attend village meetings twice a week is straining his resources. At the same time, his activities in accompanying outsiders have raised suspicions among the local people; these suspicions are mostly along the lines that he might try to arrange things for his own private profit. In the case of the cement plant, the *Chefe Aldeia*'s busy schedule in accompanying the researchers caused some resentment since some villagers believe that the Chefe is hiding information from them. Arguably, the *Chefe Aldeia* should hold more frequent community meetings to explain the ongoing activities.

At the clay mining site in the Wailacama hamlet, the leader of the *Aldeia* is also the leader of the male members in the kin group of his customary house (*rumah adat*). His election as the *Chefe Aldeia* owes much to his experience as a former Special Forces soldier in the Indonesian armed forces. However, his ideas for the development of his *aldeia* have garnered little response from the Chefe Suco. For example, his request for the repair of blocked irrigation channels leading to the rice fields in his hamlet and his suggestion for the building of a new road along the Wailacama – Ostico – Lui Lubu – Fotumata – Venelale – Osu – Wikeke route have not received any response from the Chefe Suco and the Subdistrict. As a subordinate leader, he can only complain and hope that the government's agricultural department would somehow turn its attention to his local area. He does not know how to express his hope to the relevant agencies if the Chefe Suco and the subdistrict administrators do not take a more proactive role in planning and proposing programs for their areas of responsibility, so the hamlet has been left to stagnate.

B. Informal Authority: The Political Power of Religion

A non-governmental entity with the power to affect people's lives in Baucau is the Catholic Church. The people of the Baucau district and subdistrict are devout Catholic. The tough environmental conditions (dry due to the lack of water sources suitable for intensive farming), underdeveloped market economy, longstanding isolation, and dearth of economic or human resource empowerment initiatives are all factors that have influenced group solidarity models.

As mentioned in a previous section, the basic social structure in the area is based upon kinship or lineage bonds. This model of social organization means that the structure of the hamlet community is made up of related kinship groups that stand independently of each other as social, economic, and political units that compete for survival resources. Whether consciously or not, territorial division along the lines of baptismal surnames is intended to control potential conflict over available resources. The ecological conditions that do not support intensive food-crop agriculture have prompted kin groups to lay claim over large expanses of land. Thus there is the need for a customary division of lands in order to allow coexistence between different groups.

In the past, the colonial government never raised substantial objections to the control of land by traditional elites. The distribution of ownership and possession over survival resources is made on the basis of closeness to elite groups, such as to followers, allies, and slaves. The distribution of rights over the resources could potentially lead to social stratification against the interests of lower-class groups, followers, and slaves. These facts on the ground, in contrast to egalitarian Christian teachings, may have prompted the Church to perform social engineering though the granting of baptismal names to traditional elites to delineate the boundaries of their traditional authority.

The division of territory according to baptismal identity has important implications to the Church's mission of placing all worshippers on an equal fooring. Traditional elites do not view the identification of territorial control with baptismal names as a threat to their traditional authority. However, in the long term this surname uniformity may eventually undermine traditional power structure. As a consequence, the territorial groups based on baptismal names no longer know who among them are truly descended from traditional elites. All members of a hamlet community sharing the same baptismal surname have equal rights to exploit the local resources.

The identification between baptismal surnames and individual customary lands remains in force to this day. The baptismal surname serves to identify the person's place of origin along with the concomitant rights. This issue should be considered if it becomes necessary to relocate the people closest to the project site as we will explain later.

The Church's authority in demographic matters is based upon its role in recording births upon baptism. The birth of a new family member usually prompts adult relatives to report it to the Church for baptism. The Church then records the child's date of birth, status within the household, and place of residence. The Church does not issue birth certificates but the records issued by the church are regarded as valid proof of birth by the villagers. The Church's role in this regard has not attracted any objection from village or formal government authorities since the Church's actions are seen as the manifestation of a religious obligation that must be performed by all members of the congregation. Godfatherly bonds are one of the issues that must be considered by people living closest to the project sites if they have to relocate beyond their traditional customary lands. The bond lasts for life; in particular, during death-related rituals, the godfather (priest) plays an important role in guiding the soul of the dead to their final resting place. The priest's role in building vertical relationships with the dead is seen in the handling of the deceased's body and the funeral arrangements.

As a socio-religious institution, the Church has a hierarchical organization to nurture and manage the piety of the flock. The lowest-level institution that handles religious matters at the *aldeia* level is the catechist. In daily life, the piety of the flock depends on the catechist's activity in serving and managing the believers in each *aldeia.* The cathechist arranges visits by a priest or sister to say Mass or perform other religious ceremonies in rotation between the various *aldeia* and suco. This mechanism maintains the people's closeness to the Church. Such Church activities are facilitated by the formal leadership and may even become official village or *aldeia* programs. This is most apparent in the celebration of Catholic holidays such as Christmas, New Year, Easter, Ascension Day, All Souls' Day, the Assumption of the Virgin Mary, and All Hallows' Eve. The celebration of Christmas and New Year involves all relatives within an extended family or lineage group gathering together. This mobility back to one's place of birth has an important role in the remembrance and reinforcement of kin relationships among people born in the same hamlet/village.

3.4.2 Teritorial Grouping

It has been explained above that the Baucau population originated as immigrants from Waiweko to Baucau who brought baptismal names as their group identity. Anthropologically speaking, this baptismal identity is not a clan or tribal identity. Our informants state that Tirilolo is a word in the Makasae language that means 'one word.' This means a Tirilolo is supposed to express his/her opinions in a single statement. Once the statement is made, he/she would not state any other word or decision about the matter. However, the current name of the Caisido region comes from a Waima'a word that means an inland or rural region. Language-based ethnic groups are more commonly discussed in anthropological records (McWilliam and Troubeed, 2011) than the territorial groupings based on baptismal surnames commonly used in Baucau.

Key informers name three main baptismal groups that migrated into Baucau: Bahu was settled by the Da Costa, Tirilolo was settled by the Belo, and Caibada was settled by the Flores. The question is why baptismal names are always linked to certain suco, and conversely why the name of the suco is more easily identified with baptismal surnames than with ethnic groupings. The baptismal surnames had been used by the original settlers in Baucau under Portuguese colonial rule.

This complexity can be explained as follows. First of all, the Makasae ethnologuistic grouping occupies quite a large area, so there is the need for further precision – in this case by the use of distinct (baptismal) surnames to identify territorial origin and residence. This may bear comparison with other ethnic groups that are spread over large areas, such as the neighboring Tetum and Fataluku ethnicities (see Mcwillian and Troube, 2nd. 2011) Do these ethnicities also practice the same method of territorial division and identification as in Baucau?

The second possibility is that the colonial government engaged in deliberate cultural engineering by merging ethnic identity with religious identity, so in the long term the local cultural identity becomes dissociated from its roots. This is not a particularly strong possibility either since the local inhabitants continue to maintain their social organization by keeping the customary house (*rumah adat*) as the center for the reorganization of the group's basic social structure.

The third possibility is that the Church might have wanted to unify its flock without the social stratification between elites, followers, and slaves traditionally found in Timor (Hick, 1976). This social engineering suits the Church's vision and proselytized teachings that all worshippers should be equal. This strategy appears to have been acceptable to traditional elites, who then adopted the baptismal name for all the people residing within their traditional domains. This prevented the total loss of traditional social relationships. Whether they realized it or not, the use of a common surname appears to have gradually blurred the lines between elites, followers, and slaves. This hypothesis is also unable to provide a complete explanation for the phenomenon since a different part of Timor -- particularly West Timor (Indonesia), which had historical social, economic, and political ties with the East (Gunn, 2005) – does not recognize territorial division by baptismal surnames of the kind found in East Timor, especially Baucau.

West Timor has a relatively similar history of Catholic influence; the original social structure and organization of the traditional society was also very similar, being originally controlled by patrilineal clans (*embu*). However, the clan identity there remains in force and so does the traditional social structure (see Achmad, 2002). Traditional control over territory and resources is still recognized and controlled through ceremonies centered upon the customary house (*rumah adat*). The ceremonies involve all groups such as the ruling elite, followers, allies, and slaves gathering together and reidentifying with their traditional status along with all the concomitant rights and obligations. Such ceremonies have not been observed in the customary houses of the first three settlers in Baucau (in Bahu). Traditional ceremonies are only performed in lineage groups. This fact underlines the *de facto* equality between the holders of the same baptismal surname. Marriage between people of the same baptismal surname is not prohibited either as long as the bride and groom come from different customary houses and/or different ancestors. One of the most important aspects in the territorial identification with baptismal surnames is rights of use and possession over resources available within the territory.

Apart from these theoretical possibilities, what are the consequences of this social organization model? First, there is no collective leadership that can act on behalf of all villagers. The chief of the hamlet is only a leader in the administrative sense, while much of the decision-making authority remains with the lineage *lia nain*. Second, control over local resoures also constrains the domain of the local population. The difficult ecological conditions reinforce limitations against the control of resources by external parties outside the traditional territorial systems. Third, the introduction of new resources outside traditional sectors in a customary domain may lead to potential conflict over perceptions of control over customary land. People from other territorial units (suco) can bring up the issue that kin relationships and the history of territorial segmentation by the Church should not always be rigidly followed and that there is room for compromise. This would give people from outside the project area a chance to claim the right to enjoy the benefits from the project.

3.4.3 Basic Social Structure of the Community

The use of baptismal surnames as the signifier of social territorial units gives the impression that the inhabitants of a single hamlet or suco form a single kinship group descended from the same ancestor. This is obviously mistaken since, despite their social and territorial unity, they are not always closely related by blood or by marriage.

Within the uniform surname shared by all members in a hamlet, there are smaller kin-based social units made up of individuals descended from a common ancestor. The members of such groups are aware of their closer bonds as kinsfolk to each other. In anthropological terms, this kind of social unit is known as lineages. The lineage unit is led by the oldest male member of the kin group. In Caisido, membership in the same kin group is signified by affiliation to a particular customary house (*rumah adat*).

The customary house serves not only to remember and maintain a spiritual relationship with ancestors and deceased lineage members; it also acts as a nexus of identification for the living members of the kin group (**see table 3.14**). Within a customary house, a lineage member is known and identified by his/her original traditional name and the ancestor's original name**.** This identity is an important fixture for validating each person's rights and obligation as a hamlet resident and a group member, When the lineage group gathers in the customary house, the traditional chieftain/elder (*lia nain*) – the oldest male member of the lineage – recites the traditional name of every member. For convenience's sake, all lineage members must know their ancestor's traditional name. Customary houses are normally situated together with other customary houses, as in the case of the houses owned by the people of the *aldeia* closest to the mine and plant site, However, in some cases the customary house may be built outside the consolidated site. This variation does not seem to be viewed as a transgression against customs and traditions.

Table 3.14 Some Lineage Ancestor Adat House Name of Osso-Ua

Betulale	*Cai-Ono*	*Loledeso*
Lole Utohamo	Gei-Uono	Loladeso-Anamesa
Caiada Maucul	Caiwada Cakrano Uake	Caiwada Au Bala
Rubiace	Sinielaki	Wonolila

Source: Interview with key informant, Osso-Ua, 2015

This difference has not attracted complaints from other villagers. Neither the *chefe aldeia* nor the customary head of the relevant *lineage* considers the owner aloof or asocial. They seem to be able to accept the reason offered, which is to make it easier to care for the customary house.

Nevertheless, the customary house (*rumah adat*) continues to play an important role as a symbol of identity and the people's reaffirmation as native residents of a hamlet. As a member in a hamlet/suco, the control and possession over the limited resources available in the hamlet/suco is a critical factor in ensuring survival. The customary house can be theoretically viewed as a response to the Church's attempts to impose a new identity by compressing social strata into a single egalitarian layer without any distinction in power between one class and the next. The aims and relevance of this institution has already been discussed above.

3.4.4 Marriage System and the Debt of Exchange

It has been explained above that the basic social structure of the Caisido communities (the *aldeias* Parlemento, Caisido, Lialaileso, and Osso-Ua) is the patrilineal and patrilocal lineage. This group consists of a set of nuclear families led by related males. If a daughter/sister and her husband continues to live with the group, her household does not count towards the reproduction of the lineage group, or in other words the children of female descendants are not regarded as members of the parent lineage.

The reproduction of the lineage is conducted through the marriage of a male member with a woman from another lineage. There are no rules or restrictions about which lineage's women are deemed suitable for marriage. Neither is there any prohibition against marrying people from the same hamlet, or in other words with the same group. For instance, a Belo may marry with another Belo as long as the two do not come from the same lineage (the same customary house/*rumah adat*). However, the sons of a certain lineage (such as Belo) are generally encouraged to find a mate from a surname group (such as Soares). This is meant to build wider-ranging social networks, which at the same time expands the web of socio-economic exchange and mutual political protection. Still, this does not guarantee the possibility of resource exploitation within the territory owned by the parents of the *fetosaun* (daughter-in-law). The establishment of social networks through marriage bonds will provide greater social security through a perpetual exchange arrangement.

Marriage not only allows reproduction for the members of lineage groups but also forms a perpetual exchange relationship between the two lineages (*ummane-fetosaun*). There are few or no customs that dictate whom one might marry or how the lineage might arrange marriages. Young men are generally free to choose their prospective mates. The marriage procedure is quite long and involved.

First, when a man wishes to propose marriage with a woman, the man's family must make an initial approach or state a preliminary wish to propose to the woman's family ('*ketok pintu'* or 'knocking the door'). After the proposal has been accepted, the male side must offer livestock – usually buffalo or oxen – as '*pembuka jalan*' ('opening the way.'). The livestock will then be used in a ceremony in the customary house to inform the ancestors of the woman's family about the plan; once this has been accomplished, the two parties will then discuss the size of the bridewealth (*belis*). When they have reached an agreement the male side will pay the bridewealth (*belis*). The demanded *belis* is always rather costly, but the male side does not always have to pay it immediately. In fact, even if the male side is capable of paying the entire sum at once, such a one-time payment would be rejected as being inappropriate and a customary transgression. The male side usually makes an initial payment of the *belis* in the form of a buffalo, ox, horse, or goat depending on their financial capabilities. The rest of the *belis* would be paid later after the marriage as some sort of debt repayment. The *belis* debt is called and paid when the female side needs it, whether to provide *belis* for a male member of their own lineage, to conduct ceremonies in the customary house, to defray funeral expenses, or to fulfill some similar need. The payment should ideally be in the form of livestock as in the initial *belis* payment. Neither side is allowed to make an exact reckoning of whether the debt has been paid in full or not. Any discussion about calculating the debt, especially when initiated by the male side, is regarded as a breach of taboo and a transgression against longstanding customs. If it happens anyway, a customary fine is levied upon the male side in the form of livestock similar to the original *belis* payment.

After receiving the *belis*, the female side reciprocates by giving a *modo* (or *sayur*) in the form of a pig, a chicken, a piece of cloth, etc. The relative position between the two lineages remains the same; that is, if one side wishes to throw a feast for the other, then it must remember its original role as either the woman-giving or the woman-receiving side. Any mistake in the kind or amount of payment made at any point is seen as a customary violation and the transgressor must pay a fine.

Even when the *belis* has not been completely paid out, any children from the union is regarded as a descendant of the male lineage. The children of a female member of the lineage does not count as a member of the mother's lineage, but may request baptism by one of the mother's male relatives if he/she wishes to use both the paternal and the maternal baptismal surname. Similarly, when a woman marries into a different baptismal surname, she would continue to use her original baptismal surname by appending it before her husband's surname, *e.g.* Maria Belo Suares. In this case Belo would be the baptismal surname of Maria's parents, while Soares is her husband's baptismal surname appended at the end of her own. This naming signifies identification and respect for both surnames.

The use of baptismal surnames as personal identity is closely intertwined to rights to partake of the resources in a traditional/customary territory. Today the demand for this is largely economic in nature, especially in terms of membership in the parents' customary house (*rumah adat*) and lineage grouping. The political side of these rights (such as eligibility to become a *chefe suco*) is no longer influenced by particular traditional identities, and tends to depend more on the ability to connect with ordinary people **(see sub-chapter 3.4.2. Territorial Grouping).**

Although female members of the lineage have been 'released' to their husbands' respective lineages, they still maintain some degree of connection with their parental families through brother-sister relationships. For instance, if a married woman dies, some of the first people the husband would inform are the wife's parents or *lia nain*. In the process the husband or the male side of the exchange is supposed to send livestock in a similar manner to the payment of the *belis*. Similarly, if the husband dies and the wife would like to remarry, the new husband-to-be should ask for permission from the widow's parents or lineage elders, not from the oldest male member of the late husband's lineage. In either case, the bonds of exchange between the lineages are not severed upon the death of either party in the marriage. The presence of the woman-giving side (regarded as the life-giving side) and the woman-receiving side are required for joint funeral arrangements. This involvement by both sides is deemed important not only for the sake of the soul of the departed, but also for those left behind to gain some closure. Hicsk (1976) states "that the passing of information to the woman-giving lineage is related to beliefs about how to take care of the soul of the departed so that it can rest in peace in the afterlife and so that the living members of the lineage can come to terms with the loss.".

This explanation can be summarized in that the role of female members of the lineage is not limited to being reproductive agents but also as the means for the establishment of a web of exchange relationships that can have beneficial effects to her lineage of origin. In the religious-magic sense, she plays a major role in death-related rituals as a representative of the life-gicing lineage. Her rights in her own lineage may seem quite weak since she does not have inheritance rights, but she is an important asset to her lineage in the establishment of extensive social security networks through a system of her perpetual exchange and her role in taking care of death- and funeral-related arrangements. The customary exchange system through marriage can be seen as a socioeconomic burden to the male side, while at the same time providing the customary lineage group with the social capital to accumulate surplus in the face of resource scarcity.

Under all this customary pressure, the traditional system allows the opportunity to answer economic challenges (subsistence needs) with the aid of a complex exchange network. In this context, it would appear that the apportioning of customary lands through baptismal surname groups and the harsh ecological conditions have influenced the modes of social organization. From the spatial perspective, the territory of the baptismal surname group is a *'place produced through the interaction of social relation, expression of identity and the practice of culture.'* (Appadurai, cite from Panneli, 2011: 220)

3.4.5 Women's Position and Gender

Women's position and role in the Suco Tirilolo community in general and the Caisido region in particular (the *Aldeias* Parlemento, Caisido, Lialaileso, and Osso-ua) – and even among the Baucau population as a whole – appear to be rather contradictive. As a member of the lineage group, her presence is an important asset for the rest of the kin group in establishing social relationships, especially for economic purposes. On the other hand, she lacks the right to inherit subsistence resources (particularly land) from her lineage group.

The patrilineal and patrilocal system in Tirilolo (and Baucau in general) is rather unique. In a normal patrilineal system, the woman's bridewealth (*belis*) must be paid in full, and afterwards neither she nor her husband retains any obligation to aid in the provision of dowries or bridewealth for her male relatives who would like to marry. If the husband dies, the woman (and her children) fully becomes the ward of the husband's family.

In Baucau, although the woman has to be 'purchased' by her husband, custom dictates that the man should not pay the requested bridewealth (*belis*) in full even if he is capable of doing so. The outstanding sum becomes a perpetual debt that the husband must stand ready to repay throughout the marriage, and also creates a bond of mutual indebtedness between the lineage groups that will last for generations. Neither side is supposed to raise the point of whether the price has been paid in full or not. Any discussion of the matter is seen as a taboo.

Once a bond has been formed between woman-giving and woman-receiving lineages (*ummane – fetosaun*), the relationship is perpetuated in the form of occasional exchanges. Each side must keep its original role in mind in performing later exchanges or offering aid. The woman-givers (*ummane*) would give something commensurate to the original "*sayur",* such as pigs, chicken or something similar. On the other hand, the male side must offer contributions or aid of similar form and value as the *belis*, such as buffaloes, oxen, goats, or horses. These customary obligations also apply in offering meals (or throwing a feast) for either the woman-giving or woman-receiving side. Mistakes in offering gifts or serving food would require the party at fault to pay customary fines.

Although a woman has been given by her lineage to her husband's lineage, she is required to maintain elder-younger sibling (*maun – alin*) or brother-sister bonds. If the woman dies, the husband must promptly break the news to the wife's family, especially her elder siblings. This communication is accompanied with a gift of livestock similar to the original *belis*. The notification is mostly about the process of taking care of the deceased spouse's body. Similarly, if a woman gets widowed and another man wishes to marry her afterwards, the new husband-to-be should put forth his proposal to the oldest male member of the woaman's lineage. The agreement does not have to wait for consent from the woman or her late husband's family. Afterwards the remarried woman will reside according to the terms of the agreement, sometimes with her new husband's lineage and sometimes back with her original lineage on land managed by the oldest male member in her lineage group (*lia nain*).

On one hand, women do not have equal status with their male relatives, but their role is very important in building social security networks for her lineage's descendants and in achieving closure in matters that touch the world of the afterlife. Amidst these ambiguities, women/wives need to develop strategies to guarantee their futures.

Local natural and ecological circumstances that do not support market-oriented intensive farming, stagnant subsistence patterns, the lack of local investment opportunities outside traditional sectors, the burden of mutual indebtedness between *ummane* and *fetosaun* and elder and younger siblings – all of these are challenges that must be overcome by lineage groups and especially the women in order to be able to accumulate surplus and invest them for the future (**see sub-chapter 3.3**).

3.4.6 Decision-Making Among Kin Group and The Neighborhood

It has been explained in previous sections that the patrilineal lineage constitutes the basic social structure in the Caisido community. This kind of structure places decision-making power in the hands of the oldest male member of the lineage. Although the oldest male holds the power, he must consult with his male relatives. Husbands of female relatives living with her lineage group are not counted in the consensus, and even if present they do not have the right to express their opinions.

In relation to the project, any major decisions related to land purchases and or resettlement/relocation will require several consultative meetings, since it is possible that the solutions/suggestions chosen in the local meetings may fail to garner official government approval. By the same token, any decisions or suggestions made by governmental authorities must be discussed and mooted with male relatives in the lineage group; the process goes back and forth until an agreement is reached.

At the hamlet level, the Chefe Aldeia's office as the head of the hamlet does not give him the authority to make unilateral decisions, especially when it may affect fellow villagers' assets. Any decisions must be made together by the lineage as a whole. It may take multiple meetings to reach a final decision since, as mentioned above, the decisions made by the lineage's *lia nain* cannot be implemented unilaterally without consulting with male relatives within the lineage.

Hamlet-level consultative meetings involve all *lia nain* according to the number of customary houses (*rumah adat*). Since every lineage group has decision-making authority, there is probably going to be some differences in opinion between the lineages. However, in dealing with the project, the decisions of the most directly-affected lineages should be prioritized, while the remaining lineages should not have the authority to speak for the affected lineages or for the hamlet as a whole. The chief of the *Aldeia* does not have the authority to interfere with any villager's interests. His role as the leader of the *aldeia* or suco is merely to facilitate the meeting and pass suggestions from the other parties that he represents. The chefe of the aldeia and/or suco cannot impose his will and can only offer recommendations. Should the matter fall into a deadlock, the decision would be referred to the Regent/District Administrator. The Regent's decision is binding and final, and the villagers treat the District Administrator (*Bupati*) as the symbol of the government's ultimate power, but the decision must inevitable take account of the interests of all parties without unfairly benefiting any single party over the others. Still, the lack of any written and legal proof of possession over the land resources managed by the villagers places these villagers in a relatively weak bargaining position.

3.5 Project Issues

3.5.1 Information and Responses about the Project

Efforts to disseminate information about the project by TL Cement took the form of several public consultation meetings:

On 9 May 2014, a meeting in Suco Tirilolo, attended by the Chefe Suco of Tirilolo, Bahu, Triloca, Caibada, Bucoli, Garuwai, and Wailili. The institutions involved include:

- District Administrator of Baucau
- Chief Police Commander in Baucau
- Baucau Subdistrict Administrator
- Local NGO *Hamahun*
- Director of IPG (Institute of Petroleum and Geology)
- Director of BGC/TL Cement
- Director of Land and Property of Baucau District
- Director of Environment of Baucau District
- Representative of Veterans in Baucau District
- Local Authorities
- Tirilolo community; an estimated 90% of community members from the 4 *Aldeia* closest to the project site were present at the meeting;
- Tirilolo youth

A. The response from the Caisido community can be summarized by the following points:

- Response:
    a. The Caisido community is 100% willing to welcome the investment and the cement factory in the area.
    b. The community and youth in Caisido (38 traditional houses), will not impede the progress towards the development of cement factory and will be working with the GoTL to improve the economic condition of the population.
    c. We appeal to the government to decide upon a new neighbourhood for our resettlement and to make sure that the development of the cement factory will generate benefit for our present and future generations.
    d. We appeal to the company to provide a clear plan for protecting our future livelihood and for ensuring good coordination the government.
    e. We appeal to the company to establish an agreement with the Government of Timor-Leste.

- Concerns About:

  a. Whether there are any traditional houses that the development may impinge upon.

  b. How the government and other stakeholders would pay due respect to our cultural inheritance.

  c. Clear identification of boundaries for the development site(s).

  d. The Government should clarify land ownership and possession status with the Caisido community.

  e. The Government and stakeholders should continue information dissemination and consultation efforts with the community.

B. Responses to the community's concerns from the authorities and TL-Cement Agency:

The Director of Land and Property

The Director of Land and Property responded about status of the land; first he explained that there are several types of land, *i.e.*

a. Abandoned land/state property.

b. Heritage/customary land passed down from the ancestors to become communal property, such as a suco's common lands.

c. Private property land, registered with land ownership certificates.

d. Dowry property exchange.

Furthermore, he explained that before the project begins, his team will work together with local authorities to identify the proprietor(s) of each type and plot of land, and then affected plots will be measured to calculate the appropriate compensation value.

Baucau district Administrator

"Affirmed that the company has every intention to improve the community's livelihood and that they (the community) should not pay any attention to rumors that the company will destroy Suco Caisido's natural environment. He added that he will keep fighting for the community's wishes and that his team will frequently visit the communities so that they can hear the local communities' concerns and report them to the government for consideration."

Police District Commander of Baucau

"Stated that they are ready to provide full security in the designated area and assure that since many young people will be employed, there will be no youth confrontations. He also appealed to the community to ignore rumors spread by those who clearly do not want to develop the nation. He emphasized that his team will work together to support the government by supporting the project. He appealed to the community that this is their 'battle' and that everyone should take the chance to win it as this will reduce the unemployment rate in the country and improve our economic condition."

The Youth Group

"Their full support for this project and agreed that it will generate profits for their community by reducing the unemployment rate in Baucau District."

Responses fromthe BGC/TL Cement to the community's concern, spoken by the Director

"He explained that in order to manage the HR, they will use following method:

- Training
- Assign the right person to the right position

They will also employ local people in the following capacities:

- Labour
- Janitors/Cleaning Service
- Security
- Administration
- Construction worker
- Carpenter

He also affirmed that the government and its counterparts will be working together to reduce the unemployment rate in the country and that they will keep fighting for the community's well-being. This will increase the local HR capacity so that they will not rely on other nations' HR."

1. After General meeting on may 9. The TL-Cement representative held intensive meeting with local people at several suco, i.e.
2. On 24 June 2014, another public consultation was held in Suco Tirilolo. The meeting was attended by the *Chefe Suco* and the Youth Groups of Suco Tirilolo*.* It raised the issue of the status of the land. The community expressed their hopes:
    - The Community recommended that the government and the company should prioritize the interest of the local population in the Caisido region, especially the four *Aldeia*: Caisido, Lialaileso, Parlemento, and Osso-Ua. This is the recommendation and information from the Tirilolo Community.
3. On 16 July 2014 there was a public consultation to discuss cultural ceremonies at the planned project site. For this purpose, TL Cement was requested to clearly delineate the project site's boundaries, since the community would like to perform an animal (buffalo) sacrifice ceremony at the site.
4. On 14 October 2014, a meeting was held with the *King of Suco Ostico* Status over the administrative status of Wailacama *aldeia*'s traditional territory. The explanation was intended to clarify that the clay area falls under the Ostico customary jurisdiction even though the residents are now affiliated with suco *Vemasse*.
5. On 10 November 2014, a meeting was held with the community and landowners in the Macadai *aldeia*, Suco Bucoli. The results stated that:

- The planned mine sites AD-1, AD-7, and MI-3 were formerly arable lands but they are currently abandoned. There are other plots of fallow or abandoned land, and around 5% are owned by community members. This calls for compensation to prevent conflict;
- The community is glad to hear that an industry will be established in the Baucau municipiality for the first time. It will be advantageous for the community and will benefit the livelihood of the community and future generations.

6. Meeting with the Bucoli community and landowners. The topic was an explanation by TL Cement over the public's concerns, especially about the recruitment of workers for the project. The recruitment will be '**…** based on their capacity and skill and they will be given training for the relevant positions ranging from technical ones to non-technical ones such as administration'.

All statements quoted in this section are based on the minutes of public consultation as documented by TL Cement (Project No. 301012-02135)

7. In addition, on 1 March – 7 April 2014, the stakeholders from Baucau and Vemasse Subdistricts were taken on an inspection to the central plant of TL-Cement in Australia.

3.5.2 Knowledge About and Responses to the Project Based On Survey Results

The survey was performed randomly upon the Chefe Suco and a number of local residents, especially in the Osso-Ua and Wailacama *Aldeia*. We did not manage to meet up with all the Chefe Suco who were involved in the public consultation since some of them were away when we visited the locations. We met in person with the Chefe Suco of Tirilolo and Triloca, and the Suco Secretaries of Ostico and Vemasse. These village secretaries appear to have a more forward-thinking view in the collection and expression of community opinions. Our associates indirectly collected community wishes and opinions from the Sucos Bahu, Bucoli, and Garuwai.

The overall results of the survey are: the general response from the Sucos is relatively consistent with the opinions expressed in the existing minutes of public consultations, so most of them do not bear repeating. Most of the concerns relate to the project's commitment to employ local workers, transparency in labor recruitment, and an equitable distribution of employment opportunities for the youth from all Sucos in the Sub-district, and finally the degree of TL Cement's commitment to local development.

Although the Chefe Suco had already attended the public meetings, they still expressed some doubts, *e.g.*:

1. Wouldn't the plant cause dust and noise pollution in the local area?
2. Would TL Cement really implement the same standard and type of manufacturing equipment as in the Australian plant? There are concerns that TL Cement might use lesser-grade equipment that could cause environmental problems in Timor-Leste.
3. Would TL-Cement apply the same remuneration scale and system as in TL-Cement Australia?
4. Will the project truly employ as many locals as asserted in the public meetings?

Among the common people of Osso-Ua and Wailacama *Aldeia*, there were a number of questions about the possibility of compensation and/or relocation due to the proximity of residential sites to the project site. Some of the specific questions and responses were:

1. Would the compensation for appropriated land really involve consultation? They hope that the compensation process should include appropriate discussions and consultations to take due account of the present owners' wishes.
2. If people have to be relocated, the government should ideally prepare the relocation site beforehand. The resettlement site should preferably remain within the territory of the same hamlet or teritorial area, such as Belo. Even when the relocation happens in the same suco, there must be detailed consultation with the community in the planned resettlement site to pre-empt conflicts over land use and possession. The problem would be more serious if the people are to be resettled to a different suco inhabited by a different baptismal surname, since it will be more difficult to rebuild the resettled people's livelihood.
3. In the Wailacama *Aldeia*, the Chefe *Aldeia* stated that land appropriations under his jurisdiction (for the clay site) will not be based on a purchase model, and that he would demand the use of a leasehold model; if the land was sold straightaway, he would lose ownership and possession rights for good, while with a rent/lease system he would still be able to maintain his descendants' rights to the land.
4. The possibility that some gravesites may be affected by the project. It is hoped that the graves would not have to be relocated, but merely fenced in to protect them *in situ*.
5. Most community members are already aware of the plans to build a factory/industry, but many still do not have a clear idea of when and where the factory would be built. Some who saw their Chefe Aldeia accompanying outsiders have raised questions about what the Chefe was doing, since he had not shared much information even though the people were curious about what the outsiders were up to. This lack of information has brought suspicions about what the strangers were doing in their territory.

4. IMPACT ASSESSMENT

Introduction

This chapter on impact assessment describes both the potential positive and the potential negative impacts (primary and secondary) that may result from the implementation of the TL Cement project.

The potential positive and negative impacts upon the environment are divided into three categories:

- Impact due to project pre-construction
- Impact due to project construction
- Impact due to project operation

The most common social impact prediction methods may not be perfectly applicable to the local region and/or communities, so these methods require some degree of modification and improvisation to suit the local situation. Some programs may cause both intended and unintended results. It should be kept in mind that the impact of monetization in a subsistence community would have long-term effects and the consequences of the impact might diverge into several different directions due to regional diversity. In Baucau's case, ecology is a significant factor that influences the nature of impacts. The adverse ecological situation in the Caisido area requires special attention or treatment. It should also be noted that mitigation efforts would directly impact the Caisido area as the center of social impacts.

In Caisido, the aspects of life that would be affected by the project are not restricted to employment opportunities, but also include the loss of land as a source of livelihood; the uprooting of cemeteries and traditional/customary ritual houses; noise, dust and ash pollution; intense traffic in heavy vehicles and other means of project-related transportation; and the day-to-day behavior of the labor force. Therefore, the projects's effects to daily life would be quite significant. In contrast, the impacts to other communities would be mostly a matter of emerging employment opportunities even though these opportunities would not become available in particularly large numbers.

4.1 Pre Construction Phase

The major activities in the pre-construction phase are the acquisition of land for the mine and plant sites and the construction of roads to the clay site as well as the jetty and various supporting facilities. These activities are expected to cause a number of significant positive and negative impacts in the form of:

Potential Positive impact.

- High expectations among the local people

Primary potential negative impacts.

- Conflict over the status of land
- Conflict over compensation values and systems;
- Conflict over the dismantling of graves and customary ritual houses/*rumah adat*;

- Resettlement

Secondary potential negative impacts.

- Potential conflict of interest inter-suco.
- Potential damage to household subsistence condition

4.1.1 Potential Positive Impacts

1.) High Expectations Among the Local People

The plans for the construction of a cement factory in the Baucau Subdistrict has raised great expectations among the local residents for the social and economic development of their home region. These hopes were further strengthened when the project invited local representatives to visit and review the site and activities of a cement plant in the cement industry's central location in Australia.

Other activities that have contributed to the local residents' high hopes are studies held on behalf of the project and meetings to disseminate information about the potential risks and benefits of the proposed project. The principal expectation among formal government authorities from the district level all the way down to the sucos and among youth representatives are the creation of new employment opportunities; the improvement of public and social infrastructure and facilities such as roads, medical clinics, and schools; and the revitalization of local and sub-regional economic activities. The recruitment of a large number of workers for relatively long-term employment is seen as a factor that would inject a measure of vitality into the social and economic life of the region, which has previously remained stagnant due to dependence upon the traditional agricultural sector where the limited availability of labor and the harsh environmental conditions have stood in the way of economic expansion. This difficult situation places the local residents in an uncertain and precarious subsistence situation. Change is deemed unlikely in the absence of an external stimulus (in this case, the arrival of the cement industry).

4.1.2 Primary Potential Negative Impacts

1.) Conflict Over The Status of Land

The plans for a clinker cement factory demand a considerable amount of land. The required amount of land for limestone extraction is around 576 ha, while the requirements for the clay site, access roads, processing plant, additional facilities, and the jetty have not been fully calculated. The limestone extraction area is categorized by the Director of Land and Property in Baucau District as uncultivated secondary forest. The land needed for the rest of the project infrastructure and facilities lies on a variegated landscape of gardens/orchards, rice fields, and residential properties.

According to the Director of Land and Property, the legal status of a plot of land is largely based upon the absence or presence of human cultivation. Cultivated land is treated as private property, while uncultivated or abandoned land is regarded as public or government property. This categorization according to cultivation status may lead to conflict with the owners of land that have been or are being left fallow for several years, whether due to the need to restore the fertility of the land or due to labor shortages and the underdeveloped market economy, which makes it impractical or undesirable to work more land than what the farmer needs to fulfill his family's subsistence needs; damage or neglect to traditional irrigation networks has also caused the abandonment of arable land, as in the case of the former rice fields in the planned clay extraction site.

Unlike rice fields that are worked in every planting season, garden and orchard plots are usually exploited for a specific period between 3 and 5 years long and then left fallow for roughly the same amount of time before the site is cleared and taken back into cultivation. As such, horticultural land may appear to be abandoned when in fact it is being deliberately left fallow to restore soil fertility.

Another point of difference is that rice fields that have been abandoned or left fallow tend to remain identifiable as former rice fields, unlike abandoned gardens and orchards that quickly become undistinguishable from the surrounding bush apart from traditional markers like the low stone fences used to mark field boundaries. These fences are easily damaged or brought down by livestock grazing or browsing on the land. Nevertheless, these traditional fences are acknowledged by the village community as markers of land ownership. The fences are mended and rebuilt whenever the fallow plot is cleared and reopened for cultivation.

The lack of formal land ownership certificates places traditional smallholders in a weak bargaining position. At the same time, local community structures are based upon kinship/lineage groups and socioeconomic bonds between woman-giving and woman-receiving groups, and this tends to facilitate the spread of any potential conflict. The involvement of the woman-giving side would eventually influence the morality of exchange between the woman-giving and the woman-receiving side; it may also weaken women's bargaining position as we shall explain in a later section.

2.) Conflict Over Compensation Value and System

The determination of compensation prices/values and the type or model of compensation payment is a follow-on impact of land acquisition. Another major issue is the appropriate value and system of compensatory payments for communities that still live at a subsistence level.

These secondary negative impacts may become primary impacts under the influence of two factors that may lead to the accumulation of impacts. The first stems from the unilateral determination of land ownership status according to the government's criterion of whether the land is being worked or not; the proportion of land being actively cultivated is relatively small, so the landowners' bargaining position in negotiating compensation values tends to be rather weak. The attribution of inadequate amounts of land to the local residents is the likely result of unilateral decision-making through the District Administrator's fiat. Even if the owner is capable of driving a hard bargain, the eventual amount of the compensation agreed upon by both sides would probably still be too low to allow the purchase of enough land elsewhere, especially since there is no market for land and everybody needs their own land so nobody is inclined to sell.

The amount of compensation money gained by the landowner is probably going to be inadequate for setting up a business in non-traditional sectors. The market economy is still too underdeveloped and the landowners have virtually no trading experience.

Another major issue is the choice of compensation system. The land acquisition system usually involves the outright sale of land, which suits the preference of most project investors. However, this may not be suitable for the subsistence landscape of the Caisido communities, since the money suddenly injected into a subsistence economy is likely to end up being squandered in consumptive pursuits. This would lead to more problems as the local people become trapped in a position of even more uncertain livelihood than before since they have lost their original source of livelihood. This tendency would have a particularly pronounced effect upon vulnerable groups, which make up as many as 11% of the households in Osso-Ua. Despite the availability of government stipends amounting to $30/month, the allowance is not really sufficient to fulfill all household needs. Orchard/garden plots have always been the primary source of subsistence with the government stipends as a complimentary resource that helps reduce uncertainties in the fulfillment of subsistence needs.

Compensation through cash payments would lead to potential follow-on impacts such as the proliferation of impoverished households, reduced environmental quality, the perpetuation of substandard housing, poorer healthcare (especially among vulnerable groups), and the deprivation of opportunities for finding industrial jobs, all of which are associated with the deterioration of the physical environment as the local population's subsistence resources shrink or even completely run dry. These accumulated impacts would be practically irreversible and very difficult to manage. In this way, the project would not improve the quality of local human resources, housing situation, and subsistence certainty, but instead it would lead to poorer and more uncertain livelihoods. This possibility would certainly run contrary to the hopes of the local population and the project's promises to promote the improvement of local socio-economic conditions.

Unlike Caisido landowners who do not exhibit a clear preference for any particular form or system of compensation payment, the Wailacama people have figured out that they would like to receive compensation in the form of rent rather than a cash purchase. The project would ideally not buy the necessary land outright but rather lease it from the local population. This rent system prevents the local landowners from losing their rights to the land if the industry should cease its operations in the future. The renting of land by an outside party would also keep the locals in a strong bargaining position. As native inhabitants of the suco, the local residents would retain all social, economic, and economic rights in the hamlet. This solution may seem unattractive to the project but it is socially understandable. The landowner and chefe aldeia said that a leasehold system would allow his descendants to retain their identification with their place of origin. Territorial identity is an important matter to the people of Baucau. After all, traditional territory provides the site for the customary house, which hosts the symbols of the lineage's ancestral identity.

The Wailacama landowners' preference for a lease-based compensation system creates a more complex issue than in Caisido. However, it makes perfect sense to the local landowners, since they do not face much uncertainty about the present fulfillment of their subsistence needs but they do feel some uncertainty about their descendants' future identity. This leads to a strategy oriented towards the long term. The project should not feel threatened by this particular demand. The landowners' concerns are based upon their interest in protecting their traditional identity in connection to their customary territories. As such, there are two factors that may influence how far they would press their case about the preferred compensation model. First, as long as a landowner still has a significant amount of land that is not affected by the project, he will not be so worried about entirely losing his traditional identity. Second, as the native residents of Suco Ostico, the consultation over land acquisition matters would be preferably done in their ancestral suco in order to guarantee the recognition of their identity as the original settlers of Ostico. This recognition lies at the heart of their concern for their descendants' identity. Of course, this cannot be separated from Suco Vemasse's parallel interest insofar that the opportunity to demand benefits from the project would depend to some degree on whether any of its residents are directly affected by the project. This interest must be accounted for in such matters as the allocation of employment opportunities and village development/ empowerment initiatives.

From the analysis above, it can be said that the secondary impacts of land acquisition in Wailacama are probably going to be less significant than in Caisido. With the proper mitigation measures described above, the impacts can be managed and (to some degree) reversed to prevent them from causing follow-on impacts, and there is less risk of causing the accumulation of impacts upon landowners and suco residents as long as their concerns about their loss of identity as native suco residents can be assuaged. Moreover, the project opens more opportunities to develop a more dynamic economy in both Ostico and Vemasse, especially since TL Cement has specifically promised to provide employment opportunities and regional development assistance. The development of the local economy will remain sluggish in the absence of the project's stimulus.

3.) Conflict Over The Dismantling of Graves and Traditional Ritual Houses

The construction of the cement industry would affect a number of gravesites and approximately three customary/traditional ritual houses (*rumah adat*) in the vicinity of the plant and jetty sites. The number of affected religious-cultural sites would be quite small, but it would be unwise to underestimate their significance to the traditional belief system and their importance in symbolizing the integrity of lineage identity. Any disturbance to gravesites would interfere with the spiritual connection between living family members and the souls of the dearly departed. In conjunction with the impacts of land acquisition, this may lead to an accumulation of impacts that adversely affect the psychological condition of living family members. The concomitant psychological and physiological stress would be attributed to the disturbance to ancestral graves. This stress cannot be easily reversed.

Another kind of cultural site that requires great care in its handling is the customary ritual house (*rumah adat*). Based on our informant who owned the customary house, there are 3 customary houses that will have to be relocated. These houses are located away from the hamlet's main cluster of customary houses, ostensibly so that the lineage groups that own them would have an easier time conducting their rituals. We suspect that the actual reason was that these lineages were descended from the lepers exiled to Osso-Ua. The traditional rituals are performed on an irregular schedule and the local population seems to have largely forgotten those families' identity as the descendants of lepers, so it's unlikely that there would be any major objections to their relocation.

The relocation of a customary house is expected to go much more easily than the exhumation and relocation of a gravesite. The customary house essentially symbolizes a lineage group's identity. This symbol of group identity plays an important part in allowing members of the same territorial community to distinguish themselves from each other. As the basic social structure in the area, the lineage group provides a venue for group reproduction and the establishment of social security networks through bonding rituals between woman-giving and woman-receiving groups. There is no indication that customary houses are regarded as the abode of the souls of departed ancestors. However, communication with the souls of departed ancestors is performed in the customary house, such as when the lineage would like to accept a marriage proposal from another lineage. The customary house also serves as an institution to socially bond the lineage members together. *Rumah adat* or *Ummanenum* is symbolic rute of the patrilineal linieage groups of members. Therefore the relocation of a customary house and the attendant ceremonies would require a great deal of intensive consultation beforehand.

There are no known gravesites or customary houses in the projected clay mining site within Wailacama territory. This means that the project will have an easier time in handling issues related to these two types of religious-cultural identity sites.

The degree and extent of impacts from the relocation of these cultural sites would be relatively limited, but there is the risk of accumulated impacts against the local population's traditional beliefs. The impacts would also be basically irreversible, so the mitigation efforts should involve consultation with all relevant parties to protect the interests of the living family members. This would allow the effective management of the impacts.

These issues aside, the project is still likely to end up being economically and socially beneficial, not only to the families affiliated with the relocated graves and customary houses but also to the Caisido population as a whole. This should be put into perspective against the situation in the absence of the project, in which case there would be fewer opportunities to open the region to the outside world.

4.) Resettlement

The construction of a cement factory would require the resettlement of at least 10 households in the vicinity of the mine and plant sites and 2 households near the jetty. This number is relatively small, but any population resettlement presents complicated issues. The implementation of the resettlement plan should take account of the residents' wishes, the state of the resettlement site, and assistance for the social and economic reestablishment of the relocated households.

Consultative meetings have shown that Caisido communities offer a great deal of support but also expect much in return from the cement factory. They are willing to help in overcoming potential hurdles in the interest of local economic development. Community leaders do not always seem to be aware that the construction of the cement industry would require the relocation of graves, customary houses, and households. These three issues are the prerogative of the affected lineages, whose decision-making powers cannot be assumed by a different party. Of course these affected households would probably not go openly against the majority opinion, but any decision over the appropriation or relocation of private property should involve direct consultation with the affected parties. This expectation was expressed by the households whose gravesites, customary houses, or homes would be directly affected by the project.

Resettlement action cannot be treated separately from the relocation of graves and customary houses as disparate issues that require consultation. Each issue has a unique battery of impacts in terms of extent, magnitude, and accumulation, but the mitigation demands an integrated approach. For this reason, the consultative approach would treat the discussion of these three principal issues as a single package. The consultation should discuss the management of the issues in a thorough and transparent manner with regards to the risks and benefits to the hamlet residents so that the household leaders (lineage *lia nain*) would be able to take decisions without duress or pressure. The complexity of the issues faced by the owners of the houses, graves, and customary houses due for relocation means that the project's negotiators should be willing to engage in multiple and repeated consultation sessions.

The analysis above shows that resettlement action is associated with significant primary impacts not only with regards to the restoration of livelihood for the resettled population but also in the relocation of graves and customary houses, so there is considerable risk of impact accumulation. However, the impact is largely reversible and manageable. The management of the affected groups should be relatively achievable due to their small numbers.

Neglect and lack of attention towards the resettled population's attempt to reorganize their lives may cause significant economic decline and (at least in theory) might even trap them in long-lasting poverty. As such, it would be wise to engage in the comprehensive treatment of resettlement issues and to allocate employment opportunities for at least one member of each resettled family.

Despite the complexity of the issues described above, the presence of the project is still expected to enhance the dynamism of the local socio-economic conditions. Local resources and capabilities for the fulfillment of subsistence needs have largely been constrained by various uncertainties and harsh natural conditions. The cement industry would allow the population to overcome these constraints by taking advantage of new employment opportunities and the opening-up of their region to the outside world.

4.1.3 Secondary Potential Negative Impacts

1.) Potential Conflict of Interest Between Sucos

In addition to conflicts over individual land ownership status, there is also the potential for conflict over land rights between neighboring sucos, especially on the clay site. The land historically belonged to Suco Ostico, but the owners are currently residents of Suco Vemasse. The main issue is who should represent the owners in the negotiations over land acquisition – Suco Ostico's administration, or Suco Vemasse's? This involvement issue becomes particularly important in light of the cooperative suco empowerment plans promised by TL cement in prior consultative meetings. Although the landowners reside in and are administratively regarded as residents of Suco Vemasse, they are still sociologically oriented towards their former status as the people of Suco Ostico. Reasserting their identity as Ostico residents would strengthen their bargaining position in negotiations with project personnel. However, this choice may lead to the economic and political marginalization of the 15 kin groups who originated from Suco Ostico. This marginalization may not necessarily have a substantial effect upon their livelihoods since they do not depend heavily upon the resources available in the Vemasse traditional territory. For the 44 immigrant households who live with their woman-receiving lineages, the social and economic risks are not likely to be significant either since their economic activities largely consist of harvesting firewood in Ostico traditional lands. Still, this activity provides a relatively precarious livelihood to begin with since the income thus gained is somewhat lower than that of the woman-receiving households who host them.

These immigrant households do not experience quite the same indirect impacts as the woman-receiving lineages. However, their residence in Vemasse depends heavily upon the goodwill of their woman-receiving host group; if the formal leadership in Vemasse does not approve of the Wailacama immigrants' preference to identify with their hamlet of origin, the Vemasse leader may be somewhat disinclined to include these immigrant households in the list of job-seekers registered with the project management. In this way, the immigrant households must face a greater degree of social and economic uncertainty that will place them at the mercy of the economic exchange morality between woman-giving and woman-receiving households. One possible mitigation measure would be to facilitate ricefield cultivation in hamlets that currently experience difficulties in finding access to water. The opportunity to engage in rice cultivation would help sustain the traditional norms of perpetual exchange between woman-giving and woman-receiving lineages. The landowners would be able to lease their land or hire farm workers since they are no longer interested in working the land themselves, considering the greater profits from work or investment in non-traditional sectors.

We can conclude from this analysis that land acquisition will cause different potential impacts in the two affected sucos. Around the activity centers of the cement factory, the potential direct impacts take the form of potential conflicts over land stewardship rights if the criterion of ownership is decided unilaterally according to the government's standards. The probable consequence is that the local population will receive less compensation than they actually deserve since the extent of land deemed eligible for compensation would be limited to the garden/orchard plots being presently cultivated. The affected parties would be limited to the people of Osso-Ua, but that is not insignificant since they make up 25% of the Caisido population. The impact may also exacerbate the situation when the affected household is affiliated with the customary houses (*rumah adat*) or gravesites that would be directly affected by the project; this further weakens their bargaining position and places them under greater psychological stress. These impacts can and should be managed to reduce or even eliminate the potential direct and follow-on consequences, such as by taking appropriate decisions about land ownership status, compensation value, and the relocation of graves, residences, and/or customary houses through intensive consultation with the aid of a third-party facilitator such as an NGO or the Church. It should be remembered that the project is supposed to improve the local socio-economic and residential condition. The absence of the project would leave the local population at the mercy of the present uncertainties of their subsistence livelihood, especially in the face of unpredictable weather and market price fluctuations.

In the Ostico (Wailacama) territory, the primary impact is the potential conflict between sucos over the lands to be acquired by the project. This impact is not likely to have substantial follow-on effects to the 14 households from Ostico, since the probable consequences – in the form of administrative neglect or ostracism by the Vemasse village leaders – are not likely to affect their main sources of livelihood. A different set of follow-on impacts should be considered for the 44 households hosted by woman-receiving lineages (vulnerable group), as we have explained above. In either case, the impacts to the Wailacama residents who moved in from Ostico and to later migrants are deemed reversible and manageable. These impacts do not pose much risk of the accumulation of follow-on impacts such as the loss of livelihoods, barriers against participation in the project, relocation demands, or permanent damage to exchange relationships between woman-giving and woman-receiving lineages.

Seen as a whole, the project is probably still going to have a net positive impact, especially with the opening up of the Ostico region to the outside world and the opportunities to develop currently neglected agricultural lands. These two opportunities should promote and accelerate the development of the Vemasse area. Meanwhile, the absence of the project would leave Vemasse in its current isolation with a substantially different pace of change.

2.) Potential Damage to Household Subsistence Situation

In Caisido, no matter how much land is acquired by the project, the results will inevitably affect local households' subsistence situation. This is particularly related to the change in the status of the reserve/fallow fields, which are traditionally regarded as private property but might end up being treated as government property with no attached rights for individual compensation. In that situation, even if the owner receives compensation, the sum might be insufficient to offset the loss of the land. The money/capital thus obtained would not be enough for the development of businesses outside the traditional sector that the owners are already familiar with.

The case study on household economies has revealed that households with alternative sources of income (apart from horticulture) are more likely to be able to secure their subsistence situation and accumulate surplus. The employment opportunities provided by the project may also help replace the loss of traditional subsistence resources. However, this opportunity may be beyond the practical reach of some households. The average size of a household in Osso-Ua and other hamlets is no more than 4-5 people, and as such there would normally be only one family member who could work at the factory, and even then they would likely end up in a non-skilled position with correspondingly low wages. The family will have an even harder time trying to accumulate surplus if the employment is intermediated by a third party. This situation would persist throughout the existence of the cement industry unless there are adequate efforts to empower the traditional sector with the aim of increasing field productivity.

Records indicate that 12 households in the vicinity of the mine site and 3 households near the jetty will be directly affected by land acquisition activities. The number of landowners who would be affected by the road-building project is currently unknown, but the geographical extent of the impact would be limited to the Osso-Ua aldeia. The direct impacts may be transitory but their consequences may extend far into the future, especially in the absence of initiatives to empower the traditional sector and create employment opportunities. The impacts may accumulate if the subsistence condition persists, which will lower the value of local human resources in terms of health and fitness and thus impair the local population's chances for involvement in the project. However, the impact is essentially manageable and reversible. Also, if the project is properly planned and managed, it should be able to improve the social and economic situation of local communities as a whole. The absence of the project in the Caisido region would thus leave the region in its present stagnation since there would be no external empowerment initiatives that address the core issues in local economic activities.

4.2 Construction Phase

Main Activities

- Land clearance and site preparation
- Jetty construction
- Employment opportunities
- Mobilization of heavy equipment

Primary Potential Positive Impact

- Employment opportunities

Secondary Potential Positive Impacts

  - Improvement in local households' social and economic condition

Primary Potential Negative Impacts

- Conflict Over Recruitment Job Opportunity

- Termination of employment at the end of construction

Secondary Potential Negative Impacts

- Influx of workers from outside the local region
- Women's bargaining power
- Dependence upon Cash Income/Money in Household Subsistence Arrangements
- Public health

4.2.1 Primary Potential Positive Impact

1.) Employment Opportunities

Employment opportunities are one of the main issues that the project relies upon for attracting the support of the local population. Construction activities for the cement industry are estimated to require a peak number of around 1000 workers, or about 9% of the working-age population in the two local subdistricts.

Our estimation based on analogical with similar project the employment will be 12% of the employment opportunities created would be for management staff, 28% for technical workers, and 60% for unskilled laborers. The Sub-district Baucau population, in our opinion, should ideally be able to fill all the required positions, except for management staff and technical skill. Surveys reveal that around 19% - 22% of young men and 22% of young women have senior high school education while 9% - 12% of young men and 8% - 10% of young women have college or university education. In the rural (Caisido) region about 10% - 20% of boys and 12% - 21% of girls have achieved junior high school education, 5% - 17% of young men and 12% - 25% of young women have senior highschool education, and 13% - 31% of young men and 13% - 24% of young women have bachelor's degrees.

There is a secondary technical school in Suco Uailili of the Baucau sub-district that accepts student from the entire Baucau region. The graduates from this school should be able to fill some of the technical worker positions required by the project.

However, based on our experiences, there may be some issues related to the management of workers by a third party in the form of a business partner. This kind of employee Management Company often goes overboard in implementing man-day efficiency by reducing the number of workers to the bare minimum, utlizing cheap workers brought from outside the local area, and ignoring environmental management directives. Another potential source of problems lies with the allocation/distribution of employment opportunities among local villages and administrative sub-units. Wages would be pushed down to the minimum permissible standard rather than a reasonable daily amount. It is very likely that these business partner organizations would be owned or run by local elites such as former guerrillas, relatives of high civil or military officials, or the chefe suco. As businesspeople, they would naturally try to seek profit by using the efficiency measures mentioned above. This would be particularly troublesome in light of the fact that the project has already made several promises, so it would be difficult to mitigate or prevent potential conflicts (see sub-chapter 4.2.3. sec. 1).

Table 4.1 Recommended Distribution of Employment Opportunities

Sub-District/Suco	Number of males of working age	Percentage of workforce utilization (out of 3000 opportunities)	Total number of households	Percentage of workforce utilization / household
Baucau	8,811		7,523	
Vemasse	1,629		1,866	
Sub-Total	10,640	9%	9,389	11%

Source: Processed from Table 3.3 and 3.4 in this report above.
Note: This analysis is based on our estimation in peak activities that the project will absorb approximately 1000 opportunities mostly for semi and non-skilled labors.

4.2.2 Secondary Potential Positive Impact

1.) Improvement of Household Economic Condition

The possible availability of employment opportunities in the local area is an important follow-on impact that helps provide more certainty for household subsistence. Case studies show that households with additional sources of income in non-traditional sectors are more likely to be able to fulfill their subsistence needs. The availability of $15 daily (based on our experience during site visit) pay over a fairly long period would help guarantee the fulfillment of subsistence needs for young men's parental households while the parents would still be able to work their traditional gardens and orchards. Although not all jobs will be available for the entire duration of the construction phase, several days of work per month would still help greatly towards the fulfillment of subsistence requirement. A $15 daily wage is equivalent to 1 sack or 25 Kg of rice. This much rice would fulfill 2 weeks of subsistence needs for 4-5 family members in a household. There is relatively little concern that the availability of cash will attract potential borrowers since all households in the immediate area would stand to benefit from the project.

Problems may arise since, in theory, communities with a long tradition of subsistence living may have difficulties in turning their cash (capital) surplus into productive spending. From the same theoretical standpoint, it would be difficult to make productive investments since there are few or no local opportunities. The harsh natural and soil conditions and the fragmented ownership of small, widely dispersed plots of land tend to make it difficult to improve the efficiency and productivity of the land. However, the possibility is not entirely absent.

Field productivity can be increased in two ways, namely with the more extensive planting of marketable crops and the introduction of fertilizers. These two treatments would open more opportunities of work in the traditional sector, especially for women and the elderly. These activities would also help the promotion of a market economy since the growth of the traditonal sector can be expected to aid the growth of the commerce and transportation sectors. All of these would depend on the availability of outside help, such as agricultural inspectors who can motivate and teach the farmers about ways to increase the productivity of their plots. The project may get involved in these activities by supporting the distribtion of fertilizers and high-quality seeds in cooperation with the relevant government authorities.

These steps should be begun during construction to ease further assistance efforts during the operational phase. Such efforts would be very important in getting women to be more involved in the economy of their village.

The improvement of local households' social and economic conditions is the follow-on impact from the availability of employment opportunities. This impact would only be sustainable in the presence of assistance efforts to invest surplus income in the development of a market activity for horticultural activities. Without such efforts, the surplus income would merely benefit traders who offer consumptive goods. Proper empowerment measures would result in more widespread positive impacts that would have cumulative effects in other sectors, such as the improvement of human resource quality, better certainty for the fulfillment of subsistence needs, and the greater involvement of women in the local and regional economy. Conversely, the absence of empowerment efforts can nullify the positive impacts by accustoming local households to consumptive economic behaviour. This last concern can be managed as long as the mitigation efforts are begun as early as possible (during the construction phase). In the long term, the project can help traditional subsistence agriculture patterns become more efficient in the operational phase, by facilitating the sale of vegetable produces in the open market for the fulfillment of subsistence needs (or in the production-market-consumption model). This subsistence model can be quite risky, but fortunately the types of crops planted for local consumption needs do not appear to be highly vulnerable to market price fluctuations. Local farmers have developed adequate knowledge about natural patterns for the purpose of anticipating the vagaries of the weather and natural conditions, so the risk of failure should be quite limited.

The subsistence households in Caisido are not poor per se, but their traditional gardening and orchard cultivation activities do not provide much opportunity to accumulate surplus. Without the empowerment discussed above, it would be difficult for them to improve their households' economic condition. The rise of a labor-market (industrial) economy in the midst of a subsistence economic landscape creates a developmental paradox that is initially expected to empower the regional economy but may end up causing economic dependence instead.

4.2.3 Primary Potential Negative Impacts

1.) Conflict Over Employment Opportunities and Recruitment Practices

The opportunity to exploit traditional resources has hitherto been restricted to local residents or the dominant territorial grouping in a suco.

It is not unlikely that a new resource (such as employment opportunities) would be treated under the same paradigm of control. The Chefe Suco in Tirilolo and Triloca both stated that half of the employment opportunities created by the project should be given to the people of Tirilolo while the other half would be distributed among remaining sucos. This may not sit well with the other sucos, especially with their youth groups, since this 50% scheme would mean that fewer than 1000 jobs would have to be divided between 15 sucos (8,830 workforce), thus absorbing no more than 6% of the available workforce in those sucos while Tirilolo would benefit from the absorption of 31% of its workforce (1,610 workforce), or equal 5 times more opportunity from other sucos This situation is likely to spark discontent and perhaps even open conflict between youth groups in the abovementioned sucos.

Based on our experiences and according to Cernea (1988), we suggest that the selection and management of employee applications should be handled by a special institution formed through consultative processes with sub-district and suco leadership to remove the need for an external busines partner.

The formation of the institution should ideally involve youth groups representing their sucos. In Baucau, it should also involve the KPK (*Konsellu Polisia Komunitaria*) as a protector. The project should form an institution to handle relations with formal leaderships, managements, coordinators, and supervisors and to receive complaints from the community about unfair treatment (a Grievance Mechanism). Such a measure would be necessary since there are not many employment opportunities outside the traditional sector in the Baucau district, so the appearance of a large number of employment opportunities would attract widespread interest and the concomitant conflict potential.

The employee management institution should play the role of a coordinator, opportunity distributor, and negotiator over pay scales and employment terms, in addition to organizing training programs as planned by the project by TL-Cement during socialization (**see sub chapter 3.5.1**). With regards to this plan, there is the question of whether it will be possible to hold training for all the workers required in the construction process. In our opinion, the first step would usually require induction (explanation about workplace safety) whereas the public perception is that the training would largely be about how to perform skilled and semi-skilled work. This matter should be clarified beforehand so as not to cause message dissonance with the formal institutions hitherto tasked with disseminating information to the public.

It will not be easy to perform induction for such a large number of workers. The project should thus develop an appropriate recruitment schedule with due attention to need, types of work, and project timeframes. The schedule would be an important tool for the employee management institution in distributing the demand among subdistricts and sucos according to prior agreements. Experience shows that the lack of such a schedule tends to result in tension with job-seekers from *sucos* located far away from the project site. This discontent would then spread to the *chefe suco*, who would feel that his people has been neglected. The discontent would normally be directed towards the project and lead to a breakdown in the good relations that had been so painstakingly built between the project management and the local population. This is where the grievance mechanism induction would play a crucial part.

The analysis above indicates that the employment opportunities available during the construction stage would have both positive and negative primary impacts. The positive side lies in the follow-on impacts to other aspects of life, such as increased certainty of subsistence, especially in the Caisido region; increased work experience outside traditional sectors on a massive scale; and indirect training for youth groups who handle of this big recruitment workers in the orderly management of large numbers of workers over a long period of time. These follow-on impacts would be very difficult to replicate without the presence of a major project like TL-Cement.

The primary and follow-on impacts listed above are essentially nonrepreatable since similar opportunities would not always be available. The potential negative impacts from improper management can be put under control to prevent their perpetuation.

In our opinion, the advent of the project in the Baucau District would open far more possibilities for regional development than in its absence. The traditional agricultural sector faces numerous natural and ecological difficulties that makes it hard to promote social and economic development without the aid of non-traditional sectors that can absorb labor on a far larger scale.

2.) Termination of Employment at The End of Construction

The recruitment and involvement of local labor during construction does not only result in positive impacts; it would also create a major problem at the end of construction activities. Local workers can have positive impacts upon the economic state of their own households and of the village as a whole as long as they remain actively employed. However, as construction activities reach their conclusion, the flow of income would stop. The cash income from project activities cannot be easily obtained from other locally-based activities. While the operational phase would bring about its own employment opportunities, the numbers are no more than a third of the opportunities available at the peak of the construction phase. This means that at least a quarter (± 25%) of the locally recruited construction workers would lose an important source of cash income. This possibility would present a major problem if not properly anticipated and planned for in advance.

There are a number of measures that can be taken as explained in the impact mitigation section. One such measure is to encourage the utilization of the cash income for investments that increase the productivity of the local agricultural sector. There are also several other possible paths of socio-economic empowerment, as we will explain in a later sub-chapter about the impacts of operational-phase employment opportunities and the empowerment of the local/regional economy (**see sub chapter 4.3.2. sec. 1**).

The conclusion of construction activities may have follow-on (secondary) impacts in the form of a reduction in transportation activities, the increasing dependence of the household economic structure upon sources of cash income outside the traditional sector, and/or the growth of consumerism if the cash income is not invested to achieve increased production in the traditional agricultural sector. These impacts would be relatively widespread due to the large number of employment opportunities made available during the construction phase, would be very difficult to reverse without appropriate planning for the development and empowerment of the local exonomy, and may lead to a rift in the community between project workers' families with their substantially improved socio-economic condition and the rest of the local population who still have to struggle with the low productivity of the traditional sector. Fortunately, these impacts can be mitigated with proper anticipative measures, as we shall explain later in the section about the empowerment of the local economy. Compared to the situation in the absence of the project, the impacts of the termination of employment at the end of construction are still relatively manageable, especially once the beneficial impacts of the project are taken into account.

4.2.4 Secondary Potential Negative Impacts

1.) Potential Impact of the Influx of New Workers upon Local Social and Cultural Aspects

Although the construction phase would involve the recruitment of many workers, there is relatively little likelihood for an influx of job-seeking outsiders into the Baucau and Vemasse Subdistricts. This can be largely attributed to customs that hinder the entrance of outsiders into a suco's territory. As such, we predict that the majority of skilled and semi-skilled workers will be recruited from within the two local subdistricts. Although different sucos have different dominant baptismal names, relationships between the residents of different sucos are relatively amicable except in the matter of resource control, where prohibitions exist against the entrance of a suco's residents into the territory of a different suco. There will be some employment opportunities in the cement factory for people from outside Tirilolo, but the number would not be large enough to overwhelm local workers from Suco Tirilolo.

The workers' dispersed/distributed activities and the demands of daily commute for workers from outside Suco Tirilolo means that the outsiders are not likely to have intense contact with local residents, especially local women. The devout Catholic faith of most local residents also contribute to the strength of faith-based social bonds and norms so there is little cause for worry about undesirable forms of social contact between men and women. Despite the presence of several different territorial groups, the tendency is to place more of an emphasis upon the common features of local belief systems as represented by the customary houses (*rumah adat*) along with the norms of exchange in marriage arrangements and the stewardship of graves and customary houses. Thanks to these factors, the presence of a large number of project-affiliated workers is not likely to significantly affect or change the local culture. Instead, the most likely cause of social transformation is the widespread introduction of a cash wage system, as explained in other sub-chapters.

2.) Women's Bargaining Power

The cement industry provides attractive employment opportunities for male job-seekers. On the other hand, the industry does not offer many opportunities specifically intended for women. Indeed, women were not even involved in the preliminary consultative meetings, except for the heads of the Baucau Subdistrict and Sucos Triloca and Bucoli (all three were positions that happened to be held by women at the time).

Traditionally, women have an important role in the lineage for the establishment of exchange networks. However, their decision-making position is relatively weak. The exception is in the management of the household economy, where the wife normally has the authority to determine the household's consumption pattern. The wife's role in garden/orchard cultivation is largely that of supporting the husband in his cultivation activities. Similarly, women hold a secondary position in deciding how the produce should be marketed.

The project's recruitment of a predominantly male workforce may facilitate opportunities for women to take a more significant role in horticulture or trade. Since trading activities tend to be hindered by a shortage of capital, the only major opportunity available would be to fill labor requirements in the traditional garden/orchard farming sector. Even so, such activities still provide no guarantees for the woman's future; for instance, if her husband dies, the horticultural lands will tend to fall into the hands of the husband's oldest male relative.

In theory, this situation should encourage women to develop a strategy to plant different crops from the ones hitherto cultivated by their husbands. Traditional cultivation patterns see staple crops as the main crop while cash crops are used only to make up subsistence shortfalls. In this regard, the woman's role is limited to helping the husband manage the production process to fulfill household consumption needs. The migration of male labor into the industrial sector may then encourage women to take a greater role in the traditional horticultural sector. This time their involvement would not merely be in the capacity of executing and aiding the husband's cultivation strategies, but rather would call for them to develop their own long-term strategies to guarantee their subsistence after retirement age by planting cash crops to accumulate surplus. Literature review has revealed examples of how women use accumulated surplus to improve their children's level of education. Better-educated children are expected to provide a form of insurance for the parents especially for mother in old age. This phenomenon has not been widely observed in Caisido except among the owners of larger or more tracts of horticultural land.

The empowerment of horticultural activities towards greater productivity (as suggested above) should help women in developing their household economy without having to depend on their husbands' or sons' work on the project. Their success in increasing their gardens/orchards' productivity would restore their bargaining position vis-a-vis the men and their cash income from their industrial work. The women's role in helping their male relatives pay *belis* cold elevate their position within the household since the provision of *belis* and *sayur* aid by the women would no longer depend on the fruits of men's work. This way they should theoretically be capable of increasing their decision-making role in their households.

This long-term process towards the improvement of women's bargaining position can be regarded as the indirect impact of the absorption of the male workforce by factory jobs.

On the other hand, the analysis above also reveals the possibility that the availability of industrial jobs for men may lead to the long-term weakening of women's bargaining position in the development of Caisido households' economy. This impact would have considerable extent due to the widespread recruitment of male workers from all sucos in two subdistricts. It also carries considerable risk of impact accumulation through the abandonment of traditional farming by the men, which leads to the increasing dependence of women upon men as the breadwinner in the family, the lack of physical and psychological activity for the women (which may lead to health problems), and the deterioration of the women's bargaining position in finding husbands among their household socio-economic relatively equals. These potential follow-on impacts are largely reversible since they can be mitigated through the empowerment of the traditional horticulture sector where the women can still find some productive work.

Those potential follow-on impacts present a bleak picture for women's future, but fortunately the impacts are still within manageable limits. The project can also be said to provide an opportunity to improve the women's bargaining position through their success in managinf the traditional economic sector in a more productive manner. This possibility would be quite difficult to imagine in the absence of external factors in the form of a male job market that prompts changes to stagnant traditional institutions.

3.) Dependence Upon Cash Income/Money in Household Subsistence Arrangements

The widespread availability of a large number of employment opportunities for all sucos in the two local subdistrict – and the subsequent payment of regular wages to recruited workers – could create a dependence upon cash in the household economy. The likelihood of gaining cash income from the traditional sector has been quite limited thus far, and the harsh ecological conditions of the local area have also limited the growth of market-oriented endeavors in the traditional agricultural/horticultural sector. Of course, the small amount of cash income obtained from the traditional sector has been very important, but it does not play a central role in the local economy, so the introduction of money has not caused a dramatic cultural change that eventually results in social change. An important indicator of this is the relatively weak social stratification among community members, especially in the Caisido region. Indeed, the adverse ecological conditions and the limited availability of land and labor have combined to promote the development of a relatively unstratified society characterized by a reluctance to display excess personal fortune for fears of being seen as a prideful person with a lack of social consciousness.

The introduction of a cash wage system on such an extensive and long-term basis can trigger a shift to a subsistence model that prioritizes market-oriented production over household consumption. The traditional farming sector would then be demoted to secondary priority or even neglected entirely, as in the case of Wailacama households that have abandoned farming to become merchants or salarymen. For Caisido households, the convenience of having regular pay as a principal source of subsistence resources would only last until the end of the construction phase. The sudden cessation of cash income could reduce the local residents' subsistence capacity and lead to intense competition over the fewer jobs available during the operational stage, perhaps even to the extent of open conflict between residents (**see sub chapter 4.3.3. sec 1.**).

Before the advent of the project, there is hardly any visible competition between local residents over the fulfillment of subsistence needs. This lack of competition can be attributed to the common experience of facing environmental constraints in taking out a living through the traditional sector. The accumulation of surplus through the traditional sector is performed through traditional institutional mechanisms (such as investment in livestock) so there has been no particularly strong impulse for the development of social stratification.

The introduction of money economy into the traditional sector, such as through the planting of cash crops, has familiarized local residents with the use of money. However, money has not penetrated very deeply into the traditional sector, such that the hiring of farm laborers remains rather uncommon. As a result, the process of social stratification has proceeded at a very slow and gradual evolutionary pace. This process has not resulted thus far in any sharp or distinct social segregation. In the Caisido region, there does not seem to be any major difference between the haves and the have-nots in terms of the ownership of garden/orchard plots, so any tendency towards social stratification is not immediately visible.

However, the introduction of a cash wage system through the industrial sector (with the recruitment of construction and factory workers) may precipitate a process of rapid and sharp segregation between those who benefit from the industry and those who have to continue to rely upon the traditional sector. This segregation would become particularly pronounced in the absence of any dedicated effort to facilitate the involvement of the traditional sector in the market economy. Prior to the project's arrival, the Caisido communities have managed to maintain a relatively egalitarian structure that helps guarantee mutual survival; but when the project introduces a number of powerful benefits for a large number of recruited workers, the community may fragment between an enclave of well-off factory workers and the remaining residents who have not gained any direct benefits from the factory's activities. This kind of development could cause considerable damage to the project's image and its ability to fulfill the promise to improve the social and economic condition of the local population, therefore the regional economy development is needed (analysis for this issue **see sub chapter 4.3.2**).

4.3 Operation Phase

Main Activities

- Employment Opportunities
- Development of Regional Socio-Economic Activity

4.3.1 Primary Potential Positive Impact

1) Employment Opportunities

The employment opportunities in the operational phase would be for top managers, senior experts, junior experts, computer science undergraduates, and non-specific workers with various levels of educational requirements (from high school to junior high school or even elementary school). The estimated number of employee requirements is around 700, this number is based on our estimation that the project will absorb approximately 700 opportunities mostly for skilled, semi-skilled, and unskilled labors. TL-Cement would continue to prioritize applicants from the local area. All workers would receive prior training to bring their skills up to the standards demanded by TL-Cement.

The number of workers required would be around three-quarter (75%) the number at the peak of the construction phase. However, the operational workers have the advantage that they would become permanent employees for the term of the industry's operation, with the attendant social security facilities, health insurance, and other social security measures according to the prevailing rules and regulations in TL-Cement. Similarly, the system and amount of remuneration would not differ much from the standards that apply to TL Cement plants elsewhere.

The reduction in the size of the workforce at the construction phase – for a total of around 700 workers (75%) – in our assumption means that the industry will only be able to accommodate a maximum of 7% of the working-age men in the two associated subdistricts (10,640 workforce). If the distribution of opportunities is calculated down to a household basis (9,389 workforce), only 7% of households in the two subdistricts would be accommodated, which constitutes a rather low number amidst the scarcity of employment opportunities outside the traditional sector. This might cause high competition and conflict (for this potential impact **see sub chapter 4.3.3. sec. 1**).

4.3.2 Secondary Potential Positive Impact

1) The Development of Regional Socio-Economic Activity

The TL-Cement management promised during the information dissemination and consultation meetings that the: 'Government and its counterpart will be working together to reduce unemployment rates in the country and that they will keep fighting for the community's well-being.' This statement would obviously be repeated and remembered among the sucos. In our opinion, it should not be too difficult to turn these promises into reality. Major companies have an inherent responsibility to promote the empowerment of local communities through Corporate Social Rensposibility (CSR) programs. The impact mitigation and management measures suggested for the individual impact categories above can be made into an integral part of CSR. However, this requires consultation and cooperation with the suco administration and related government agencies at the district level.

Community representatives and survey results both indicate that the local residents would like to see repairs to irrigation infrastructures in order to restore rice field productivity in certain areas where rice cultivation has recently become impracticable. They would also like the introduction of more productive garden/orchard farming practices, especially for environmentally-friendly organic vegetable crops. These efforts would empower the local economy through increased transportation activity, the emergence of vegetable commodity middlemen, and increased trade in agricultural supplies such as tools and fertilizers. These developments would open employment opportunities for women who are largely unable to apply for industrial jobs.

These efforts would not be entirely free of risks, since the introduction of money as a predominant mode of exchange may lead to the rationalization of *belis* or *sayur* exchanges. This possibility is very real, but certain kinds of exchange goods such as buffaloes, oxen, goats, pigs, and chicken are more likely to remain irreplaceable since there seems to be certain constancy in the ritual practices at the customary house and the involvement of woman-giving and woman-receiving lineages in the care of deceased relatives. This can be seen in the fact that the introduction and spread of a new faith (Catholic Christianity) over several centuries has not managed to entirely wipe out local belief and ritual systems. Similarly, money may become a new common exchange medium but its functions would remain constrained by existing cultural exchange practices that place a great deal of emphasis in preserving the local cultural identity. In fact, the ease of acquiring and accumulating surplus with the use of money may help the local population carry out their traditional social functions while at the same time improving their children's level of education.

Another issue that may arise from the workings of the agricultural/horticultural sector is the demand for labor. Both rice and garden/orchard cultivation in the area is predominantly handled by men. Traditional farming practices have not maximized the use of women's labor, partly because women remain less effective and efficient in working the land. This problem may be addressed through intensive education and training programs to encourage women's involvement not only as farm workers but also as agricultural/horticultural entrepreneurs. The demand for farm labor may be filled by inviting or involving workers from women-giving groups outside the local territory. Alternatively, the demand may attract people from other areas to work as paid farm laborers in the Baucau and Vemasse Subdistricts. This possibility is facilitated by the availability of facilities for daily or weekly horizontal mobility.

The explanation above shows that CSR efforts constitute the unforeseen or indirect impact of the cement industry. This impact would have considerable geographical extent due to not only the growth of the commercial farming sector but also the incentive for inter-regional labor mobility (a cumulative impact). The potential negative follow-on impacts from the introduction of a money economy are probably going to remain within controllable bounds. The Church and customary institutions have hitherto played their respective parts in preserving group identity and the traditional exchange system, thus maintaining the integrity of local cultural valies. However, there is a case for strengthening the Church's involvement in maintaining the consistent implementation of religious norms. Theoretically speaking, cultural change is unlikely as long as the main elements of the culture remain functonal. In this case, the most important cultural elements for the Baucau community are the customary (ritual) house and the exchange morality.

4.3.3 Primary Potential Negative Impacts

1) Potential Conflict Over Employee Recruitment and the Distribution of Opportunities

During the consultative meetings, the sucos outside the project area expressed their desire to get a share of the employment opportunities.

The relatively high pay and attractive social and health security facilities during the operational period would obviously be very attractive to job-seekers, and this may lead to struggles over the employment opportunities – not only among the job-seekers themselves, but also among chefe sucos who would like as many of their people as possible to be admitted as workers. The outcome of this competition over a limited number of jobs would depend on how the distribution of employment opportunities is managed during the construction phase. The successful management of this issue would help greatly in defusing potential conflicts over employment opportunities in the subsequent operational phase. On the other hand, if the local labor recruitment institution (run by the local youth) fails to manage it properly, tensions will persist and may grow into open conflict.

Employee recruitment for the operational stage is probably going to be a more sensitive subject than in the construction phase. The recruitment of employees in the formal sector tends to raise suspicions about nepotism, whether to the benefit of lineage groups, territorial surname groups, or individual loyalties to former freedom fighters. One of the factors that contribute towards the intense competition is the scarcity of employment opportunities outside the traditional sectors, especially jobs with attractive employment benefits similar to those offered by TL-Cement. Fortunately, it is possible to manage this potential conflict.

The explanation above marks employment opportunities in the operational phase as a significnt direct impact. Although the number of jobs available would not be as large as during the construction phase, the impact is more sustainable and irreversible due to the scarcity of similar jobs in the Baucau region; the impact has considerable extent and causes accumulated impacts in the form of guaranteed and comfortable livelihoods for a reasonably long period, increased trust due to the fulfillment of the project's promises, and improved human resource quality thanks to the training programs. The follow-on impacts include the increase of public transportation activity, more income for shopkeepers and small taders, and increased quality of housing in the Caisido region. However, if the employee recruitment process is not properly managed, the employment opportunities may produce the opposite primary impact in the form of potential conflicts between sucos.

2) Potential Development of Enclave Communities

One of the undesirable potential impacts from employment opportunities in the cement industry/factory is the segregation of a relatively well-off community of factory laborers and employees from the majority of subsistence/traditional farmers who remain incapable of overcoming the barriers to the growth of the agricultural and horticultural sector. Therefore, it would be wrong to neglect the social and economic empowerment of the traditional farming sector. The empowerment of the traditional sector should pay appropriate attention to the difficulties and potentials presented by the local ecological landscape, so as to minimize the likelihood for the development of local and regional disparities. (**See sub-chapters 4.3.4. sec. 2. below**).

4.3.4 Secondary potential Negative Impact

1) Potential Dissatification Over Actual Results Compared to the Project's Promises

As the operational phase begins, local stakeholders will begin to closely scrutinize TL-Cement over its promises to provide employment opportunities and improve the local socio-economic situation. The issues that would stand out in the eyes of local communities include worker recruitment and the distribution of employment opportunities, wage levels and remuneration systems, the handling of land acquisitions, and the relocation of gravesites, customary houses, and local residences. Efforts to empower the local population through CSR (Coorporate Social Responsibility) programs initiated by the project in the interest of transformingg the local/village and sub-regional economy (as promised in information dissemination meetings with formal leaders from the District Administrator all the waydown to the heads of individual villages, and with local youth groups) is another matter that would determine how the local population sees the project's intent to contribute towards the local economy.

The project's willingness to turn these promises into reality – such as by setting up a special institution within the project to listen to and address the local people's complaints against the project – would be a crucial element in building a synergistic relationship with local stakeholders. If the project does not devote sufficient attention to the development of such a harmonious relationship, all the effort put into impact mitigation and management would not be able to stop the growth of dissatisfaction among the local communities. This would in turn tarnish the project's image in the eyes of external donors and investors. In this kind of situation, while the cement industry would be able to continue its operation, it would lose the trust needed to expand into new raw material extraction sites. Even if such plans manage to obtain the support of local authorities, resistance by the local population would become a cause for worry. The ultimate impact would be to discourage investors from contributing to the industry's financial sustainment.

Since the opportunity for social and economic empowerent through the project would develop in a gradual manner, the full benefits from the project would not be immediately felt. However, once these benefits take root, their impact would be irreversible.

2) Potential Development of Disparities in the Regional Economic Condition

If the empowerment of local social and economic potentials (as promised by TL Cement leadership) is not properly integrated with the abovementioned impact mitigation efforts, or if it does not pay adequate attention to local variations in ecological potentials and constraints, there is the risk that the effort may lead to disparities in local economic development.

The variation in local ecological conditions between the Baucau and Vemasse subdistricts has not caused any dramatic difference in social and economic development between the two. This situation can be attributed to the lack of effort to optimize the development of the traditional sector. The project's arrival in the middle of this stagnant socio-economic situation must be properly managed to prevent the local residents from becoming overly dependent on the project. This might involve the development of hinterland regions around the proj ect. The project itself does not have to be the leading actor in these empowerment effort, but it should be willing to initiate plans and provide motivation for the development of the local region. The project's long-term presence places it in a position to become an important agent of development, which incidentally would fulfill the hopes expressed by local stakeholders in consultative meetings.

Variations in local ecological and demographic conditions remain an important factor that may cause disparities in local social and economic development among sucos. However, the customary system for the exchange of women through the giving of *belis* and *sayur* presents an institution that can facilitate cooperation between the local communities. This institution forms the principal mechanism in managing and balancing the relationship between suco communities. The bonds of exchange between woman-giving and woman-receiving lineages are a form of social capital that can curb potential development disparities.

There is no way to completely eliminate the potential for disparities in local social and economic development since this potential has it roots in the unavoidable reality of ecological factors (especially soil condition). However, this does not excuse any lack of attention towards the social and economic development of the local area. On the contrary, the development of the hinterland/buffer zone around the centers of project activities is likely to benefit both the project and local communities by reducing the communities' dependence upon the project's resources (especially employment opportunities as a source of household income). This impact is unavoidable and may be difficult to accept but it is essentially manageable. The devout Catholic faith of the local population can help them cope with this reality. In the long run, the social and economic disparity between sucos may balance out against the possibility of social segregation between relatively well-off project employees and other local residents who still have to rely on the relatively unproductive traditional sector. This interaction between factors may help even out the rate of local social and economic development so that any disparities would only grow in a slow, gradual, and manageable manner.

Another issue that must be anticipated is that while local residents can be assisted and motivated in increasing the productivity of their agricultural/horticultural ventures, the distribution (marketing) of their produce out of the local region and the provision of food items and agricultural supplements from the outside remain under the control of traders/entrepreneurs coming from outside the Baucau and Vemasse subdistricts. This situation promotes unbalanced social and economic development across different regions. On one hand the Baucau and Vemasse residents still have to contend with the low rate of return in the primary agricultural sector, while entrepreneurs from outside these two subdistricts would be able to extract most of the surplus by the control they exert over the buying of farm produce and the sale of farming tools and everyday needs that the local residents can't produce on their own. Therefore, the empowerment efforts for the population of the Baucau and Vemasse subdistricts should not be restricted to the improvement of the farming sector, but must also involve the development of entrepreneurship capabilities in the mercantile and transportation sectors.

3) Potential Local Community Health Condition

Operation phase activities in mine and plant site will be generated particulate matter and gases. Based on air quality modelling, the dispersed pollutants are predicted to be able to reach the sensitive areas, but the concentration level reaching these areas are all below the standard for each averaging time. From the modelling, it is known that only NO_2 paramater is exceed the standard, however the dispersed only around the Plant or Mine Site where the operation phase is undertaken to the North West Direction.

Higher concentration of these pollutant may occur during the dry season which last from July to November, because during these months wet deposition rarely happens.

From the above description, the activities in operation phase would potentially affect to the community health in the long term (as long as the operation phase of the project). Therefore, to mitigate all unexpected possibility from the dispersed, it is sugessted to provide buffer zone or green belt around plant site and/or mine site. Moreover, for safety reason, it is necessary to re-develop the settlement near the site. This activity could be included as corporate social responsibility programme/fund and can be categorized as corporate compensation without using money toward the community (see **sub-chapter 4.1**).

5. IMPACT MITIGATION

The table below presents summaries of the mitigation efforts for significant impacts. The detailed description will be presented in following section.

This report does not account for the cost of the mitigation measures from TL-Cement's viewpoint and for the project's economic viability from the costs-and-benefits standpoint. Such feasibility evaluations are beyond the scope of this study.

Table 5.1 Summary of Proposed Impact Mitigation Measures

Potential Impact	Proposed Mitigation Measures
Land acquisition: • Loss of subsistence resources • Loss of bargaining power over land status, value, and compensation system	Intense negotiation with landowner, chefe aldeia, chefe suco, and *lia nain*
Population displacement/resettlement Relocation of ancestral cultural sites: graves and customary ritual houses (*rumah adat*)	Comprehensive resettlement program
Recruitment of workers and distribution of employment opportunities	Establishment of a labor recruitment institution
Loss of women's bargaining power Dependence upon cash income in household economic subsistence systems Transformation of traditional agriculture and the promotion of regional development	Development of an agricultural development and market integration plan Establishment of a regional development board Empowerment of women's role in agricultural and horticultural production

5.1 Intensive Negotation with Landowners

The determination of land ownership status by the Director of Land and Property on the basis of present cultivation status would weaken local landowners' bargaining position over land that is being left fallow in their rotational cultivation system. The lack of formal written proofs of ownership is another factor that weakens the landowners' bargaining position. The determination of land ownership status according to present cultivation status means that each individual landowner would only be compensated for a small amount of land. This prevents the landowners from negotiating a truly fair amount of compensation. With the relatively small amount of land attributed to them under the government's criterion, they would be unable to obtain enough compensation to buy an amount of land that will replace the actual extent of their losses. The lack of existing land sale and purchase instiitutions, the small amount of compensation made available, and the socio-economic dependence (especially in Caisido) upon subsistence agriculture means the owners would face difficulties in making use of the compensation money for productive pursuits. As such, it would be preferable to present the compensation to Caisido's subsistence farmers in some form other than cash, except in the case of Wailacama households that are better acquainted with the money economy. Some of the suggested solutions in this regard are:

- To involve multiple stakeholders in the negotiations, such as the chefe aldeia, chefe suco, dan suco *lia nain*
- To replace cash payments with another form of compensation, such as social security over a certain period or the construction of replacement houses for displaced households;
- To guarantee the recruitment of one productive family member for long-term employment with the project.

These efforts would contribute towards the mitigation of the principal impact to these groups, which is the loss of the subsistence resources they have relied upon thus far.

5.2 Resettlement Plan for the Osso-Ua People

Introduction

The resettlement is expected to affect no more than 15 households. It is not clear whether the relocated group includes the owners of all the lands affected by the project. In any case, the resettlement will proceed according to the wishes of the households that understand their position as people affected by the project:

- The households wish that their new settlement would remain within the territory of the same hamlet or the same baptismal name group (such as the Belo);
- The site and house construction costs should be borne by the project or the government;
- If the new settlement is located close to another populated settlement, there must be proper consultation to ensure the existing residents' willingness to accept the resettled hoiseholds, since this issue is related to the availability of livelihood resources in the future;
- The resettled households need some form of certainty about their future livelihood (especially for their descendants), particularly if all their traditional resources have been taken over by the project.

5.2.1 Outline of Proposed Resettlement Program

According to the resettlers' wishes, the choice of the resettlement site would be made under the following methods:

1. If an owner still has some land left unaffected by the project, a new house may be built upon this available land;
2. Some government-owned land unaffected by the project would be found for a cluster of houses for the 15 resettled households. The location would be chosen with due regard to ease of access to schools, medical clinics, work (i.e. project) location, and essential resources such as clean water.

3. At least 500 m² of garden/orchard land would be made for intensive cultivation by women while the men are given the opportunity to work in the project.
4. The 1.5 ha needed to establish a new house and garden/orchard plot is provided by the project with a guarantee of the land's legal status for the benefit of the resettled households; this would constitute the non-monetary form of compensation suggested in a previous section. This policy should only be taken after proper consultation with the households to be resettled.

5.2.2 Ressetllement Components

The components of resettlement include land axquisition, the construction of a residential complex and its houses, the construction of public facilities, agricultural mechanisms, and the establishment of a grievance institution/mechanism.

A. Land acquisition

The acquisition of land for resettlement purposes is the responsibility of the project as an integral part of other land acquisition activities (for the main site, plant site, jetty, clay area, etc.). The choice of the resettlement site should involve proper consultation with local residents, both those about to be resettled and those already living in or near the resettlement site. This consultation is intended to provide closure so that the resettled population would have no lingering doubts about their new settlement.

B. Site preparation and construction of houses

Site preparation (land clearance) and the construction of new houses should involve not only the resettled population but also existing residents around the resettlement site and their *lia nain.* These groups' involvement would be necessary in the determination of the resettlement timeframe, the alignment of buildings, the choice of sites for graves and customary houses, and the model and arrangement of houses within the housing complex. The involvement of these related parties would help establish good relations with neighboring communities so that the settlers can establish themselves in peace.

C. Construction of public facilities

The construction of public facilities and infrastructure (especially clean water distribution systems and access roads) should take account of not only the resettled population's needs but also the interests of existing residents in and around the resettlement site. If there is a significant difference in quality between the resettlement houses and the houses of current residents, the existing houses may also have to be renovated to prevent dissatisfaction among the local population. The funding for this could be taken for the compensation funds originally intended for the people displaced by the project, of specially budgeted as part of the special costs by the project for its environmental management efforts.

D. Provision of subsistence rations during the wait for resettlement and the initial resettlement period.

The provision of food rations while the displaced population waits for the resettlement site to be constructed and during the initial resettlement period at the new site is an unavoidable part of the resettlement process. A truly significant issue would appear when a particular settler's traditional subsistence resources have been completely taken over by the project, so the settler would have to rely entirely upon the project's goodwill from the moment of the resources' acquisition all the way through the first few planting cycles for gardens/orchards in the resettlement site. The provision of such rations would depend upon the state of the household economy restoration program as explained in the next segment. The main issue here is how to make sure that the provision of rations would not engender a dependence upon such handouts, which may hamper the redevelopment of the local economy for many years to come.

E. Medical services

People who cannot avoid resettlement away from their original residences are likely to experience psychological and psychological stress. This stress can be attributed to physical exhaustion, lack of proper nutrition, and/or to belief/supernatural factors. This situation calls for regular medical examinations of the affected population. This should not be too difficult to arrange since the Caisido region already has a clinic with a doctor and three nurses. The project can make use of the clinic's services by sponsoring the clinical staff in the performance of this service.

To avoid psychological stress due to cultural/religious belief issues, especially over the relocation of gravesites and customary ritual houses, the project should facilitate the performance of the traditional ceremonies needed to maintain the balance of the spiritual relationship between the living and the dead. The project will be responsible for funding such ceremonies.

F. Planning and execution of the relocation

The last step in the resettlement process is the physical relocation of the settlers from their old residences to the new resettlement site. This activity should not present unsusual difficulties since the new and the original settlement are still located within the same aldeia. The actual relocation can be performed without involving any other communities, although it would be better to invite their involvement for the sake of maintaining good relations between local communities. These other communities' involvement does not necessarily require payment in cash, and can be facilitated through existing social mechanisms such as invitations to traditional ceremonies and ceremonial banquets. Such activities would principally be performed by the *lia nain* of the suco and the chefe aldeia along with youth and women's representatives from the villages involved.

5.2.3 Economic Restoration

The restoration of the resettled populations's social and economic well-being should be relatively straightforward. Case studies show that the availability of a steady source of cash income would adequately guarantee the fulfillment of the affected households' subsistence needs. The restoration of the settlers' household livelihood can be implemented through:

A. Employment opportunities with the project

A steady job at the project would provide a very important source of cash income for settlers deprived of their previous livelihoods. There is no fundamental barrier against the project hiring one member out of every affected family on a long-term basis. This employment opportunity constitutes one form of non-cash compensation through the provision of steady and reliable employment.

B. Empowerment of the horticultural sector

It has been suggested before that the resettlement site should make a provision for at least 500 m² of horticultural land per household. If planted with market-oriented cash crops, this much land should provide sufficient security of household subsistence. In combination with the cash income from a family member working in the project, each household should be able to guarantee the fulfillment of its subsistence needs. The intensive cultivation of garden/orchard crops would be the responsibility of the women or older people, partly as a measure to counteract the weakening of women's bargaining power due to the uncertainty of their role in the household economy.

C. Development of animal husbandry

Beyond the agricultural/horticultural sector, there should be an effort to facilitate the keeping of economically viable livestock such as goats. This kind of animal husbandry work can be undertaken by women or older people. The project shall provide the necessary capital.

D. Development of mercantile ventures through shops and kiosks

This kind of venture does not have the involve all settlers; instead, the participants would only consist of people who express an interest in taking up this line of work. The project can provide business capital in the form of a revolving fund.

5.2.4 Institutional Development

The development and management of the resettlement effort should ideally be handled by a dedicated institution specifically tasked with ensuring the success of the relocation program. Due to the small number of people to be resettled, this institution can be set up within the project's organization so that it would not require a great deal of external funding. This institution is part of the effort to build and strengthen other institutions it will be explained in the monitoring sub-section.

5.3 Development of Labor Institutions

The large number of employment opportunities with relatively high pay would not be available without the cement industry. As explained in the chapter on initial environmental conditions, the rural workforce is largely under-utilized due to the lack of suitable opportunities. Although the center of project activities is located deep in the rural areas and concentrated in only one suco, the availability of a new resource (in the form of employment opportunities as laborers or clerical workers) would attract job-seekers from far and wide.

In this case, the major issue is customary (*adat*) prohibitions that prevent people from entering the terriotory of a different suco or baptismal surname group and exploiting the local resources there. Even marriage cannot overcome these prohibitions. It remains to be seen whether the utilization of the new resource would have to obey these established customs. The creation of exceptions or circumventions for job-seekers coming from outside the customary territory of the industrial center would inevitably lead to some degree of social tension and negotiation, especially among younger generations that are generally somewhat better educated than their patents. The demand for fairness and transparency in the recruitment of workers may have to compromise with local custom, especially in the recruitment of long-term operational workers. The limited number of workers that can be recruited, the high and regular wages, and other privileges made available to the factory workers (especially compared to the situation in the construction phase) may become a source of tension over the allocation of employment opportunites. Some suggested solutions are:

- The development of a labour recruitment institution managed by the youth organisations of local sucos under the supervision of TL-Cement and KPK;
- Avoiding the use of a third party for employee management, in the interest of supporting the local labour recruitment institution's function in the distribution/allocation of employment requirements and opportunities;
- Transparency in the worker selection and negotiation procedure;
- Enlisting church institutions to reinforce moral values and faith in divine providence;
- Negotiating an equitable scheme of employment allocations for Suco Tirilolo as the project's central location and other sucos within the Baucau and Vemasse Subdistricts

5.4 Agricultural Development and Market Integration Plan

If the project only devotes its management activities to the people directly affected by the project, the management effort should not be particularly difficult. The most direct and immediate impacts would only fall upon a small number of residents within a relatively small and isolated area. The larger issues would arise from the project's introduction of a cash income system on a large scale, both in the number of workers and the geographical area from which these workers would be recruited. Aside from this substantial cash income, the project would provide additional benefits in the form of health insurance, housing, and several other facilities normally unavailable to the local residents. The opportunity to gain these benefits would only be available to a limited number of mostly male workers, especially in the construction phase. The operational phase would open more employment opportunities for women but the number would be quite small. On the other hand, the traditional sector also provides employment opportunities for women, but it remains rather underdeveloped. The majority of ricefield and garden/orchard cultivators still struggle with the limitations of primitive technology as well as the low productiviy of traditional farming systems and methods. Although this sector already produces a limited amount of cash crops for the market, the market reach and penetration of traditional farm produce remains quite limited, and as a result most local farmers have to take out a subsistence living with painstaking effort. These factors hinder the transformation of the rural economy in the absence of external intervention.

In this kind of situation, a paradoxical change could result from the introduction of a cash wage system with a high value relative to the kind of cash income normally available from the traditional sector. On one hand, the cement industry can provide enormous benefits to the people affiliated with it, while the majority (especially women and productive workers who are not recruited into the project) would still have to contend with the stagnation of the subsistence economy. This could lead to a hitherto unprecendented degree of social stratification.

For this reason, the project's direct or indirect involvement would become necessary for the transformation of local traditional agriculture into a more market-oriented form. This can be implemented through:

- The development of agricultural programs and market integration plans;
- The establishment of a regional economy board;
- Empowerment of women's role in agricultural production (ricefields and gardens/orchards);
- Empowerment of agricultural merchants to enhance their capability to bring new agricultural technologies into the local region and market agricultural products out of it.

These efforts would help in:

- Preventing the local residents from becoming dependent upon the cement industry as their principal source of cash income;
- Enhancing the dynamic growth of the traditional sector according to its own cultivation cycles so that any disturbances to the industrial sector would not cripple the local and regional economy, and so that social and economic class segregation would not become too pronounced;
- Encouraging the involvement of women in the regulation of the household economy so that their position vis-a-vis the men would not be weakened.

6. ENVIRONMENTAL MONITORING

The analysis of a project's social impacts is mostly focused upon the impacts caused in the course of the project's activities. The mitigation of these impacts requires the presence of an institution – either within the project's structure or in the local government's bureaucracy – that takes the responsibility for implementing the management actions. It also requires the monitoring of ongoing management/mitigation efforts to see whether the major impacts develop as predicted, and to provide feedback for the modification of management measures to tailor them to the actual issues encountered in the field.

This basically calls for the establishment of a unit or board within the project to undertake the management function. This unit does not have to take the form of a large environmental division with many experts and supporting staff members tasked with mitigating, managing, and monitoring the various environmental issues in the field. The unit can be as small as a single principal staff member – an environmental expert acting as the manager of the environmental organization. This environmental organization has an equal standing to other divisions that answer directly to the project leader. It has the authority to take emergency actions on its own initiative without requesting the project leader's permission. It also has the power to make decisions in negotiations with external parties, local government institutions, and local community stakeholders in matters directly related to environmental issues and environmental management according to the definitions laid out in the officially approved impact analysis documents.

In its role as an environmental unit, the organization must coordinate with related institutions in planning short-term, intermediate-term, and long-term environmental management measures according to operational directives. The organization possesses the authority to modify the management scheme to take account of the feedback from monitoring activities. As such, the leader of the organization must be capable of composing budgets so that the activities described above would not be hampered by delays in the budgeting process. Such budgets would be proposed as needed when the relevant issues arise (Cernea, 1988).

The manager of the environmental division is aided by the following experts in the performance of his/her duties:

- Community Development Expert
- Medical Expert
- Agricultural Extension Worker

A suitable doctor/medical expert and an agricultural extension worker are already available in the Caisido region, or at least in the Baucau and Vemasse Subdistricts in general. Therefore, the project can coordinate with the appropriate government agencies to take advantage of their expertise in the implementation of its environmental management and monitoring scheme. On the other hand, the comdev staff should preferably be a permanent staff member in the project. Apart from more general management and monitoring tasks, the comdev officer would be responsible for receiving and recording local residents' complaints over any dissatisfaction with the services of the environmental management workers (*i.e.* he/she woud run the Grievance Redress Mechanism).

To facilitate the local residents' access to environmental management officers, this special staff should be given a workspace at or near the entrance of the factory so that any local community member who wishes to file a complaint would be able to do so without having to contend with the project's security checkpoints. This workspace should include a meeting room designed to put visitors at ease.

6.1 Monitoring Activities

Monitoring activities would focus on the indicators identified for predicted impacts:

Table 6.1 Monitoring Parameters and Schedules

Potential Impact	Mitigation	Parameter to be monitored	Monitoring schedule
Loss of subsistence resources	Integrate part of resettlement plan	The number of landowners and the size of plots outside the affected area	Once after the direct identification of affected households
Loss of bargaining position over the status and value of land and the compensation system	Intensive negotiation with landowners	• Trends complaints and requests from the landowners • Negotiation deadlocks • The effectiveness of an independent third party's involvement in negotiation	Once within three months after negotiation
Dissatifaction/ conflict over the relocation of gravesites and customary/ traditional ritual houses	Integral part of the resettlement plan	• Trends in the numbers and intensity of rites of integration (where the body is incorporated in the world of ancestral ghosts, giving it a sacred status in the cosmos)	Duration of the adjustment period (1-3 years after relocation)
Resettlement	Comprehensive resettlement plan	• The performance and effectiveness of the resettlement plan and the implementation of resettlement schedules • Trends the effectiveness of household economic restoration	Every 3-6 months during the 3-year adjustment process

Potential Impact	Mitigation	Parameter to be monitored	Monitoring schedule
		• Trends number of disease and malnutrition cases • Trends in rites/ceremonies of integration (see explanation above) • Integration with neighboring people (host communities)	
Potential conflict over worker recruitment and the distribution of employment opportunities	Establishment of a labor recruitment institution	• Trends in the effectiveness of the labor management institution • Trends in the number of complaints and conflict incidents • The development of recruitment schedules • Transparency and fairness in worker registration and recruitment criteria	Every three months since the establishment of worker accommodations in the first year; then every 6 months for the duration of construction and operational activities
The loss of women's bargaining power Dependence of the household economy upon cash income Transformation of traditional agricultural practices	The creation of an agricultural development and market integration plan	• Establishment of a regional economic development board • Trends in the development of agricultural market plans • Trends in the empowerment of women's role in the agricultural sector • Trends in the improvements made by agricultural extension workers	Every years for the 5-year plan; or upon every review of the programs

7. REFFERENCE

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APPENDIX

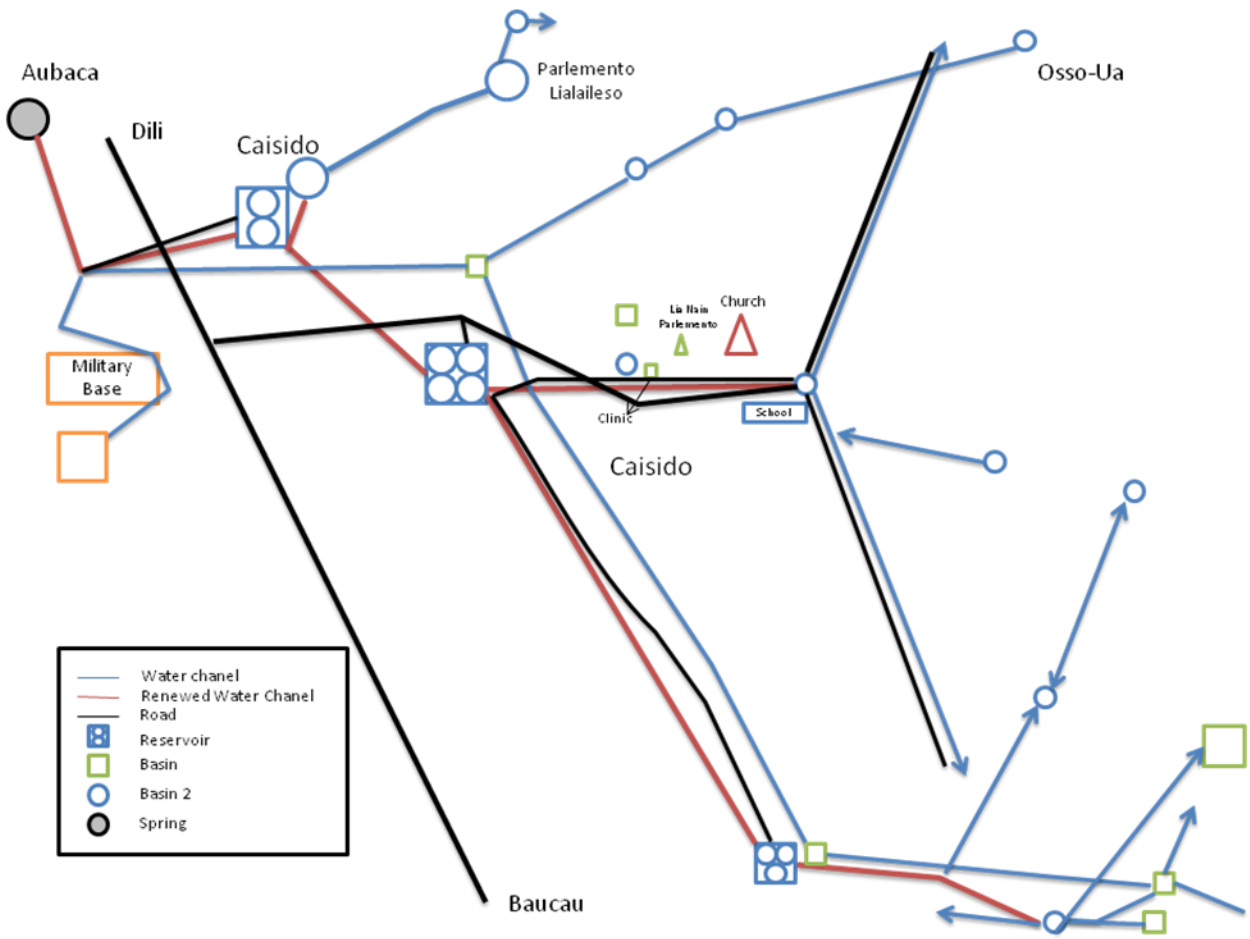
Appendix 1: Groups Domination in Suco near Project Area

Sub-District	Suco	Most Group Dominant	Other Group Dominant
Baucau	Bahu	Da Silva (D+), Buavida (D+)	Do Santos, Correia
	Tirilolo	Belo (D)	Da Silva Belo, Dacosta Belo, Asis Belo
	Bucoli	Da Silva (D),	Da Costa, Dus Reis, Correia, Reis
	Buruma	Ximenez (D+), Da Costa (D+)	-
	Buibau	Xarmento (D+), Ximenez (D+)	Durosario, Correia
	Uatulili	Guiteres (D)	Da Costa, Da Silva
	Samalari	Guiteres (D+), Da Silva (D+), Ximenez (D+)	Da Costa, Xarmento
	Garuai	Da Costa (D+), Da Silva (D+), Guiteres (D+)	Do Santos
	Triloca	Dasilva (D), Da Costa (D)	-
	Seical	Ximenez (D)	Guiteres, Da Silva, Da Costa
	Caibada	Da Costa (D), Da Silva, Ximenez	-
Vemasse	Vemasse	Freitas (D)	-
	Ossoala	Correia (D)	-
	Luilubu	Gamma (D)	-
	Uaiga	Gusmao (D+), Da Silva (D+)	-
	Uatu-Lari	Soares (D+), Da Silva (D+)	-
	Caicua	Da Silva (D+), Soares (D+)	-
	Ostico	Freitas (D)	-

Source: Survey Inventaritation, Mei 2015.

Note: (D) : The Most Dominant; (D+): Half Dominant (share with other group).

Appendix 2: Water Reservoir Map



Source: Sketch by Suco Tirilolo Secretary, 2015

Appendix 3: Occupations and Employment Status Communities

Source: Suco Tirilolo Family Card Record, 2015

Osso-ua

Occupation	Householder	Spouse	Child		Sum
			Son	Daughter	
Agriculture	88	86	67	46	287
Housewive		2			2
Student			90	112	202
Health Officer					0
Public Functionary					0
Merchant		2		2	4
Driver					0
Nurse/Mother					0
Technician					0
Private Sector					0
National Parliament					0
Bussiness					0
Kindergarten			19	19	38
Security					0
Educator	2	1	1	1	5
Police Officer					0
NGO					0
Cleaner					0
Carpenter					0
Village Officer					0
Military					0
Photographer					0
Art Design					0
Doctor					0
Journalist					0
Mechanic					0
Banker					0
Mason/Bricklayer					0
Fishermen	3				3
Sheperd					0
Project Officer					0
Veteran (retirement)					0
Tailor					0
Total	93	91	177	180	541

Lialaileso

Occupation	Household	Spouse	Child		Sum
			Son	Daughter	
Agriculture	72	63	53	40	228
Housewive		15			15
Student			126	119	245
Health Officer					0
Public Functionary	1			1	2
Merchant	6	10	1	2	19
Driver	1		1		2
Nurse/Mother					0
Technician	3				3
Private Sector	5		2		7
National Parliament					0
Bussiness					0
Kindergarten			9	6	15
Security	2		2		4
Educator	2				2
Police Officer		1			1
NGO					0
Cleaner			1		1
Carpenter	1				1
Village Officer	2	1			3
Military					0
Photographer					0
Art Design					0
Doctor					0
Journalist					0
Mechanic					0
Banker					0
Mason/Bricklayer					0
Fishermen					0
Sheperd	6		1		7
Project Officer			1		1
Veteran (retirement)					0
Tailor					0
Total	101	90	197	168	556

Source: Suco Tirilolo Family Card Record, 2015

Caisido

Occupation	Household	Spouse	Child		Sum
			Son	Daughter	
Agriculture	100	97	45	96	338
Housewive		8			8
Student		1	180	114	295
Health Officer	8		2	2	12
Public Functionary	2	2			4
Merchant	1	13	2	3	19
Driver	5		1		6
Nurse/Mother					0
Technician					0
Private Sector	8		2		10
National Parliament					0
Bussiness					0
Kindergarten			29	21	50
Security	2				2
Educator	3	1		1	5
Police Officer					0
NGO	1				1
Cleaner					0
Carpenter					0
Village Officer					0
Military			1		1
Photographer					0
Art Design					0
Doctor					0
Journalist					0
Mechanic					0
Banker					0
Mason/Bricklayer	9		4		13
Fishermen					0
Sheperd	3	1			4
Project Officer					0
Veteran (retirement)	3	1			4
Tailor					0
Total	145	124	266	237	772

Source: Suco Tirilolo Family Card Record, 2015

Parlemento

Occupation	Household	Spouse	Child		Sum
			Son	Daughter	
Agriculture	63	53	17	17	150
Housewive		12			12
Student			97	90	187
Health Officer					0
Public Functionary	1			1	2
Merchant	5	5	1	1	12
Driver	1		1		2
Nurse/Mother				1	1
Technician	1		1		2
Private Sector	2		6	1	9
National Parliament					0
Bussiness					0
Kindergarten				2	2
Security	2				2
Educator	1	1		1	3
Police Officer					0
NGO			2		2
Cleaner					0
Carpenter					0
Village Officer	1				1
Military				1	1
Photographer					0
Art Design					0
Doctor					0
Journalist					0
Mechanic					0
Banker	1				1
Mason/Bricklayer			1		1
Fishermen					0
Sheperd	1				1
Project Officer					0
Veteran (retirement)					0
Tailor	1				1
Total	80	71	126	115	392

Source: Suco Tirilolo Family Card Record, 2015

Lutumutu

Occupation	Household	Spouse	Child		Sum
			Son	Daughter	
Agriculture	130	7	2	5	144
Housewive		167			167
Student	1	3	399	396	799
Health Officer	5	2			7
Public Functionary	15	13	3	5	36
Merchant	10	1			11
Driver	19	1			20
Nurse/Mother				1	1
Technician					0
Private Sector	13	3	1	1	18
National Parliament					0
Bussiness	4	1	1	1	7
Kindergarten			37	37	74
Security	3				3
Educator	12	7			19
Police Officer	8	1			9
NGO	4		1		5
Cleaner	1				1
Carpenter					0
Village Officer					0
Military	1		1	1	3
Photographer					0
Art Design					0
Doctor	1	1		1	3
Journalist	1		1		2
Mechanic					0
Banker					0
Mason/Bricklayer	4				4
Fishermen					0
Sheperd					0
Project Officer					0
Veteran (retirement)					0
Tailor	1				1
Total	233	207	446	448	1334

Source: Suco Tirilolo Family Card Record, 2015

Betulale

Occupation	Household	Spouse	Child		Sum
			Son	Daughter	
Agriculture	116	145	16	19	296
Housewive		123			123
Student		2	676	704	1382
Health Officer	6	4	1	2	13
Public Functionary	25	17	8	8	58
Merchant	4	1		1	6
Driver	21				21
Nurse/Mother				1	1
Technician	1		2		3
Private Sector	82	13	19	10	124
National Parliament	2	2			4
Bussiness	4	1			5
Kindergarten			40	43	83
Security	26		3		29
Educator	20	10	1		31
Police Officer	11	4			15
NGO	7	2	5	3	17
Cleaner	1	1		2	4
Carpenter	4				4
Village Officer	1	1			2
Military	2				2
Photographer	2				2
Art Design	1				1
Doctor			3	1	4
Journalist				1	1
Mechanic	2		2		4
Banker	1				1
Mason/Bricklayer	1				1
Fishermen					0
Sheperd					0
Project Officer					0
Veteran (retirement)					0
Tailor					0
Total	340	326	776	795	2237

Source: Suco Tirilolo Family Card Record, 2015

Appendix 4: Educational Levels

Educational levels for each Aldeia in Tirilolo

Lutumutu

Degree	Household	Housewive	Child	
			Son	Daughter
Non-Educational	78	44	5	4
Kindergarten	*	*	90	90
Elementary	48	19	172	170
Junior Highschool	24	27	43	56
Senior Highschool	71	77	83	100
Diploma	10	10	*	1
Bachelor	29	21	41	34
Total	260	198	434	455

Source: Suco Tirilolo Family Card Record, 2015

Betulale I

Degree	Household	Housewive	Child	
			Son	Daughter
Non-Educational	68	50	*	4
Kindergarten	*	*	46	59
Elementary	65	52	147	150
Junior Highschool	11	18	123	71
Senior Highschool	67	73	113	105
Diploma	9	6	3	8
Bachelor	15	14	50	41
Total	235	213	482	438

Betulale II

Degree	Household	Housewive	Child	
			Son	Daughter
Non-Educational	57	28	11	10
Kindergarten	*	*	53	60
Elementary	23	19	92	114
Junior Highschool	8	21	69	54
Senior Highschool	60	57	89	67
Diploma	16	11	4	*
Bachelor	15	7	46	32
Total	179	143	364	337
Total I+II	414	356	846	775

Source: Suco Tirilolo Family Card Record, 2015

Caisido

Educational Degree	Educational Status			
	Student		Non-Student	
	F	M	F	M
Elementary	64	63	0	0
Junior Highschool	31	21	2	2
Senior Highschool	27	37	2	4
Bachelor Degree	33	30	18	30

Source: Suco Tirilolo Family Card Record, 2015

Lialaileso

Educational Degree	Educational Status			
	Student		Non-Student	
	F	M	F	M
Elementary	63	54	0	1
Junior Highschool	11	23	2	2
Senior Highschool	16	14	3	4
Bachelor Degree	22	21	10	26

Source: Suco Tirilolo Family Card Record, 2015

Parlemento

Educational Degree	Educational Status			
	Student		Non-Student	
	F	M	F	M
Elementary	44	55	0	0
Junior Highschool	14	12	0	0
Senior Highschool	5	12	0	0
Bachelor Degree	28	24	2	4

Osso-Ua

Educational Degree	Educational Status			
	Student		Non-Student	
	F	M	F	M
Elementary	55	45	1	0
Junior Highschool	15	15	1	2
Senior Highschool	12	11	12	8
Bachelor Degree	10	11	30	42

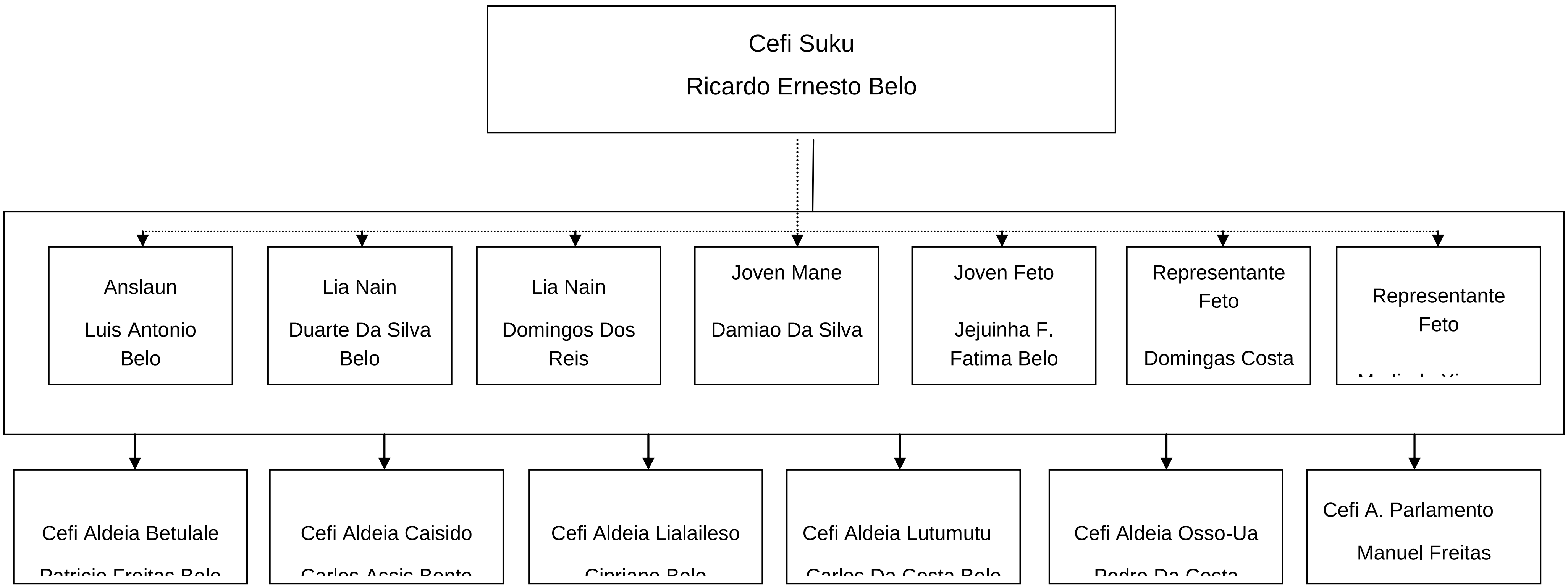
Source: Suco Statistical Report 2015

Population by Age of Five Years Old and over by Level of Education, Subdistrict, and Sex.

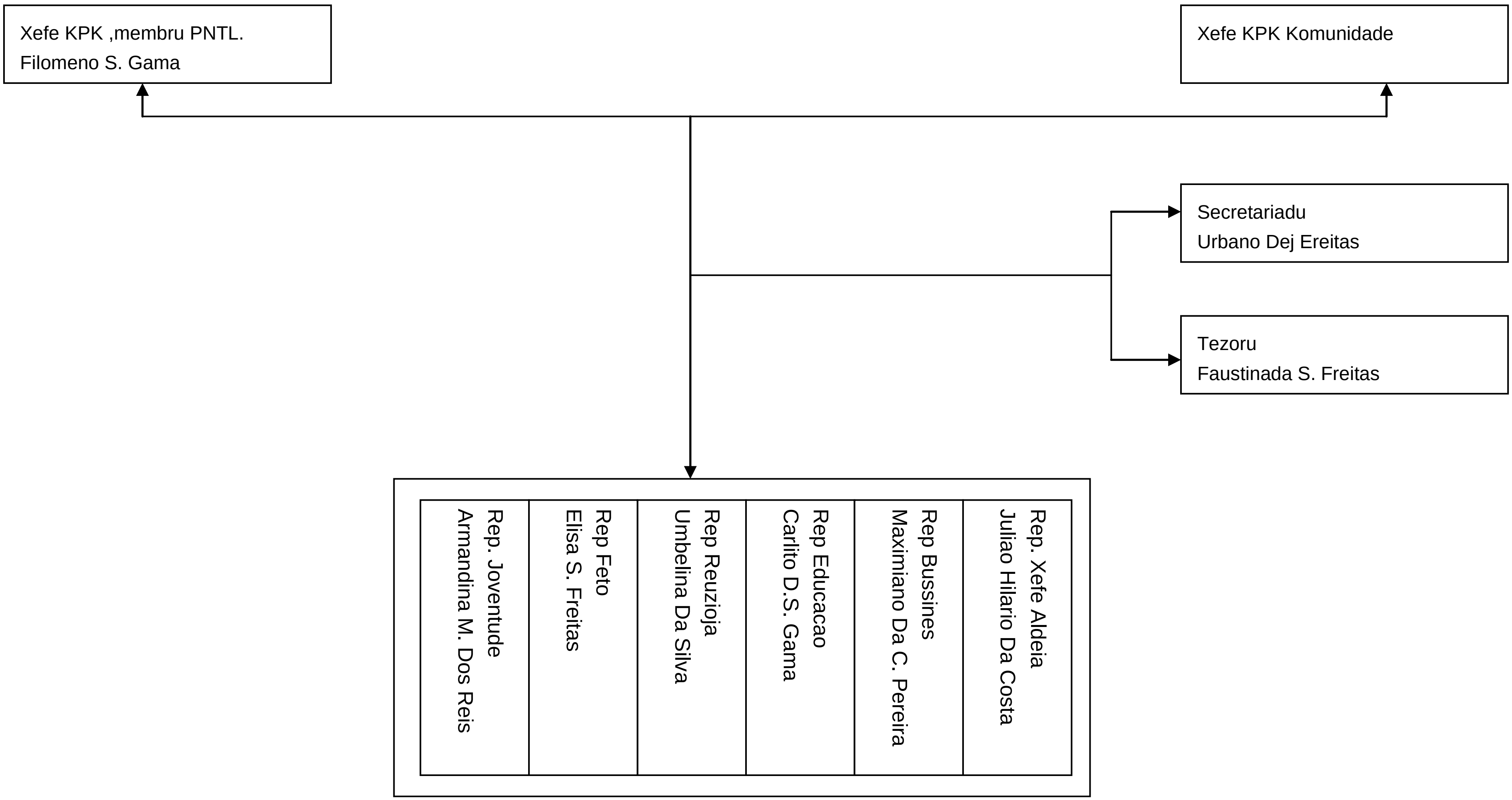
Level Education	Sub-District			
	Baucau		Vemasse	
	Male (%)	Female (%)	Male (%)	Female (%)
Pre-primary	7 %	6 %	5,1 %	0,8 %
Primary/Elementary	46 %	42,5 %	58 %	61,4 %
Pre-Secondary/ Junior Highschool	15 %	18,4 %	17,7 %	20,9 %
Secondary/Senior Highschool	25 %	27,4 %	15,6 %	14,8 %
Polytechnic/Diploma	1,7 %	1,5 %	0,6 %	0,5 %
University	4,3 %	3 %	2,1 %	1 %
Non-Formal Education	0,7 %	0,9 %	0,3 %	0,5 %
Total	100 %	100 %	100 %	100 %

Sumber: Census, 2010

Appendix 5: Suco Tirilolo Formal Leadership Structure



Appendix 6: Konsellu Polisia Komunitaria (Community Police Councils)



Appendix 7: Public Consultation Minutes

WorleyParsons
resources & energy

EcoNomics

Project No: 301012-02135
Project: TL Cement EIA

Public Consultation Minutes

PARTICIPANT NAME & ORGANISATION:

- Administrator Distrito Baucau
- Chief of Police District Commander in Baucau
- Baucau sub-district Administrator
- Local NGO *Hamahun*
- Director of IPG (Institute of Petroleum and Geology)
- Director of BGC/TL Cement
- Director of Land and Property of Baucau district
- Director of Environment of Baucau district
- Representative of Veterans in Baucau district
- Chief of Suco Trilolo, Bahu, Triloka, Kaibada, Bukoli, Garuwai, Wailili
- Local authority
- Trilolo community
- Trololo youth

DATE: 09 May 2014

LOCATION: Suco Kaisidu
Baucau Timor-Leste

OBJECTIVE: Consultation with Community and Youth Group in Suco Trilolo

- **Statement from Kaisidu Community**

1. **Positive feedback from Kaisidu community:**
   - Kaisidu community are 100% ready to welcome the investment and the cement factory in the area
   - The community and youth in Kaisidu, 38 Traditional houses, will not impede the progress towards the development of cement factory and will be working with the GoTL to improve the economic condition of population from as well as other districts

- We appeal to the government to decide a new neighbourhood for our resettlement and that when the development of cement factory begins, we it can generate some benefit to us and our generations
- We appeal to the company to clarify a clear plan for our future livelihood and to coordinate well with the government
- We appeal to the company to establish an agreement with the Government of Timor-Leste

2. Negative feedback from Kaisidu community:

- The community are concerned if the Traditional houses are also included in the development land
- How the government and the stakeholder paying respect to the cultural inheritance
- Clear identification of the development land
- Government should clarify the land with Kaisidu community
- Government and stakeholder should continue socializing with the community

- **Statement from Environmental Department**

Quite often the community expressed their concern about the environmental impact which will affect community who reside in the fabric's surrounding area.

The Director of Environmental responded to this concern by highlighting that the fabrics nowadays are operating in a different system from the old one which tends to emit smog and poses negative impact to the local community. He added that his team had paid a visit to Australia, directly observed the condition of the cement fabric to be established in Timor-Leste and was introduced to this system of new technology used in Australia which doesn't produce smog to a level that is harmful to the nearby community.

- **Statement from Director of Land and Property**

The community also showed their concern about the status of their farmland that will be developed into the fabric site or mining site and how will compensation be decided.

The Director of Land and Property responded to this concern by explaining that the land will have the following situation:

- Abandoned land / state's property
- Heritage land, passed down from the ancestors
- Community's property such as suco's land
- Private property, when there is land certificate
- Dowry property exchange

- **Statement from IPG**

The community also would like to know the quantity of limestone and rock to be mined.

The director of IPG responded that when the mining activity is about to start, the Government and the company will establish an agreement on which mineral to be mined. He added that right now his team is conducting a research or study on the limestone that will be used for the industry. He affirmed that the community should not worry about this or lose any hope because they (government and company) will not cause any damage to people's domestic product.

- **Statement from Baucau District Administrator**

Baucau district Administrator affirmed that the company has an intention to improve community's livelihood and that they (community) should not pay attention to anecdote that the company will destroy Suco Caisido's natural environment. He added that he will keep fighting for community's aspirations and that his team will always visit the community so that they can hear community's concerns and report it to the government for considerations.

- **Statement from Sub District Baucau Administrator**

Sub District Baucau Administrator emphasized that during his visit to Australia, he learned that BGC is a big company in Australia. He added that during the meeting, the company also explained how they are planning to invest in Timor-Leste. He assured the company that that they will provide full support to the company regarding security. The company promised to recruit up to 5000 employee and will follow Australia's system. The company also mentioned that they will not discriminate people who don't have the capacity. Moreover, he stated that every new thing always has pro and cons and that happens in any countries in the world.

- **Statement from the Chief of Police District Commander of Baucau**

To respond to security concern raised during the meeting, the Chief of Police District Commander of Baucau stated that they are ready to provide full security in the designated area and assured that that since many youth will be employed, there will no youth confrontation. He also appealed to the community to ignore the anecdote from those who clearly do not want develop the nation. He emphasized that his team will work together to support the government by supporting the project. He appealed to the community that this is their "battle" and that everyone should take the chance to win it as this will reduce employment rate in the country and improve our economic condition.

- **Statement from Chief of Suco**

This above statement was supported Chief of Suco who stated that the time for development has come whether or not we want it. Likewise, he appealed to the community to ignore any rumors.

- **Statement from the Youth Group**

The youth group also expressed their full support for this project and agreed that it will generate profit to their community by reducing employment rate in Baucau District.

- **Statement from The director of BGC/TL Cement**

Both community and the youth expressed their concern regarding the recruitment and HR

- Assign the right person in the right position

They will also employ people in the following field:

- Labour
- Cleaner
- Security
- Administration
- Construction worker
- carpenter

He also affirmed that government and its counterpart will be working together to reduce employment rate in the country and that they will keep fighting for the community's wellbeing. This will increase the local HR capacity so that they will not rely on other nations' HR.

- **Statement from the government**:
  - Government will always work together with the community when any stakeholders want to invest in the country
  - Government will study the investor's investment process in Timor-Leste
  - Government will work with departments that are relevant with the development of factories such as : Land and Property, Environmental department, Health and Geology

This is the statement from May 9th 2014 meeting with 90% of population from 4 sucos in Kaisidu area.

TL Cement representative

Edmundo Ximenes de Sà

Project: TL Cement EIA

Public Consultation Minutes

PARTICIPANT NAME & ORGANISATION:	DATE:	24 June 2014
- Community of Suco Trilolo	LOCATION:	Suco Trilolo
- Youth group of Suco Trilolo		Baucau Timor-Leste
	OBJECTIVE:	Consultation with Community and Youth Group in Suco Trilolo

TOPIC:

During this meeting, the population of Aldeia Trilolo mentioned that the excavation site covers 10% of community's farmland and 90% of abandoned land. The following vegetation is found in the area close to the shore for jetty: breadfruit, teak, coconut and other vegetation that are primarily found in community's farmland.

RECOMMENDATION:

The community recommended that the government and the company should prioritize the interest of population in Kaisido area, such as the four Aldeias: Kaisido, Lielailesu, Parlamentu, and Osowa. This is the recommendation and information from Trilolo community.

TL Cement representative

Edmundo Ximenes de Sà

Project No: 301012-02135

Project: TL Cement EIA

Public Consultation Minutes

PARTICIPANT NAME & ORGANISATION:	DATE:	16 July 2014
- Member of Traditional council - Member of Suco council - Member s of GoTL - TL Cement Staff	LOCATION: OBJECTIVE:	Kaisidu Suco Center, Baucau Timor-LESTE To coordinate plan for cultural ceremonial activity

TOPIC:

Prior to the commencement of TL cement construction and production activities, it is important to identify the exact location in order to hold the cultural activity, including Animal slaughter.

The following details must be confirmed prior to the commencement of the construction purposes:

- Plan/venue
- Decision
- License
- Determination of the location
- Cultural activity/ traditional counsel
- Animal to be utilize etc.

Material to be purchased as follows:

- Buffalo
- Goat
- Pig
- Spade (surik)
- Tais Mane (waving cloth for man)
- Tais feto (waving cloth for female)
- Belak (traditional necklace)
- Beetle nut
- Chicken

TL Cement representative

Edmundo Ximenes de Sà

PARTICIPANT NAME & ORGANISATION:		**DATE:**	14 October 2014
- King of Suco Ostico		**LOCATION:**	Suco Ostico Baucau Timor-Leste
		OBJECTIVE:	Consultation with King of Suco Ostico

TOPIC:

During a chat with the king of Ostico, he stated that the area of Wailacama, from where the clay sample was extracted for laboratory analysis, is a part of suco Ostico. During the Indonesian time, the wailacama area was under suco Tasi Vemasse Vila, but it has been added back into Aldeia Baha Mori Suco Ostico. The population is still under the administration of Suku Tasi Vemasse Vila, but historically they are still maintained as part of Ostico.

In the 4 areas where the clays are, the majority of abandoned land (98%) belongs to the state while the remaining belongs to the population who are using it as farmland, coconut and teak plantation. The community is excited that the cement company will create employment opportunity which will improve their livelihood and economic condition in Baucau District. Therefore, many youth support the government's plan to establish cement industry in the designated areas.

TL Cement representative

Edmundo Ximenes de Sà

Public Consultation Minutes

PARTICIPANT NAME & ORGANISATION:		
- Community from Suco Bucoli Aldeia Macadai, Lulihen - The landowners Mr. Virgillio G Antonio, Mr.Oscar Da Silva, Mr. José Da Silva	**DATE:**	10 November 2014
	LOCATION:	Bucoli Baucau Timor-Leste
	OBJECTIVE:	Consultation with Community and landowners

TOPIC:

The excavation sites, AD - 1- AD-7 –MI – 3, used to be an area where they farmed; there are no trees planted in the area. They only established old fences around the area. They also declared that there are many abandoned land, and 5% of them belongs to the community while the rest to the state. They expressed their concern on how the government and the company are going to value their heritage to avoid any conflict. Community are happy that there will be an industry to be established in Baucau municipality for the first time. It will be advantageous to the community and will benefit the livelihood of the community and the future generation.

TL Cement representative

Edmundo Ximenes de Sà

Project No: 301012-02135
Project: TL Cement EIA

OBSERVATION

BY:	**DATE:**	
- TL Cement	**LOCATION:**	Bucoli Baucau Timor-Leste
	OBJECTIVE:	Consultation with Community and landowners

TOPIC:

Based on the information we have been capturing from seven sucos: Baha-hu, Trilo-lo, Waili-li, Gari-uai, Bucoli, Caiba-da, and Triloka, many populations frequently concern with Government and the private sector (company)'s mechanism to manage employment when the project is in operation.

To respond to population's concern, we told them that we always explain this matter to the community and we have done socialization with all Sucos and Aldeias about this project and that in the future we will still maintain our work with government representative in the District, Sub-district or Suco that are involved in this project. Quite often, we explained to all the community that when we conduct the recruitment, it will be based on their capacity and skill and that they will participate in training in the relevant positions ranging from technical to non-technical such as Administration.

TL Cement representative

Edmundo Ximenes de Sà

Appendix 9 Community Meeting Minutes

1. Stakeholder Consultation - Lao Hamutuk

Date: 07/01/2016, Time: 09:10

Venue: Lao Hamutuk's Office, Bebora, Dili

Attendees:

- Adilson da Costa (Researcher in Governance and Economy)
- Niall Almond (Researcher in Economic and Natural resources)

WPTL:

- Joana Belo
- Chris Serjak

Comment:

- Lao Hamutuk is interested in many sectors and considers Environment as cross-cutting issues.
- The EIA for Suai Supply Base (SSB) was not completed especially due to no public consultation taken place.

Mitigation:

- Hope WorleyParsons Timor-Leste (WPTL) conducts significant public consultation, not only to socialize project but also to understand the socio economic impact.
- Need mitigation and compensation for affected /displaced persons, eg. Displacement and compensation: Documenting impact of cash compensation on Suai population especially for woman. Proponent should provide housing for displaced persons. Cash compensation is not adequate/suitable or sustainable.
- Public consultation required by category A project GoTL has focused on socialization. Not consultation especially with vulnerable and affected people.
- Need to provide specialty on number and type of Jobs available for local community
- Benefit need to be accrued locally and not offshored to foreign investors, eg. Suai Airport Project used imported Indonesia labor
- Support renewable energy and solar component
- Local community bears brunt of AQ impact from power plant
- Increased activity from traffic and operations
- Land right are a complicated issue
- Land conflict in Timor-Leste has many problems for relocation. Suai Communities unable to be settle
- Need more robust and better implemented plan than SSB.
- Importance of place for livelihoods and destroy communities and families
- Multiyear monitoring and ongoing compensation or benefit from project

- Traffic, safety, pollution, noise peacefulness training of drivers, signage awareness campaign
- Not used to large traffic, night operations?
- Water chemical concentration.
- Concern that only small subset of population represented as per list of attendance most people attended the meeting have the same sure name(Belo)
- Provide Tetum translation of EIS, (Need to respond)
- Need to document /disclose signature, eg. social impact due to lack of land Law

Question and Answer (QA)

1. Type /method used for Relocation/Displacement Management Plan
   Answer: Out of WPTL Scope of Work
2. Environmental impact assessment for coal generated power?
   Answer: Noted but no answer
3. Waste management Plan
   Answer: Solid and liquid waste are treated before disposal
4. Land and Mining Law not yet adopted how would project be implementing without laws?
   Answer: Noted but no answer
5. Power supply is big Question: Why not use national grid? Undermines local source system which had goal of attracting investment capacity of 250 WM at demand of 40MW increased usage is benefit to GoTL
   Answer:
6. Coal fired plant has impacts on environmental as well, need justification
   Answer: due to the low
7. Groundwater Management Plan?
   Answer: See Groundwater Management Plan

8. Stakeholder Consultation - Foundação Haburas

Date: 07/01/2016, Time: 14:30

Venue: Haburas's Office

Attendees:

- Virgilio Guterres (Executive Director)
- Antonio , Vice Executive Director
- Domingos, Rede Ba Rai (advocate Officer)
- Pedro Viera (Advocate Researcher)

WPTL:

- Joana Belo
- Francisco Neto

Mitigation:

- To include community in the decision making process as they need to understand the short, medium and long term impacts of the project and mitigation measures, as well as the advantages/benefit to community.
- Cultural Heritage issues need to be clarified.
- Mining will affect the ground water. WPTL need to come up with a proper Ground water management plan.
- Environmental impact assessment for coal generated power and if substantial, "polluters pay" approach can be applied.
- The history of Baucau water run from Luca , Viqueque, as described by Lisa Palmer Mok, on her book "

Question and Answer (QA):

1. The method used for the relocation / displacement plan.
   Answer: out of WPTL scope of work
2. What is the mitigation to the ground water distraction by the mining in Caisido area.
3. Answer: See Ground water management plan.
4. What is the impact assessment for the energy production from Coal?
   Answer: Several stations for ambient air quality will be set up around the project site and air quality will be monitored every 6 months.
5. What is the pollution management like?
   Answer: The Pollution risk will be low however; several stations will be created around the mine site and it will be reviewed every 6 months.

9. Stakeholder Consultation – Direcção Nacional Controla Qualidade Agua (DNCQA)

Date: 13/01/2016, Time: 14:00

Venue: DNCQA's Office

Attendees:

- Gregorio de Araujo, Director of DNWQC
- Francisco Xavier, technical Staff Hydrology

WPTL:

- Joana Belo
- Chris Serjak

Comment:

1. There is a need for good mitigation measures especially compensation for affected /displaced persons, eg. Documenting impact of cash compensation on Suai population especially for woman. Proponent should not compensate displaced persons with cash as cash compensation is not adequate, suitable or sustainable.
2. Benefit need to be accrued locally and not offshored to foreign investors, eg. Suai Airport Project used imported Indonesia labor.
3. Increased activity from traffic and operations, thus require best approach to dust and noise management.
4. Land right is a complicated issue in Timor-Leste. Unsolved land conflicts in Timor-Leste caused by the lack of land law has resulted in conflict especially relocation process eg. Suai communities that have been relocated by the Tasi Mane Project so far are unable to settle.
5. Water chemical concentration.
6. Waste management.
7. Only small subset of population is represented on public consultation, eg, most of people attended the first consultation has the same surname (in Timor same surname means related to each other).
8. Environmental impact assessment for coal generated power need to be conducted
9. Ground water will be affected by mining activities therefore, the ground water management plan need to be conducted as well as the chance that mining could hit/intersect with water conduit in karst limestone formation (impact on the local hydrology).
10. Dust and Noise management
11. Concern the water supply will be insufficient as 36.4 litter required per second

Question and Answer (QA):

10. Stakeholder Consultation - Luta Hamutuk (LH)

Date: 13/01/2016, Time: 10:00

Venue: LH's Office

Attendees:

LH:

1. Jose Alves da Costa, Coordinator of Community Network and Initiatives (CNI)
2. Jaime Ribeiro, Staff CNI

WPTL:

1. Joana Belo
2. Francisco Neto

Comment:

- LH appreciates WPTL Initiatives to involve NGO's in listen to their ideas.
- TL Cement activities will benefited Timor-Leste's Economy
- Make well used of Natural resources

Mitigations:

1. Study on dust and its mitigation measure
2. Government plan on resettlement/relocation plan
3. Strategy to maintain the current farming activities in the presence of industry
4. Provide training for local farmers on animal husbandry to provide standardize meat production to project cafeteria and local market
5. TL cement to help improve the livelihood of locals through vivid contribution towards health and education sector
6. Company should identify working age target group for training

Appendix 10 Community Questionnaire

INTERVIEW QUESTIONNAIRE

Ref: -

Introduction: Explain purpose of Interview

INTERVIEW PARTICIPANT		
	Date and time of interview:	
1.1	Participant name:	
1.2	Position	
1.3	Aldeia / Suco/ Post administrative	
1.4	Telephone number:	
1.5	How long have you been living here:	

KNOWLEDGE OF THE PROJECT		
2.1	Are aware of the Project?	
2.2	If yes, how did you get the information and when?	
2.3	What do you know about the project?	
COMMUNITY RESPONSE		
3.1	Do you agree? Why	
3.2	You don't Agree? Why	
3.3	Any idea what Government/Company should do to prevent any destructions /problems raised?	

YOUR HOPE FOR THE PROJECT		
4.3	What is your expectation towards the project?	
4.14	Any other closing remarks / comments?	