AMANDI ENERGY LIMITED - GHANA

UPDATED ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

190 MW COMBINED CYCLE POWER PLANT AT ABOADZE, GHANA

ENVASERU Research Consult

Environmental Consultancy & Laboratory Analytical Services

PARSONS BRINCKERHOFF

CONTENTS

LIST OF ABBREVIATIONS

%	Per cent
°C	Degrees Celsius
AAQG	Ambient Air Quality Guidelines
ACC	Air-cooled condensers
AEB	Amandi Energy BVI
AEL	Amandi Energy Limited
AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
Aldwych	Aldwych International Ltd.
ANLG	Ghanaian EPA Ambient Noise Level Guidelines
ASG	All Services Group
atm	Atmosphere
BS	British Standard
BOO	Build, own and operate
BTEX	Benzene, Toluene, Ethyl benzene and Zylene
CCGT	Combined Cycle Gas Turbine
CESMP	Contractor Environmental and Social Management Plan
cfu/g	Colony/forming unit per gram
CITES	Convention on International Trade in Endangered Species
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical oxygen demand
dB	Decibels
dB(A)	A-weighted decibels
DEM	Digital elevation model
DFO	Distillate Fuel Oil
DMP	Dust Management Plan
ECG	Electricity Company of Ghana
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPA	Ghanaian Environmental Protection Agency
EPC	Engineering procurement and construction

EPFI	Equator Principle Financial Institution
EQS	Environmental quality standard
ESC	Environmental Solutions Centre
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EU	European Union
g / s	Grams per second
GCSA	Government Consent and Support Agreement
GIS	Geographic information system
GLC	Ground level concentration
GPS	Global Positioning system
GRIDCo	Ghana Grid Company Limited
HIV	Human immunodeficiency virus
hr	Hour
HRSG	Heat Recovery Steam Generator
HV	High voltage
Hz	Hertz
IAQM	Institute of Air Quality Management
Inc	Incorporated
IPP	Independent Power Producer
ISO	International Organization for Standardization
IUCN	International Union for the Conservation of Nature
K	Kelvin
Kg	Kilogram
km	Kilometres
kV	Kilo volts
l/s	Litres per second
L_A	A-weighted equivalent sound pressure level
$L_{Aeq,T}$	A-weighted equivalent sound pressure level measured over time
LCO	Light Crude Oil
LI	Legislative Instrument
LNG	Liquid natural gas
LoW	List of Waste

m	Metres
m^3	Cubic metres
MBT	Sodium meta bisulphite
mg/Nm^3	Milligrams per nominal meter cube
MJ	Megajoule
mm	Millimetres
MSDS	Material safety data sheet
MW	Megawatts
MWe	Megawatt electricity
MWth	Megawatt thermal
NFP	National Fire Protection Association
NGO	Non-governmental organization
NLCD	National Liberation Council Decree
Nm^3 / s	Nominal meter cube per second
NO	Nitrous Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrous Oxides
NOSCP	National Oil Spill Contingency Plan
NSRs	Noise sensitive receptors
O_2	Oxygen
O&M	Operations and Maintenance
OPIC	Overseas Private Investment Corporation
OSRMP	Oil Spill Response and Management Plan
PAH	Polyneclear Aromatic Hydrocarbon
PAPs	Project Affected People
PCB	Polycholrinated biphenyls
PEC	Predicted environmental concentration
PERs	Preliminary environmental reports
PM_{10}	Particulate matter with less than 10 microns diameter
PNDCL	Provisional National Defence Council Law
PPA	Power Purchasing Agreement
PPE	Personal Protective Equipment
PPV	Peak particle velocity
PS	Performance Standard (with respect to IFC)
PURC	Public Utilities Regulatory Commission

Radewood	Radewood Energy Ltd
rWFD	Revised Waste Framework Directive
s	Seconds
SEP	Stakeholder Engagement Plan
SO_2	Sulphur Dioxide
SPM	Single point mooring
SSS	Side-scan sonar
STI	Sexually Transmitted Infection
t/h	Tonnes per hour
TDS	Total dissolved solids
THC	Total hydrocarbon concentrations
TOC	Total organic compounds
TOM	Total organic matter
TPH	Total Petroleum Hydrocarbons
TSP	Total suspended particles
µg/l	Micrograms per litre
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund
USA or US	United States of America
VERs	Valued Ecological Receptors
VOC	Volatile organic chemicals
VRA	Volta River Authority
w / w	Weight of solute / weight of solution
WAGP	West African Gas Pipeline
WB	World Bank
WHO	World Health Organisation
yrs	Years

NON-TECHNICAL SUMMARY

NON-TECHNICAL SUMMARY

Introduction

Environmental Solutions Centre (ESC) with Parsons Brinckerhoff has undertaken this Updated Environmental and Social Impact Assessment (ESIA) of the Amandi Energy Limited (AEL) Combined Cycle Gas Turbine (CCGT) Project (the 'Project'). AEL is a special purpose company, incorporated in Ghana, set up to develop, design, finance, own, construct, commission and operate the Project.

This report was preceded in 2013 by an ESIA Scoping and Terms of Reference stage, in accordance with the Ghanaian Environmental Impact Assessment Regulations. The original ESIA, prepared by ESC, fulfilled the requirements of the Environmental Protection Agency (EPA) Act (1994) Act 490 and associated Acts relevant to protection of the environment, social wellbeing and electricity regulations. It was submitted to the EPA and the Environmental Permit for the Project was issued to AEL, in July 2014.

This document has been prepared by Parsons Brinckerhoff, using ESC's original report and incorporating the results of a number of surveys and additional information, in order to develop the impact assessment and ongoing management in accordance with the international standards that may apply to the Project including those of the World Bank Group, the International Finance Corporation Performance Standards and the Equator Principles.

Project Description

The Project comprises the development of a CCGT with a generating capacity of approximately 190 MW. The Plant will consist of one gas turbine coupled with a generator, one heat recovery steam generator and one steam turbine.

The Project will operate on light crude oil (LCO) as the primary fuel for the first few years of its operation. It is envisaged that natural gas may then be used from Ghana's Jubilee oil fields, which are currently under development. However the natural gas option is not investigated as part of this ESIA as the LCO fuel is considered a worst case scenario in relation to emissions when compared to Natural Gas.

All of the power generated by the Project will be sold to the Electricity Company of Ghana via a 25-year Power Purchase Agreement, with the option of a 5-year extension.

The site proposed for the Project consists of approximately 62.55 acres of land in an area designated for industrial development. The Volta River Authority (VRA) currently operate the existing thermal Takoradi T1, T2 and T3 Power Plants (VRA Takoradi Power Plants) with a combined generating capacity of approximately 800 MW, to the east of the site. There are currently plans to develop an additional 190 MW (T4) as well as various other plants in the vicinity. Existing plants and proposed plants / development in the vicinity of the Project are described in Section 4.8. These descriptions will also form the basis of the identification and assessment of potential cumulative impacts.

The Project will also incorporate four key elements which extend outside of the main site boundary and are considered as development ancillary but necessary to its successful implementation:

a. LCO supply pipeline (approximately 1.7 km in length);

b. Raw water intake / effluent discharge pipework (1.2 km and 600 m in length respectively);

c. Site access road (approximately 2 km in length); and

d. Diversion of the high voltage overhead connection via the AEL switchyard to the existing Ghana Grid Company Limited (GRIDCo) substation (required construction of new overhead lines approximately totalling 1.3 km in length).

The LCO pipeline, intake/effluent discharge pipeline and access road will be developed by AEL and are considered part of the Project. The overhead transmission line will be built, owned and operated by GRIDCo.

The selection of the optimal location of the plant was influenced by factors including proximity to existing infrastructure, access and logistics for LCO and gas supply, ease of evacuation, distance to water supply, and environmental considerations.

The site is located approximately 2 km west of Aboadze Township, 5 km south west of Shama and approximately 12 km from Takoradi, the western regional capital of Ghana. The red line on the plan below shows the outline of the Project site.

Location of Project

Location in relation to Existing and Proposed Developments

NOTE: Descriptions of existing and identified proposed future development are provided in Section 4.8

The Baseline Physical, Natural and Human Environment

The climate of Ghana is tropical and there are two main seasons, the wet and the dry seasons. The climate in southern Ghana where the Project is situated experiences the rainy season from April to mid-November. Average annual precipitation measured in Takoradi town is approximately 1200 mm, with June and July being the wettest months, when over 250 mm of rain falls each month.

The climatic conditions in Aboadze are characterized by stable temperatures throughout the year. The mean temperature between July and September is 27°C. The mean temperature between November and April is 30°C to 31°C. The temperature rarely drops below 21°C (daily mean). Humidity levels at the site have a consistent diurnal variation, reaching 95 per cent overnight, decreasing to between 70 to 80 per cent in the day time.

The Project will be located in the Shama District of the Western Region of Ghana. The land north of the site is mostly undeveloped grassland. Between the VRA Takoradi Power Plants and the site there is marshland. The western boundary of the site is defined by the Anankwari River which flows into the Atlantic Ocean (Gulf Of Guinea). The southern boundary of the Project site is approximately 100 m inland from the coast.

The natural habitats surrounding the site are varied in nature. Immediately south of the Project site there are coconut plantations lining the beach; this strip of land has been acquired by agreement with the landowners and forms part of the land owned by AEL. Along the coast, and through the coconut plantation, is a footpath used by the community members of Abuesi and Aboadze, to access the Anankwari lagoon, to the west of the Project. The site, and to the north and east of the site, there is a combination of marshland and relatively higher grounds. The marshland forms part of the Anankwari

lagoon catchment. The vegetation types include mangroves and other shrubs as well as isolated palm and coconut trees.

Summary of Potentially Significant Effects

The scoping stage of the ESIA identified the need to consider potential impacts during the preconstruction / construction and operational phases of the Project on: air quality, traffic and transport, noise, water resources, land use, soils and geology, flora and fauna, landscape and visual perception, man-made hazards, socioeconomic, and cultural heritage on the functionality of the Project.

A summary of the assessment of possible effects on the physical natural and human environment is presented below. The significance of these effects is presented in detail in the individual technical chapters.

Summary of Potentially Significant Effects

Topic	Construction Phase Impacts	Operation Phase Impacts
Air quality	Increase in dust levels.	Burning of gas / oil increases the emission of SO_2, NO_x, CO, and particulate matter which can adversely affect health, vegetation, buildings, etc.
Sustainability	-	Changes in carbon equivalent / greenhouse gas emissions.
Noise & vibration	Noise from construction machinery and traffic.	Excessive noise from turbine units within plant detrimental to workers' health. Excessive noise from stack emissions. Excessive noise from air intake fans. Disturbance from single tonal sources, i.e. transformers, fans, etc. Overall Increase in noise level at adjacent communities from plant operation.
Water	Contamination to local watercourses from high sediment loads, oil and grease, etc.	Reduction of water quality in the Anankwari River. Contaminated runoff from site to the Anankwari River. Potential increase of salinity of receiving water bodies. Risk of hazardous substances spills. Effects on water supply and sanitation. Risk of pollution to other surface or groundwater features.
Ecology	Loss of natural habitats. Fragmentation of habitats. Disturbance of habitats. Disturbance of species. Habitat contamination. Changes in land use.	Effects on number, diversity, breeding sites (aquatic and terrestrial), etc. of flora and fauna. Effects on ecology of wetlands, river and marine environment. Risk of introducing pests, species vector of diseases and weeds.

Summary of Potentially Significant Effects

Topic	Construction Phase Impacts	Operation Phase Impacts
Social (Health)	Pressure on existing housing and medical facilities, water and electricity usage. Increase in traffic and road traffic accidents. Influx of migrant workers. Disruption of local communities. Risk of disease (including HIV/AIDS).	Health implications relating to the following aspects of normal operation of the Project: Air quality; Noise and vibration; Water quality; Land contamination; and Waste.
Social (Landscape and visual)	Temporary visual impacts of construction (e.g. particularly tall / large scale equipment).	Permanent visual impacts of transformation of landscape, loss of vegetation and trees, introduction of permanent structures. Permanent change of land use. Permanent visual impact.
Social (Cultural)	Aesthetically displeasing appearance, disturbance to potential tourist appeal of coastline	
Social (Economic)	Job opportunities (direct and indirect). No physical resettlement on site. Compensation to land owner (in the form of leasing the land) and land users (i.e. for assets – fruit trees and disused/abandoned structures). Pressure on existing housing and medical facilities, water and electricity usage. Competition for food supplies leading to an increase in prices. Small scale local businesses such as installation of chop bars, selling of goods and provision of services to construction staff.	Improvement in incomes. Impacts on and diversification of livelihoods. Job opportunities (direct and indirect). Improvements in local economy, such as a growth of the service industry, the development of small businesses etc. Macro-scale benefits of increase in electricity availability and thus greater accessibility to electricity for the country; and further stability of national grid. This will translate into further positive social and health impacts, such as improvements in the educational sector and in the provision of health services. Increase in heavy goods vehicles and other construction traffic. Risks to pedestrians, cyclists and other road users.
Soils and geology	Loss of topsoil. Risk of pollution by oil / hydrocarbon spills. Soil erosion and run off. Generation of construction and hazardous wastes. Risk of pollution by oil / hydrocarbons spill; and faecal and solid waste disposal.	Soil erosion and runoff. Risk of soil pollution from spillages and waste.

Mitigation / Monitoring and the Environmental and Social Management Plan

The ESIA proposes various mitigation and monitoring measures that seek to protect (and demonstrate the protection of) the environment in the vicinity of the Project. These proposals have been used to prepare an Environmental and Social Management Plan (ESMP) that specifies each measure, the anticipated timing for implementation, identifies who was responsible for the implementation and how each measure would be funded (see Appendix X).

The ESMP defines the principles and policies of AEL in respect of mitigation and monitoring of all phases of the Project. The document will be incorporated into the contractual obligations for all supplier / contractors in order for such contractors to develop a detailed and final Contractor ESMP (CESMP) for their works during construction / operations / decommissioning as applicable.

SECTION 1

INTRODUCTION

1 INTRODUCTION

1.1 Overview

1.1.1 Amandi Energy Limited (AEL) is a power company incorporated in Ghana under the Companies Registration Act 1963, (Act 179) to build, own and operate (BOO) a Combined Cycle Gas Turbine (CCGT) power plant of 192.4 megawatts (MW), capable of operating on both light crude oil (LCO) and natural gas (the Project).

1.1.2 AEL is a power company established by Radewood Energy Ltd (Radewood) and incorporated in Ghana under Companies Registration Code 1963, Act 179, to engage in the business of producing electrical energy for sale to prospective customers. In June 2014 Radewood signed a Joint Development Agreement with Aldwych International Ltd (Aldwych). Together, Radewood and Aldwych will work in partnership to complete the development of the Project, to jointly manage the construction and operation phases of the Project and to be co-investors in the Project.

1.1.3 Radewood holds the project shares in a fully owned subsidiary Amandi Energy BVI (AEB). AEB is an infrastructure project developer focussed in Ghana, and has worked in a variety of projects with the government authorities including rail, power, ports, and water supply, amongst others. Aldwych is a UK based power development company, focussed on sub-Saharan Africa with various operations in Kenya and South Africa. The developers will also seek Lenders from the international community to invest in the Project.

1.1.4 An Environmental and Social Impact Assessment (ESIA) was prepared by consultants, Environmental Solutions Centre (ESC), to meet the requirements of the Ghanaian Environmental Protection Agency (EPA) Act (1994) Act 490 and associated Acts relevant to the protection of the environment, social wellbeing and electricity regulations. ESC is a Ghanaian consultancy with a range of experienced air quality, noise, land-use and social consultants.

1.1.5 The ESIA was preceded in 2013 by an ESIA Scoping and Terms of Reference stage, in accordance with Environmental Impact Assessment (EIA) Regulations. The EPA issued the Environmental Permit for the Project, to AEL, in July 2014.

1.1.6 The ESIA was updated and consolidated in this document by Parsons Brinckerhoff in order to develop the assessment in accordance with the international standards that may apply to the Project including those of the World Bank Group, the International Finance Corporation (IFC) Performance Standards (PS) and the Equator Principles. An addendum to the EPA approved ESIA, containing the updated information presented here, will be submitted to EPA in due course. The team from Parsons Brinckerhoff comprised specialists in air quality, noise, water, ecology and general ESIA. They were also supported by Envaserv for ecology, a Ghanaian consultancy with particular expertise in aquatic ecology.

1.1.7 This document consolidates all the environmental and social information and studies on the Project to date (as of March 2015).

1.2 Proposed Development

1.2.1 The Project is located in the Western Region of Ghana at Aboadze (Latitude 4.9702, Longitude -1.6648), approximately 12 km from Takoradi, the regional capital. The site location is shown in Figure 1.1. The Project site is adjacent to the Volta River Authority (VRA) T1, T2, and T3 thermal power plants, which have a total generating

capacity of about 850MW. The selection of the plant location was influenced by factors including proximity to existing infrastructure, access and logistics for LCO and gas supply, ease of evacuation, distance to water supply and, environmental considerations.

Figure 1.1 Location of Project

Figure 1.2 Site Location in relation to Existing and Proposed Developments (Site boundary outlined in red.)

NOTE: Descriptions of existing and identified proposed future development are provided in Section 5.8

1.2.2 AEL intends to build, own and operate (BOO) the Project to produce electricity for sale to the Electricity Company of Ghana (ECG) as the sole off-taker. All of the power generated by the Project will be sold via a 25-year Power Purchase Agreement (PPA) signed by the ECG on the 31st of July 2013 with the option of a 5-year extension.

1.2.3 It is conservatively assumed that the plant will use LCO as the primary source of fuel for the full duration of the PPA. The PPA stipulates that the plant should switch to natural gas as soon as natural gas fuel becomes available. If the development strategy announced by the Ghanaian Government is implemented successfully, it is possible that the conversion to gas could take place as soon as 1-4 years after the Commercial Operation Date (COD). However the natural gas option is not investigated as part of this ESIA as the LCO option represents the worst case scenario in relation to emissions and therefore presents the most appropriate assessment. Once converted to natural gas, the environmental impacts would be less than have been assessed in the ESIA, representing an improvement on the situation at the time of conversion.

1.2.4 AEL will have LCO storage facilities on the plant site capable of storing 40 days of untreated LCO and 14 days of treated LCO. The tanks and related infrastructure are included in the Engineering Procurement Construction (EPC) Contractor's scope.

1.2.5 AEL will establish a Construction Management Company for construction management service and an Operations and Maintenance (O&M) company for the operations and maintenance of the Project.

Combined Cycle Gas Turbine Technology

1.2.6 The Project will comprise an industrial type gas turbine that will consist of an inlet air filter, an air compressor, combustion chambers, power turbine and exhaust silencer. Air will be compressed in the compressor of the gas turbine and gaseous fuel injected into the combustion chambers where the fuel will burn producing hot, high-pressure gases. These gases will expand across the rotor blades of the gas turbine, which will drive both the compressor and the electrical generator(s).

1.2.7 The low-pressure exhaust gases from the gas turbine will still contain useful and recoverable heat energy; the exhaust gases will pass through a heat recovery steam generator (HRSG) where this heat will be extracted from the exhaust gases to raise steam. The HRSG is likely to comprise separate high, medium and low pressure steam circuits. The resultant steam will be provided to a condensing steam turbine at a range of elevated pressure levels and will expand across the steam turbine blades. This expansion will, as within the gas turbine, rotate the turbine and drive the same or additional electrical generators to increase the electrical output of the Project. The residual heat within the spent steam will be rejected via a condenser system and the resultant condensate will be returned to the HRSG for re-use.

1.2.8 Lubricating oil will be supplied to the gas and steam turbine and generator bearings and will also be supplied for the turbine control and hydraulic oil systems.

1.2.9 The HRSG will be of the unfired multi-pressure type and may use assisted or natural circulation.

Ancillary Development

1.2.10 The Project will see the construction of four key elements outside of the main site boundary considered as development ancillary but necessary to its successful implementation:

- A 1.7 km LCO supply pipeline to transfer the oil from where it is unloaded by tanker at the VRA Takoradi Power Plants to the AEL plant;
- High voltage overhead connection of approximately 700 m to the existing GRIDCo substation;
- Raw water intake / effluent discharge pipework extending approximately 1.2 km and 600 m respectively offshore; and
- A site access road extending approximately 2 km from the existing access to the VRA Takoradi Power Plants.

1.3 Need for the Project

1.3.1 Analysis of the current Ghanaian power generation / supply revealed an energy supply deficit (as demand for power is constantly over growing the supply). This is evidenced by the current energy crisis and the general challenges facing the sector and the economy as a whole. The government of Ghana has planned to increase total production of power to 5,000 MW by 2015.

1.3.2 The advent of power sector reform in Ghana that commenced in 1994 opened up the sector to allow investment by the Private Sector in the development and operation of power plants for the supply of electricity for socio-economic and industrial development.

1.3.3 The reform programme aimed at creating a conducive environment in the energy sector to attract private capital and also provide a reliable energy supply system to support socio-economic development of the country. This situation has been very greatly helped by the discovery of oil off the shore of Ghana.

1.3.4 The country has also put in place institutions and is developing infrastructure to harness the associated natural gas for power generation and other industrial use. Currently a number of Independent Power Producers (IPPs) have shown great interest and made investments to construct and operate power plants.

1.4 Project Standards

1.4.1 AEL has adopted the following standards for the Project:

a National Laws of Ghana;

b World Bank Group Environmental, Health and Safety (EHS) guidelines and standards, including;

i IFC PS (January 2012);

ii IFC General EHS Guidelines (April 2007);

iii IFC EHS Guidelines for Thermal Power Plants (December 2008);

iv IFC EHS Guidelines for Electric Power Transmission and Distribution (April 2007); and

v IFC EHS Guidelines for Construction Materials Extraction (April 2007).

c Equator Principles (June 2013);

d All relevant international conventions for the individual technical specialities, which are identified in the appropriate sections of the report; and

e Those standards adopted by the international lending community and prospective Project Lenders, to the extent enabled at time of writing. Cognisance has been taken of the standards of the United States (US) Overseas Investment Corporation (OPIC), European Investment Bank (EIB), and African Development Bank (AfDB).

1.5 Project Categorisation

1.5.1 The IFC categorises projects as a way of indicating the level of environmental and social concern of a proposed investment. Projects are assigned a Category of A, B or C, in descending order of environmental and social sensitivity. The project category governs how IFC's Disclosure Policy applies to the proposed investment. Different lending organisations may apply different specific criteria to categorisation, but the principals are aligned.

1.5.2 For Category A Projects, these are expected to have significant adverse social and/or environmental impacts that are diverse, irreversible, or unprecedented. Category B Projects are expected to have limited adverse social and/or environmental impacts that can be readily addressed through mitigation measures. Category C Projects are expected to have minimal or no adverse impacts,

1.5.3 The previous ESIA process concluded that a thermal power project would most likely fall within Category A, and an ESIA report was prepared including an evaluation of the

possible environmental and social impacts of the Project, measures designed to manage, mitigate and monitor those impacts and details of public consultations.

1.5.4 Further studies and assessment have confirmed the AEL Project as Category A for the following reasons:

- The Project's greenhouse gas emissions will exceed 900,000 of carbon dioxide equivalent (CO_2eq) tonnes/year.
- The mangrove found within the project site supports three mangrove species of Least Concern per the International Union for the Conservation of Nature (IUCN) Red List and as such mangrove habitat is considered to be a 'critical natural habitat' under the IFC Funding criteria. Overall, the Project has aimed to avoid the mangrove where possible and identified an area to provide compensation habitat.

1.6 Purpose of the Document

1.6.1 The purpose of this document is to consolidate the findings and recommendations of the ESIA undertaken for the Project by ESC in 2014 and update the report in line with the international standards adopted by AEL.

1.6.2 This updated ESIA document provides:

- Comprehensive details of the nature, scale, location and likely significant impacts of the Project;
- Comprehensive baseline of the existing environment of the site and its surroundings, both natural and social;
- Proposal of how negative impacts can be avoided, reduced or offset through further design or mitigation;
- Proposal for how positive impacts can be enhanced or maximised;
- Identification of any cumulative impacts and proposed mitigation; and
- Proposal of options as to how any significant residual impacts would be mitigated, managed or monitored.

1.7 Content of the ESIA

1.7.1 The document is set out as follows:

- Non-Technical Summary
- Introduction
- Policy, Legal and Administrative Framework
- Description of Project
- ESIA Methodology
- Impacted components:
  - Air Quality
  - Noise and Vibration
  - Water Resources and Quality

- Ecology
- Socio-Economic
- Soils and Geology
- Waste

- Summary and Conclusions
- Appendices – Volume II of the ESIA

SECTION 2

POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Introduction

2.1.1 There are a number of relevant national and international policies and regulations that provide safeguards for development projects. As previously discussed, AEL has adopted certain Project Standards which are discussed in this section; it sets out the principal administrative, legal and policy framework relevant to the Project at international, national, regional and local levels.

2.2 National Laws of Ghana

2.2.1 Some of the legislation, guidelines, and policies which are considered to be of relevance to the preparation and use of the ESIA for the Project are reviewed, and include among others:

The Environmental Protection Agency Act (1994) Act 490

2.2.2 The EPA Act 1994 (Act 490) was promulgated by the Government of Ghana to replace the erstwhile Environmental Protection Council Decree (NRCD 239). The Act provided the Agency with the compliance and enforcement powers necessary for the achievement of the environmental policy objectives.

2.2.3 Act 490 established the authority, functions, structure and funding of the EPA and gave mandate to the Agency to ensure compliance of all investments and undertakings with the provisions of the Environmental Assessment procedures in the planning and execution of development projects, including compliance in respect of existing ones.

2.2.4 The Act empowers the EPA Board to appoint officers to be designated as "Environmental Protection Inspectors" and have such other officers and employees as may be necessary for the proper and effective performance of its functions under this Act. The Board may create such departments or divisions in the Agency as the Board may consider necessary for the efficient discharge of the functions of the Agency.

Environmental Assessment Regulations (1999)

2.2.5 In order to give effect to provisions of Act 490, the Environmental Assessment Regulations 1999 (LI 1652) was enacted in February 1999, in accordance with Section 28 of the Act 490. The LI sets out the requirements for environmental permitting, EIA, the production of preliminary environmental reports and subsequent environmental impact statements, environmental certificates and environmental management plans.

2.2.6 The EIA procedure is not only a regulatory tool to be enforced pursuant to Section 24 of LI 1652, but also a compliance promotion tool to ensure effective prevention, minimisation and mitigation of potential impact of industrial developments existing prior to and after the coming into force of LI 1652.

2.2.7 The legislative functions conferred on EPA by the Act, included the authority to request from categories of undertakings, enterprises, construction or development an EIA to assess the impacts associated with projects and environmental management plan for the evaluation of compliance with set guidelines and standards to ensure environmental integrity of operations.

2.2.8 The Agency may by notice in writing require any person responsible for any undertaking which in the opinion of the Agency has or is likely to have adverse effect on the environment to submit to the Agency in respect of the undertaking an EIA containing such information within such period as shall be specified in the notice.

2.2.9 Where it appears to the Agency that the activities of any undertaking poses a serious threat to the environment or to public health, the Agency may serve on the person responsible for the undertaking, an enforcement notice requiring him to take such steps as the Agency thinks necessary to prevent or stop the activities.

2.2.10 Where a person to whom a notice has been served under subsection (1) of section 13 fails to comply with the directives contained in the notice within the stipulated time or such further period as the Agency may grant, the Minister, may without prejudice to a prosecution under subsection (4) of section 13, take such steps as he considers appropriate to ensure compliance with the notice.

2.2.11 Under Schedule 1 Regulation 3, 13 (a-e) for Power Generation and Transmission Projects, construction and operation of thermal power plants such as the Project is one of the undertakings for which an EIA is mandatory.

Environmental Agency Fees and Charges (Amendment) Instrument LI 2206, 2013

2.2.12 In exercise of the powers conferred on the Minister responsible for the Environment, under section 28 of the EPA Act, 1994 (Act 490) and on the advice of the EPA Board this Legislative Instrument was promulgated to serve as legal backing to the Environmental Processing and Permit fees charged under the principal act.

2.2.13 The LI 2206, 2013 stipulates the "fees and charges for environmental permits and certificates" and is accompanied by Schedules indicating the respective fees for processing, permit and environmental certificates for different categories of undertakings (large scale and others). The fees are graded according to the scale of impact entailed by the project activities, and in the case of hotels, the occupancy or number of rooms. Some of the industrial groups covered under the LI 2206 of 2013 include the Mining, Energy, and Tourism, Manufacturing, Agricultural and General Construction Sectors among others.

Pesticides Control and Management Act (1996) Act 528

2.2.14 The Act which is now part of the EPA Act 490, was enacted to ensure the control, management and regulation of chemicals and pesticides and related matters in Ghana. It provides the EPA the powers to register and classify chemicals, to determine “Restricted” and “Suspended” chemicals, license and approve chemical dealers, and to ensure enforcement and penalties. The Act states that no person shall import, export, manufacture, distribute, advertise, sell or use any chemical in Ghana unless the chemical has been registered by the EPA in accordance with this Act.

2.2.15 Any person seeking to register any pesticide shall submit to the Agency an application for registration which shall be in such form and be accompanied with such fee, information, samples and such other material as the Agency may determine.

Energy Commission Act (1997), Act 541

2.2.16 Act 541 established the Energy Commission with functions including the regulation, management, development and utilization of energy resources in Ghana in addition to

granting of licenses for the transmission, wholesale supply, distribution and sale of electricity and natural gas; refining, storage, bulk distribution, marketing and sale of petroleum products and to provide for related matters.

2.2.17 The provisions of the Energy Commission's Public Notice EC N.003 requires AEL to register the proposed project with the Commission and to obtain a permit prior to the commencement of construction of the proposed project. This permit is subject to the granting of an Environmental Permit by the EPA.

2.2.18 A Manual for Service Providers in the Electricity Supply Industry was developed and issued by the Commission in 1996 to formally establish the framework for licensing electricity production, supply, and distribution and sale services in the power sector of Ghana as stipulated by the Energy Commission Act (Act 541), 1997.

Public Utilities Regulatory Commission (PURC) 1997, Act 538

2.2.19 The PURC 1997, Act 538 requires the PURC to set up guidelines for pricing of power generated by utility companies taking into consideration assurance of financial viability of power produced, investor interests and best use of natural resources. PURC is also responsible for the determination of actual tariffs for both production and service providing utilities including electricity hence will be responsible for pricing of the electric power to be generated from the Project.

Ghana Investment Code, Provisional National Defence Council Law (PNDCL) 116, 1985

2.2.20 The 1985 Investment Code, PNDCL 116, requires that the Ghana Investment Promotion Centre, which is the government agency for the promotion and coordination of private investment in the Ghanaian economy must in its appraisal of enterprise, have regards to any effect the enterprise is likely to have on the environment and the measure proposed for the prevention and control of any harmful events to the environment before giving approval for its establishment.

Factories, Offices and Shops Act (1970) Act 328

2.2.21 Act 328 promotes and ensures the health, welfare and safety of persons employed in the country as well as the responsibilities of the employer. Under the Act, employers are required to ensure that a safe and healthy workplace is provided for the safety, health and welfare of all employees.

Labour Act No (2003) Act 651

2.2.22 Part XV, Section 118 (1) and (2 a-h) of the Act enjoins employers to ensure that every worker employed by him or her works under satisfactory, safe and healthy conditions, and is further obliged to provide necessary information, instructions, training and supervision to ensure the health and safety at work of those other workers engaged in a particular work.

National Museums Decree (1969), National Liberation Council Decree (NLCD) 387

2.2.23 NLCD 387 provides for the care of any archaeological finds. This is the law governing the activities and operations of the National Museums and Monuments Board. Procedures to be followed on the discovery of any such artefacts are outlined in NLCD 387. Any archaeological finds during the construction activities shall be reported accordingly.

Ghana National Fire Service Act of 1997 (Act 537)

2.2.24 The Ghana National Fire Service Act of 1997 (Act 537) states that a Fire Certificate shall be required for premises used as a public place or place of work. The owner or occupier of the premises shall apply to the Chief Fire Officer for a Fire Certificate, valid for 12 months from the date of issue and subject to renewal.

Electricity Regulations, L.I. 1937: 2008

2.2.25 The purpose of these Regulations is to provide for:

a The planning, expansion, safety criteria, reliability and cost effectiveness of the national interconnected transmission system;

b The regulation of a wholesale electricity market;

c The market operations of the electricity transmission utility;

d The technical operations of the electricity transmission utility;

e Minimum standards and procedures for the construction and maintenance of facilities and installations;

f The protection of the mains and electrical installations and services;

g The protection of life and property and the general safety of the public in respect of electricity services;

h Minimum reserve margins to satisfy demand; and

i The development and implementation of programmes for the conservation of electricity.

Fire Precaution (Premises) Regulations, 2003, LI 1724

2.2.26 LI 1724 among other requirements requires that adequate measures are taken to eradicate potential sources of fire outbreaks and that a fire certificate be acquired for any project or facility.

Lands Commission Act, (1994), Act 483

2.2.27 Act 483 provides for the management of public and vested lands and the certification of stool lands transactions. Indeed, the 1992 Constitution requires that there shall be no disposition or development of any stool land unless the Lands Commission of the region in which the land is situated has certified that the disposition or development is consistent with the development plan drawn up or approved by the planning authority for the area concerned.

Lands Statutory Way leaves Act, (1963) Act 186

2.2.28 Act 186 provides for entry on any land for the purpose of the construction, installation and maintenance of works of public utility, and for the creation of rights of way for such works. The owner / occupier of the land must be formally notified at least a week in advance of the intent to enter, and be given at least 24 hours‘ notice before actual entry. An authorized person may enter at any time for the purpose of inspecting, maintaining, replacing or removing any specified works (Section 5). Any damage due to entry must be compensated in accordance with the established procedure, unless the land is restored or replaced. In the case of roads, not more

than one-fifth of a plot may be taken and the remainder must be viable, or the entire plot must be taken; Section 6-3(b).

The Lands (Statutory Way leaves) Regulations, 1964 (LI334)

2.2.29 LI 1334 law restates the principles of the Lands (Statutory Way leaves) Act of 1963, and establishes provisions for Way leave Selection Committees to determine the optimal routing and to ensure that the selected way leaves are consistent with town and country planning.

Water Resources Commission Act, 1996

2.2.30 Act 1996 established a Water Resources Commission, with mandate for the regulation and management of water resources in Ghana as well as the co-ordination of any policy in relation to these functions. The Commission is also mandated to propose comprehensive plans for the utilization, conservation, development and improvement of water resources; initiate, control and co-ordinate activities connected with the development and utilization of water resources; grant water rights; collect, collate, store and disseminate data or information on water resources; require water user agencies to undertake scientific investigations, experiments or research into water resources in addition to monitoring and evaluating programmes for the use and management of water resources.

National Energy Policy

2.2.31 The National Energy Policy outlines the Government of Ghana‘s policy direction regarding the current challenges facing the energy sector. The document provides a concise outline of the Government‘s policy direction in order to contribute to a better understanding of Ghana‘s Energy Policy framework. It is hoped that the document will facilitate the effective management and development of the energy sector as well as provide the public with information about the Government‘s policy goals. The energy sector vision is to develop an Energy Economy to secure a reliable supply of high quality energy services for all sectors of the Ghanaian economy and also to become a major exporter of oil and power by 2012 and 2015 respectively.

National HIV/AIDS Sexually Transmitted Infections (STI) Policy (2004)

2.2.32 The National HIV/AIDS STI Policy has been developed to address the very serious health and developmental challenges posed by HIV/AIDS. The policy provides the framework for Ghana‘s strategy to reduce the spread of HIV infection. It provides the necessary statement of commitment around which a legislative framework will be built for an Expanded Multi-Sectorial Response to reduce further spread of the epidemic, and for the protection and support of people infected with HIV/AIDS in Ghana. Subsequently, a National HIV/AIDS Strategic Framework for Ghana has been formulated in recognition of the developmental relevance of the disease. Ghana, by this document has joined the global community in a united effort to combat the epidemic. The Strategic Framework document is updated periodically and it provides for a Workplace HIV Policy. Ghana has now developed a National HIV/AIDS Strategic Plan 2011-15.

National Oil Spill Contingency Plan (NOSCP) – 1986 (revised in 2009)

2.2.33 The NOSCP of Ghana aims to bring together the combined resources of the national government organisations and the oil industry (including shipping and extraction), to

provide a level of preparedness to the potential threats posed by oil and chemical spills.

2.2.34 The NOSCP highlights that the focus of any oil spill plan should be firstly on protecting human health and safety, secondly minimising environmental impacts and thirdly restoring the environment to pre-spill conditions. In the process of preparing oil spill response plans, the Environmental Sensitivity Atlas and associated reports will be considered in order to understand the risk index rating that has been applied to the coastal area of the project.

Guidelines

2.2.35 The EIA Guidelines for the Energy Sector, Volume 1 & 2, of September 2011, has been prepared to guide the development of energy projects as well as ensure the sustainable use of energy resources and also contribute towards sound environmental management in the energy sector.

2.2.36 Environmental Assessment in Ghana, A Guide (1996) produced by the EPA provides detailed guidance on the procedures to be adhered to when undertaking an EIA.

2.2.37 EPA's Environmental Quality Guidelines for Ambient Air provide advice on maximum permissible levels for various air pollutants.

2.2.38 EPA's Environmental Quality Guidelines for Ambient Noise provide the maximum permissible noise levels at various facilities including educational and health institutions, places of worship, commercial areas as well as light and heavy industrial areas.

2.3 International Standards

World Bank Group EHS Guidelines

2.3.2 The EHS Guidelines produced by the World Bank Group are technical reference documents on cross-cutting environmental, health, and safety issues applicable to all industry sectors. They cover general and industry-specific examples of Good International Industry Practice, as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement.

2.3.3 The General EHS Guidelines (April 2007) contain the performance levels and measures that are normally acceptable to the IFC and are generally considered to be achievable in new facilities at reasonable costs by existing technology.

2.3.4 When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

2.3.5 Specific industry EHS Sector guidelines relevant to the Project are:

a Thermal Power Plants (December 2008);

b Electric Power Transmission and Distribution (April 2007); and

c Construction Materials Extraction (April 2007).

Performance Standards

2.3.6 To manage the social and environmental risks and impacts of IFC projects, the IFC has developed a number of environmental and social PS. The IFC PS, updated in 2012, and the accompanying Guidance Notes have been adopted for this Project.

2.3.7 IFC PS indicate that the party responsible for implementing and operating the project must comply with the applicable national laws, including those laws implementing host country obligations under international law. The project operator is also required to meet the requirements of the standards throughout the life of an investment by IFC or other relevant financial institution. These are as follows:

a Performance Standard 1:
Assessment and Management of Environmental and Social Risks and Impacts

b Performance Standard 2:
Labour and Working Conditions

c Performance Standard 3:
Resource Efficiency and Pollution Prevention

d Performance Standard 4:
Community Health, Safety, and Security

e Performance Standard 5:
Land Acquisition and Involuntary Resettlement

f Performance Standard 6:
Biodiversity Conservation and Sustainable Management of Living Natural Resources

g Performance Standard 7:
Indigenous Peoples

h Performance Standard 8:
Cultural Heritage

2.3.8 All the above Performance Standards are applicable for this Project other than PS 7 Indigenous Peoples. As determined in the socio-economic baseline (Section 9), no persons or group that could be reported or defined (based on accepted criteria) as “indigenous” have been identified as being potentially affected by the Project.

Resettlement

2.3.9 There are no settlements within the proposed Project site therefore it is anticipated that there will be no physical displacement as a result of the Project. It should be noted that neighbouring proposed projects are undertaking resettlement to IFC standards as part of project development. Where resettlement is planned, this is noted in the socio-economic assessment in Section 9.

2.3.10 Part of the site is used for agriculture (mainly coconut plantations) and there will be some economic displacement. A separate Compensation Report has been prepared and presented in Appendix 9A in Volume II - and impacts are addressed in Section 9 of this ESIA.

Equator Principles

2.3.11 The Equator Principles, revised in June 2013, are a set of voluntary principles for financial institutions to ensure that the projects financed are developed in an environmentally and socially responsible manner. The financial institutions that have signed up the Equator Principles are called Equator Principle Financial Institutions (EPFIs). The principles (see Table 2.1) are intended to serve as a common baseline and framework for the implementation by each EPFI.

2.3.12 The Principles apply to all new EPFI project financings globally with total project capital costs of US$10 million or more, and across all industry sectors.

Table 2.1: Summary of Equator Principles

Principle	Description
Principle 1: Review and Categorisation	Relates to the categorisation of projects based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the IFC.
Principle 2: Social and Environmental Assessment	Requires a Social and Environmental Assessment. The Assessment should propose mitigation and management measures relevant and appropriate to the nature and scale of the Project.
Principle 3: Applicable Social and Environmental Standards	Establishes the IFC PS and EHS Guidelines to complement the host country legislation as the basis for social and environmental performance.
Principle 4: Action Plan and Management System	Requires preparation of an Action Plan which should describe and prioritise the actions needed to implement mitigation measures, corrective actions and monitoring measures.
Principle 5: Consultation and Disclosure	Requires consultation with project affected communities in a structured and culturally appropriate manner, ensuring free, prior and informed consultation and facilitate informed participation.
Principle 6: Grievance Mechanism	Requires the establishment of a grievance mechanism as part of the management system which addresses concerns promptly and transparently, in a culturally appropriate manner, and is readily accessible to all segments of the affected communities.
Principle 7: Independent Review	Requires an independent social or environmental review of the Assessment.
Principle 8: Covenants	Requires compliance with all relevant host country social and environmental laws, regulations and permits, Action Plan implementation commitments, periodic reviews of reports, and facility decommissioning in accordance with an agreed decommissioning plan.
Principle 9: Independent Monitoring and Reporting	Requires ongoing monitoring and reporting over the life of the loan through the appointment of an independent environmental and / or social expert.
Principle 10: EPFI Reporting	Commits the EPFIs to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.

2.3.13 The Equator Principles are based on the IFC PS on social and environmental sustainability and on the World Bank Group EHS Guidelines. These principles are relevant for the purposes of this Project as they represent industry best practice and given that the financing arrangements for the Project have not been finalised by AEL.

Implementation of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

2.3.14 Parsons Brinckerhoff has considered CITES in relation to this Project. CITES published lists in the form of Appendices (CITES Appendices, 1975) which limit global trade of certain categories of animal species:

a Appendix I species are threatened species which cannot be traded in; and

b Appendix II species are species for which levels of trade are limited.

2.3.15 The Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995 also categorise animal species into two main Schedules based on the level of protection required for a particular species:

a Schedule I species are completely protected (i.e. their hunting, capture or destruction is prohibited at all times); and

b Schedule II species are partially protected (i.e. their hunting capture or destruction is absolutely prohibited between 1 August and 1 December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).

Other Standards

2.3.16 Furthermore, Parsons Brinckerhoff has reviewed certain prospective Lenders' EHS requirements (including those of OPIC, EIB and AfDB). With respect to this Project, the standards were found to be broadly in line with those of the World Bank Group/IFC and any differences have been considered and incorporated into this ESIA and the ESMP.

SECTION 3

DESCRIPTION OF THE PROJECT

3 DESCRIPTION OF THE PROJECT

3.1 Introduction

3.1.1 This Section provides a full description of the proposed Project that is the subject of the ESIA. It includes a description of the site, the technology proposed for the generation of electricity and the associated / auxiliary equipment enabling its operation; the Project phases – construction, operations and decommissioning – will also be discussed.

3.2 Site Description

3.2.1 The proposed site is located approximately 2 km west of Aboadze Township and approximately 12 km north east of Takoradi town, bordered to the east by Shama, to the west by Kojokrom and to the south by the Atlantic Ocean.

3.2.2 The land proposed for the site presently consists mainly of undeveloped farmland with scattered vegetation and gradually increasing site elevation in a northward direction. This land is (or is bordered by) marshy, wet ground conditions across a wide area with small streams feeding towards the Anankwari River, to the west of the site. The wet ground conditions in the general area are expected to be in part due to the silted mouth of the Anankwari River which prevents downstream flow to the sea during wet seasonal periods.

3.2.3 Within the vicinity of the plant, there are currently three power stations owned and operated by the VRA. It is understood that land surrounding the site is proposed for a number of power station developments (see section 4.8).

3.2.4 A plot of approximately 62.55 acres has been allocated for the Project, which includes the power plant, pressure reducing and metering station, switchyard and roads; however it is expected that the power plant will occupy only part of the land available, as a portion of the site will be reserved for mangrove offset (see Chapter 8) or the potential future expansion of the Project (i.e. by the addition of another CCGT unit of a similar capacity).

3.2.5 The site is arranged such that there are logical boundaries between the key elements of the proposed plant:

a Storage / treatment of fuel;

b Power generation; and

c Export of electricity.

3.2.6 The location of these elements reflects the existing landscape and topography with regards to the connection to the existing substation, which is approximately 700 m north east of the site. The indicative arrangement shown in Figure 3.1 has been selected in order to minimise the required high voltage (HV) cable route distance to the existing GRIDCo 330 kV substation.

3.2.7 A security fence will be constructed around the site for security reasons and the site will be fitted with closed circuit television. A new access road will provide access to the site via the southern boundary.

3.2.8 The site layout has considered existing physical and topographical constraints including the Anankwari River to the west of the site and an existing small stream that currently provides drainage from the existing VRA Takoradi Power Plants.

3.2.9 As required by the Ghanaian EPA, the site layout will not include development within 20 m of the Anankwari River. In addition, the existing drainage system will be diverted to enable development of the Project without adversely affecting the existing drainage provisions of the VRA Takoradi Power Plants.

3.2.10 The marshy conditions and proximity to the Anankwari River has required AEL to consider potential flood risk of the site. The mouth of the River is known to silt up periodically which retains river water within the marshy area surrounding the site.

3.2.11 The site preparation / pre-construction works are anticipated to require a cut and fill method of raising the current ground level to approximately 4 m above mean sea level. This level is currently considered appropriate as this will be equivalent to the elevation of the existing VRA Takoradi Power Plants which are understood not to have experienced serious flooding events (if any).

3.3 The Proposed Plant

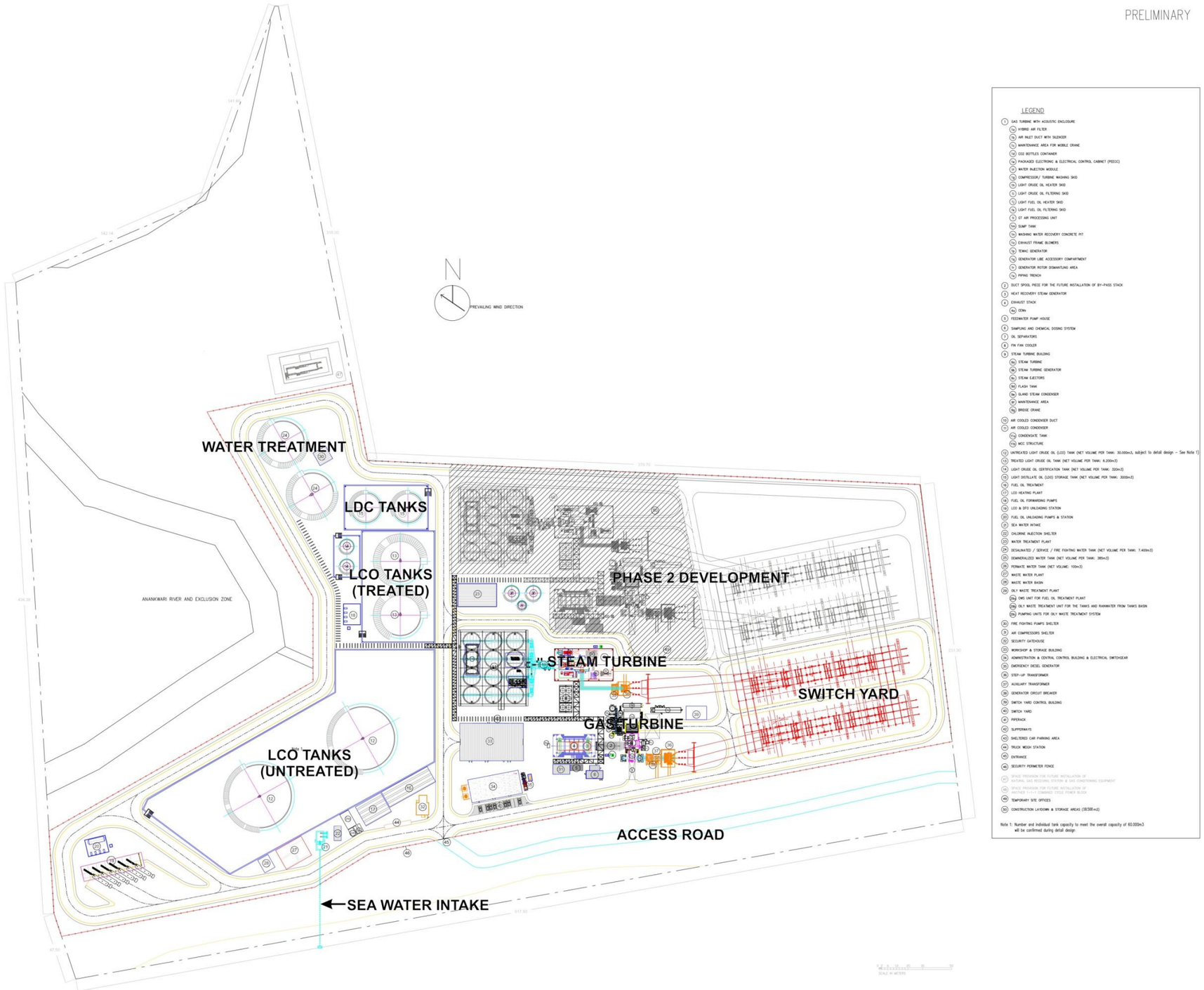
3.3.1 It is expected that for the majority of its life the Project will operate continuously throughout the year, except for essential maintenance and statutory inspections. The plant will be capable of two shifting in the event that it is required to operate in this fashion. It will be designed and constructed with a high average annual availability (i.e. above 90 per cent).

3.3.2 The plant will be designed to have an expected operational life of 25-30 years, though could potentially continue generation beyond this. The civil infrastructure, on site roads etc. will be designed to have a minimum working life of 30 years.

3.3.3 The plant will consist of one gas turbine, primarily fuelled by LCO, complete with associated HRSG and a single steam turbine. The thermal input of the proposed plant will be approximately 390 MWth (with a net efficiency of approximately 49 per cent). Approximately 68 per cent of the 190 MWe power generated at the station will be produced by the gas turbines with the steam turbine providing the remaining 32 per cent.

3.3.4 A preliminary layout of the plant is shown in Figure 3.1.

Figure 3.1: Indicative Project Layout



Combined Cycle Gas Turbine Technology

Process

3.3.5 The Project will comprise an industrial type gas turbine that will consist of an inlet air filter, an air compressor, combustion chambers, power turbine and exhaust silencer. Air will be compressed in the compressor of the gas turbine and gaseous fuel injected into the combustion chambers where the fuel will burn producing hot, high-pressure gases. These gases will expand across the rotor blades of the gas turbine, which will drive both the compressor and the electrical generator(s).

3.3.6 The low-pressure exhaust gases from the gas turbine will still contain useful and recoverable heat energy; the exhaust gases will pass through a HRSG where this heat will be extracted from the exhaust gases to raise steam. The HRSG is likely to comprise separate high, medium and low pressure steam circuits. The resultant steam will be provided to a condensing steam turbine at a range of elevated pressure levels and will expand across the steam turbine blades. This expansion will, as within the gas turbine, rotate the turbine and drive the same or additional electrical generators to increase the electrical output of the Project. The residual heat within the spent steam will be rejected via a condenser system and the resultant condensate will be returned to the HRSG for re-use.

3.3.7 Lubricating oil will be supplied to the gas and steam turbine and generator bearings and will also be supplied for the turbine control and hydraulic oil systems.

3.3.8 The HRSG will be of the unfired multi-pressure type and may use assisted or natural circulation.

3.3.9 Figure 3.2 shows a schematic representation of the combined cycle gas turbine principle.

3.3.10 Figure 3.3 shows an indicative mass and energy balance for the Project (assuming the base case of LCO-firing).

Figure 3.2: Indicative CCGT Process

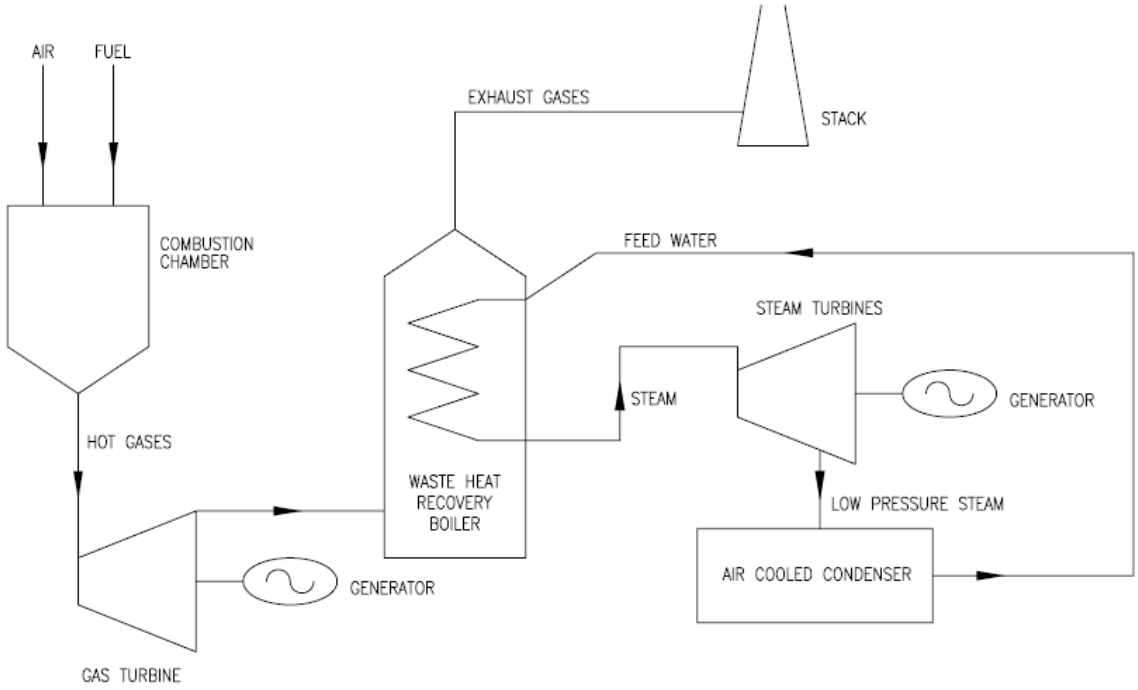
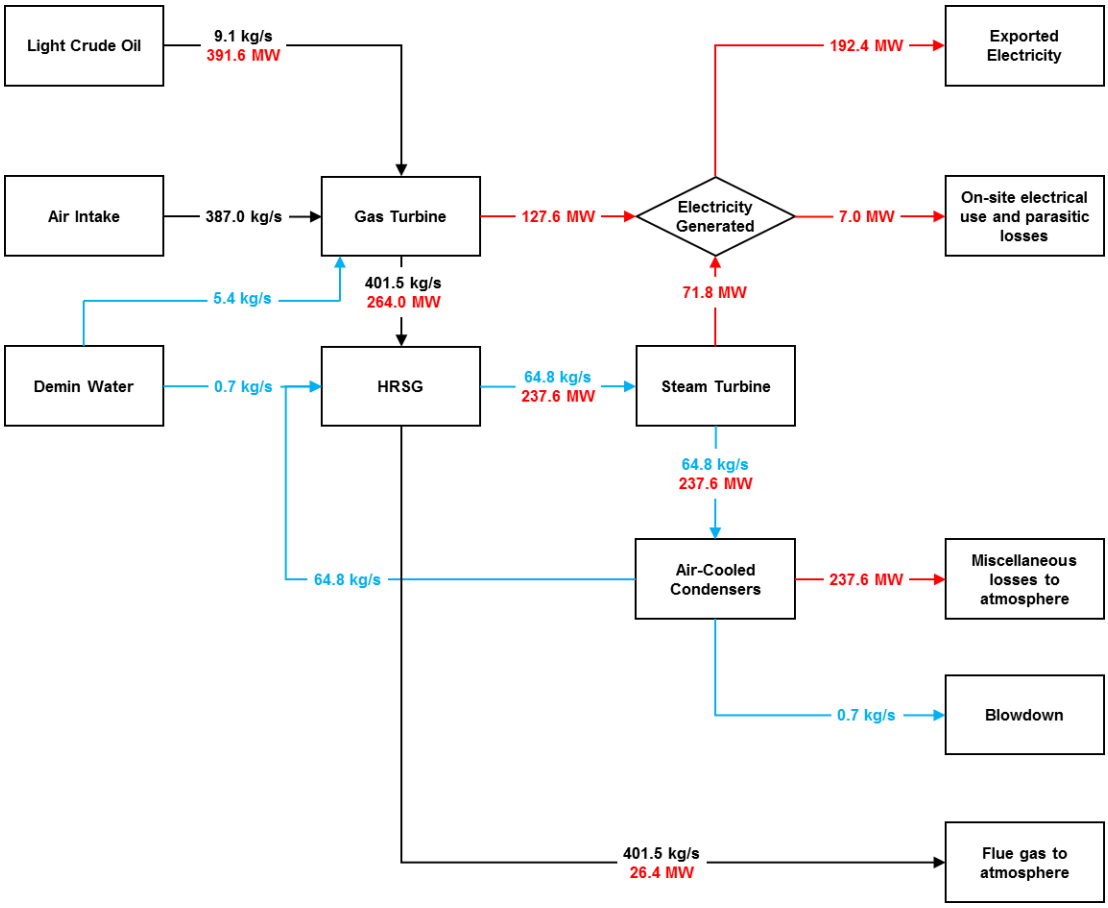


Figure 3.3: Indicative Mass / Heat Balance



Cooling

3.3.11 Air-cooled condensers (ACC) will be used to cool and condense the steam for re-use in the HRSG. The heat rejected by the condenser steam is passed to, and thus heats, the cold cooling water. The system operates by circulating water between the condenser and the ACC.

3.3.12 The hot water leaving the condenser is passed through a heat exchanger consisting of a series of fin-fanned tubes. Large fans (typically located below the heat exchanger) blow air across the tubes of the heat exchanger warming this air and thus rejecting the heat within the cooling water to atmosphere. The cold water exiting the ACC system is then returned to the condenser.

3.3.13 The use of air as the cooling medium for the Project will significantly reduce the raw water requirements for the Project compared to wet-based cooling systems such as once-through cooling or hybrid cooling towers.

3.3.14 The recirculation of the cooling water can result in a small build-up of non-condensable gases that may require purging from the system, though this is considered to be insignificant.

3.3.15 The performance of ACCs is dependent on the ambient temperature and is also sensitive to prevailing wind direction, gusty conditions and the height and position of buildings and other structures in the vicinity of the ACC. The Project will be designed to minimize the impact of these sensitivities.

Stack and Emissions

3.3.16 After passing through the HRSG, the exhaust gases will be discharged into the atmosphere through a dedicated stack, with a proposed height of 65 m.

3.3.17 As discussed above, the principal fuel for the Project will be LCO. LCO can contain: fuel-bound nitrogen; sulphur; and ash. The respective amounts of each of these substances in the fuel will be dependent upon the source of the fuel. The flue gases from the stack will therefore contain:

a CO_2;

b water vapour;

c oxygen;

d nitrogen;

e carbon monoxide (CO);

f oxides of nitrogen (NO_x);

g sulphur dioxide (SO_2); and

h particulate matter.

3.3.18 NO_x is primarily formed by two reaction routes. 'Thermal' NO_x is formed by the reaction of atmospheric oxygen and nitrogen at the high combustion temperatures within the gas turbine, whilst 'prompt' NO_x is formed by the reaction of atmospheric nitrogen with free radicals from the fuel via a complex series of reactions.

3.3.19 A third route for the production of NO_x exists whereby 'fuel' NO_x is produced by the oxidation of fuel-bound nitrogen.

3.3.20 Water / steam injection will be used to control NO_x emissions in the exhaust gases from the gas turbine by lowering the flame temperature within the combustion chamber. It is proposed that the gas turbines chosen for the plant will be equipped with this proven pollution control technology, which will limit the production of NO_x to a maximum of 152 mg/Nm^3 at gas turbine loads above 50 per cent of its rated capacity. This is relative to concentrations of the order of microgrammes per metre cubed (µg/m^3, or 0.001mg/m^3) naturally occurring in the atmosphere.

3.3.21 This water will evaporate in the combustion chamber and be discharged to atmosphere within the Project flue gases.

3.3.22 The anticipated composition of the flue gases, together with the expected physical parameters (e.g. temperature, volumetric flow rate) for the combustion of LCO is discussed in Section 5.

3.3.23 Stack emissions will be monitored for NO_x, O_2 and CO. Unlike the emissions of CO and NO_x, emissions of SO_2 directly correspond with the sulphur present in the fuel supply. Therefore, the emissions of SO_2 will be calculated from the sulphur content of the LCO (confirmed by on-site testing in accordance with the relevant international standards).

Water Treatment

3.3.24 All water required for the operation of the Project will be obtained from the Atlantic Ocean via a buried / submerged pipeline that will extend to 1.2 km distance offshore. A sea water pumphouse on the shore will be implemented to transfer water from the submerged intake to the site. The raw sea water will be treated, desalinated (reverse osmosis) and demineralized (ion exchange) on-site in dedicated water treatment plants to provide water of different purities as per the requirements of the relevant processes that will form part of the Project.

3.3.25 The demineralisation plant will consist of the following: a raw water tank, treated water (demin) storage tanks, sand filters, active carbon filters, ion exchange streams, an acid storage tank, a caustic storage tank, an automatic effluent neutralizing system, a control panel and all interconnecting pipe work. The water used for boiler make up will be treated in mixed bed units before being used in the boilers.

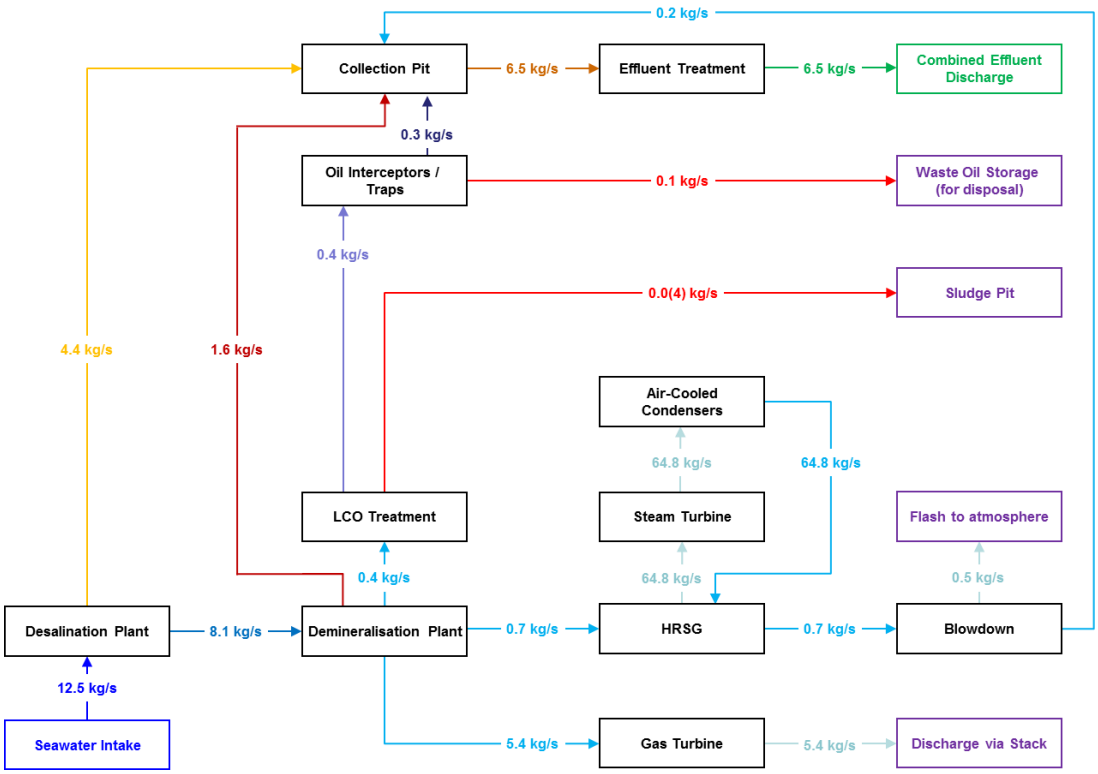
3.3.26 The treatment process to be used involves sand filters, active carbon filters prior to reverse osmosis followed by the exchanging of cations in the supply (calcium, magnesium, sodium, etc.) for hydrogen ions by using cation exchange resins and then exchanging the anions in the decationised water (sulphate, chloride, carbonate, silicate, etc.) for hydroxyl ions by using anion exchange resins. When the resins are exhausted the resin beds are backwashed, regenerated with dilute acid (for the cation resin) and with dilute caustic soda (for the anion resin), rinsed to remove any excess regenerant and returned to service.

3.3.27 The effluent from each water treatment plant will contain salts removed from the raw (feed) water, and also some additional sodium sulphate that may be produced by neutralization of the effluents (as required).

Requirements for Water

3.3.28 An indicative water balance is shown in Figure 3.4. This figure relates to the process water requirements only (i.e. no allowance is made for on-site domestic / sanitary use).

Figure 3.4: Indicative Operation Water Balance



3.3.29 Desalinated water will be used as make-up to two fire / service water storage tanks for use either as part of the fire protection system or for domestic / sanitary use on-site. Effluents from the on-site canteens, toilets, etc. will be treated in a sealed septic tank and subject to aeration and sterilisation. The treated effluent from this tank will be fed to a collection pit where it will be mixed with the (clean) surface water drainage system effluent and the treated industrial / oily water drainage effluent, prior to treatment and discharge (via pipeline approximately 600m offshore) to the Atlantic Ocean.

3.3.30 The solid waste / sludge collected within the septic tank will be removed from site for disposal by a suitable licensed contractor.

3.3.31 The principal use of demineralised water will be for injection into the combustion chamber of the gas turbine to control the emissions of NO_x (as described above). This water is of extremely high purity and is used in order to protect the gas turbine blades against corrosion and / fouling. This water will evaporate and form part of the flue gases that will be discharged to atmosphere via the stack.

3.3.32 The HRSG will generate steam from high purity (demineralised) water which is, similarly, used to protect the HRSG against internal corrosion and reductions in operational efficiency as a result of fouling / scaling of the equipment that will form the steam cycle for the Project. Although of extremely high purity, this water will still contain some dissolved solids; water quality within the water / steam circuit will be controlled by continuously purging small quantities from the system (blowdown) to prevent the excessive concentration of dissolved solids within the HRSG.

3.3.33 The blowdown will be drained to a collection pit where it will be mixed with the (clean) surface water drainage system effluent and the treated industrial / oily water drainage effluent, prior to treatment and discharge to the Atlantic Ocean.

3.3.34 Demineralised water will also be used as part of the pre-treatment of LCO prior to its introduction into the combustion chamber of the gas turbine. Due to the content of sodium and potassium, untreated LCO will be mixed with some demineralised water (to prevent the addition of these substances to the LCO) and transferred to a centrifugal separator. Oil and water are immiscible and the sodium and potassium solids will, within the separator, separate out into the demineralised water. The resultant streams will be:

a Treated LCO (that will feed the treated LCO storage tanks);

b A sludge (consisting of the separated sodium and potassium together with some of the demineralised water); and

c An effluent that will enter the site oily water drainage system.

3.3.35 The sludge will be stored on-site for removal by a suitably licensed contractor.

Miscellaneous Water Requirements

3.3.36 Other miscellaneous water uses on-site will be intermittent and principally relate to on-going or planned maintenance of the Project.

3.3.37 From time to time it will be necessary to wash the blades of the air compressor section of the gas turbines to remove debris that has penetrated the inlet air filters and become lodged on the compressor blades. This will be done at times when the performance of the gas turbines has degraded and will depend upon the air quality in the vicinity of the Project.

3.3.38 Washing can be done in two ways: by on-line washing where a fine spray of water is allowed to pass through the gas turbine; or by off-line washing where the compressor blades are rotated slowly through a detergent solution. The resultant effluent will consist of waste water containing detergent that will be discharged to a dedicated storage system with capacity sufficient for the storage of around 50 m^3 (i.e. the volume generated by approximately three such off-line washes).

3.3.39 Sludge removed in the oil / water separators will be removed by road tanker and disposed of by a suitably licensed contractor.

3.3.40 HRSG flue gas side washing is not anticipated. However, during commissioning and at infrequent intervals during the life of the Project, it will be necessary to chemically clean the water side of the HRSG tubes. These effluents will be tankered off-site by a licensed contractor for treatment and disposal at an appropriately licensed disposal facility.

3.3.41 During maintenance it may be necessary to drain down the HRSG, the closed circuit cooling water system or parts of these systems. All such drains will be discharged to the sea after treatment in the neutralisation pit. The drained water will be of a similar composition to the blowdown and will be high purity water containing traces of ammonia, phosphate and suspended solids. The closed circuit cooling water will be high purity water containing small amounts of corrosion inhibitor (probably carbohydrazide). During the detailed engineering of the Project, consideration will be given to the storage, recovery and re-use of these effluents.

Fuel / Chemical Storage

3.3.42 LCO will be provided from the single point mooring (SPM) that is currently used for deliveries of such fuel to the existing VRA Takoradi Power Plants. On-site provisions for the storage of liquid fuel (to the west of the site) will be of sufficient capacity for the Project to operate, at full load, for up to 65 days. Treated and un-treated LCO will be stored separately with capacity for 14 days and 40 days respectively.

3.3.43 Up to 2000 m^3 of distillate fuel oil (DFO) will be stored on-site, for use in the gas turbine, principally for start-up (for which LCO cannot be used) or shutdown, or for the emergency generators and diesel fire water pump(s).

3.3.44 Process chemicals anticipated for use by the Project during operation are presented in Table 3.1.

Table 3.1: Identification of Anticipated Process Chemicals

Chemical	Source	Packaging	Area of Use
Sulphuric acid	European Union	Polyethylene drums	Demineralised Water and Neutralisation System
Sodium hydroxide	European Union	Polyethylene bags	Demineralised Water and Neutralisation System
Calcium Hypochlorite	European Union	Polyethylene drums	Effluent Treatment
Sodium Carbonate	European Union	Polyethylene bags	Neutralisation System
Hydrochloric acid	European Union	Polyethylene drums	Neutralisation Sump
Sodium meta bisulphite (MBT/23)	European Union	Polyethylene bags	Desalination (Reverse Osmosis) Plant
Q 600	European Union	Polyethylene drums	Oily Waste System
Aquatreat	European Union	Polyethylene drums	Effluent Treatment Plant
Ammonia (as 25 per cent solution)	European Union	Polyethylene drums	HRSG Oxygen Scavenger
Nalco 7208 Phosphate	USA	Polyethylene drums	HRSG Anti-Scalant
Nalco Tri-act1800; NH4OH	USA	Polyethylene drums	HRSG pH Booster
Cerflux 3130	European Union	Polyethylene drums	HRSG Oxygen Scavenger
Flouroprotein Foam Concentrate	European Union	Polyethylene drums	Fire Fighting
Ultra Coolant	European Union	Polyethylene drums	Gas Turbine Cooling

3.3.45 All oil and chemical storage tanks (and areas where chemical drums are to be stored) will be surrounded by an impermeable bund. Single tanks will be within bunds sized to contain at least 110 per cent of capacity and multiple tanks or drums will be within

bunds sized to contain the greater of 110 per cent of the capacity of the largest tank or 25 per cent of the total tank (or drum) volume within that bund.

3.3.46 Permanently fixed taps, filler pipes, pumping equipment, vents and sight glasses will also be located within the bunded area. Taps and valves will be designed to discharge downwards and will be shut and locked in that position. Manually started electrically operated pumps will remove surface water collected within the bund and its composition will be verified prior to disposal. Daily visual inspection of bunded areas will be made to ensure the effectiveness of these systems.

3.3.47 Transformers will be provided for plant electrical supplies. All transformers will be oil filled and each transformer will be provided with a containment bund that will contain all the transformer oil in the event of a spillage, plus an allowance for fire water. Pumps will drain these sumps to an oil separator which in turn will discharge treated water to the site drainage system. The sumps will be installed with high level alarms to avoid overflow and will be subject to regular inspection with collected sludge removed from site for disposal by an appropriately licensed contractor; sludge will not be treated on-site.

Electrical Connection

3.3.48 As part of the Project, a new HV switchyard will be built to the east of the site. The switchyard will be an air insulated system configured to serve the electrical export / import needs of the Project with the ability to extend the switchyard in the future, if required.

3.3.49 The switchyard will provide connection for the generator transformer and the interconnector circuit to the existing 330 kV substation to the north east of the site. The potential expansion will allow for the connection for a second generator transformer that will be required should the capacity of the Project be increased in the future and either interconnection to a future third-party power plant in the vicinity of the Project or a future GRIDCo 330 kV transmission line.

Plant Auxiliaries

3.3.50 The remainder of the plant will consist of air compressing equipment, a gas pressure reduction and metering station, electrical switchgear and control equipment. Control facilities will be provided, as well firefighting services.

3.3.51 The compressed air system will be provided to compress and deliver air of a quantity and quality suitable for all general, instrument and control purposes at all appropriate points in the plant.

3.3.52 The Project will comprise of two separate compressed air systems, one for control and instrumentation and one for the operation of maintenance tools. These systems will interface with the Project control systems to enable remote start / stop, if required.

3.3.53 The Project design includes a complete stand-alone fire protection and fire detection alarm and notification system. These systems and their related subsystems are collectively referred to as the fire protection system:

a sprinkler systems;

b fixed water spray systems;

c fire protection water supply systems;

d clean agent extinguishing system;

e standpipe and hose station connections; and

f hand held portable fire extinguishers.

3.3.54 The designing, fabricating, and furnishing of the system shall be in accordance with Ghanaian National Fire Protection Association requirements and recommendations, applicable local Building and Fire Codes, and the relevant local authorities.

Operational Considerations

3.3.55 The plant will be designed with high levels of automatic operation with minimum operator intervention. Full facilities for interfacing information, control and alarm systems will be installed so that the plant can be operated from the existing central control room. The operating system will include monitoring alarms and trending information from the process monitoring systems and a continuous emissions monitoring system (for emissions to air). Any significant deviations will be alarmed and corrections carried out on occurrence. Records of performance and deviation shall be maintained.

3.3.56 In the event of a gas turbine, HRSG or steam turbine trip the plant will shut down in an orderly manner.

3.3.57 The design of buildings, enclosures and plant will also minimize regular and long term maintenance. Sufficient spares will be held on site to ensure reliable operation of the plant. Materials and finishes will be selected to meet this objective and to ensure that the appearance of the plant does not deteriorate with time. Materials and finishes for components will take into account proximity to the ocean and higher rate of corrosion.

3.3.58 Major plant maintenance shut downs will be planned on a long-term basis with intermediate stoppages being infrequent and of short duration only.

Waste

3.3.59 A feature of the gas turbine technology, on which the proposed power station is based, is that the discharges to the land are minimal and would be restricted to the following:

a used gas turbine air intake filters (typically replaced annually);

b used ion exchange resins (typically replaced at 5 year intervals);

c separated oil / sludge from oil / water separators;

d sludge from the LCO pre-treatment equipment;

e used oil or chemical containers;

f sanitary waste; and

g general office waste.

3.3.60 These wastes would be returned to the original supplier where possible or removed by an appropriate licensed contractor for disposal in an appropriate manner.

3.3.61 Disposal of all such solid wastes will be carried out under a service agreement between the Project, the VRA Takoradi Power Plants and the Shama District Assembly Waste Management Department.

3.3.62 A hazardous waste disposal agreement will be signed with the Shama District Assembly and all such disposals will be monitored by AEL.

3.4 Safety and Emergency Provisions

3.4.1 The hazards associated with combined cycle gas turbines have been studied over many years and a considerable volume of design and procedural experience has built up in this area.

3.4.2 The design of the Project will incorporate all the features needed to comply with relevant safety regulations.

3.4.3 Fire detection and protection systems will be provided throughout the plant and site area. These will include fixed water and foam protection systems, fire alarms, portable appliances, etc.

3.4.4 A comprehensive fire protection system will be installed to cover equipment on site, which could constitute a significant fire risk. For the protection of equipment within the gas turbine package, where water or foam spray would cause damage, a total flood carbon dioxide system will be used. An automatic foam spray system for the protection of the oil storage tanks, turbine lubricating oil tank, fuel handling areas and associated pipe work will also be provided. Heat sensors or smoke detectors will be used in conjunction with automatic spray nozzles. Non-combustible and fire resistant building materials will be utilized. Venting systems will be designed to prevent explosion of air / gas accumulations. Ignition sources will be protected from damage. Testing of fire protection systems will be carried out as appropriate, in accordance with documented manufacturer procedures.

3.4.5 The plant will employ the standard mechanical and electrical protective devices, including emergency relief valves, shut down sequence controls, safety interlocks, fault detection and alarm systems. There will be back up systems and protective measures to deal with emergency situations such as electrical power failure, water supply failure, compressed air failure, major equipment failure and lightning strikes.

3.4.6 There will be no drains within the bunds and all valves and couplings will be within the bunded areas. In the event of leakage or spillage from any oil storage tank any oil will be contained within the bund surrounding the tank. Any oil found in the bund will be removed for disposal by a suitably licensed contractor.

3.4.7 An oil spill or chemical spill is recognized as being one of the principal environmental emergencies that could arise at the Project. Emergency response plans will be developed by the contractor during the detailed design on the plant as follows for both construction and operation periods, including:

a Chemical-specific emergency procedures for all storage, based on the specific risks identified by the material safety data sheet (MSDS);

b Emergency procedures in the event of a spill of fuel oil or lubricating oil; and

c Completion of Oil Spill Reporting Form.

3.5 Ancillary Development

3.5.1 As previously discussed, the Project will see the construction of four key elements which extend outside of the main site boundary and are considered as development ancillary but necessary to its successful implementation:

a LCO supply pipeline;

b Raw water intake / effluent discharge pipework;

c Site access road; and

d High voltage overhead connection to the existing GRIDCo substation.

3.5.2 The LCO pipeline, intake/effluent discharge pipeline and access road will be developed by AEL and are considered part of the Project. The overhead transmission line will be built, owned and operated by GRIDCo.

LCO Supply

3.5.3 LCO is currently delivered by ship tanker to the existing VRA Takoradi Power Plants via an SPM located approximately 4.5 km offshore. The SPM is owned by VRA.

3.5.4 AEL has agreed with VRA that LCO deliveries for the Project will be unloaded at the SPM and forwarded to the site via a new dedicated LCO pipeline. The pipeline will be approximately 1.7 km in length. The pipeline will be routed along the southern border of the existing VRA Takoradi Power Plant site and then continue alongside the access road to the Project site. As discussed above, the LCO will be stored to the west of the site.

3.5.5 AEL has obtained the necessary authorisations to run the pipeline through the land between the site and the SPM.

3.5.6 Backup fuel supply routes in the event that the SPM is down are being considered. The most likely option is road tanker DFO supply from Port of Takoradi (approximately 22 km from the site) or from the nearby fuel supplier terminal.

Water Abstraction / Discharge Infrastructure

3.5.7 All water required for the Project will be obtained from the Atlantic Ocean via a buried / submerged pipeline (of approximately 500 mm diameter) that will extend approximately 1.2 km offshore (see Figure 3.1 & Figure 3.5). A sea water pumphouse on the shore will be implemented to transfer water from the submerged intake to the site.

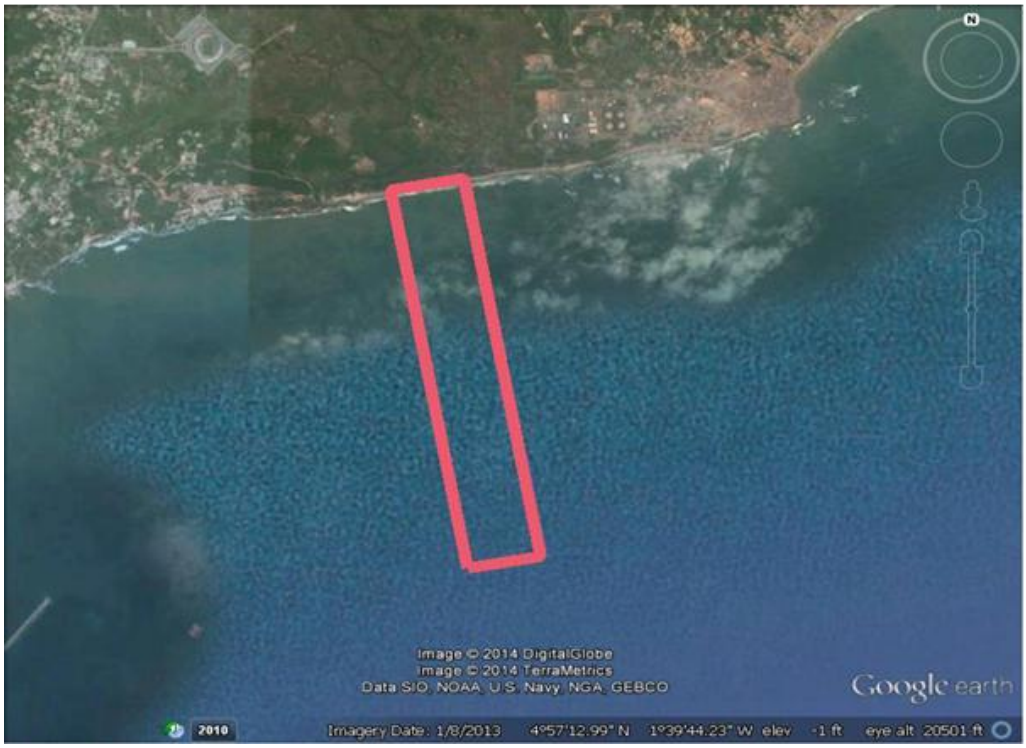
3.5.8 The submerged pipeline will be laid in an excavated channel up to 2.5 m below the sea bed; the overall extent of the pit will be approximately 35-40 m square. The pipeline will be fixed with concrete weights at regular intervals in order to secure the route of the pipeline during construction. Bedding material consisting of a well graded sand and gravel mix will be laid around the pipeline and topped with additional articulated concrete blocks to provide protection from bed scour. The channel with then be backfilled either with suitable dredged material or additional sand / gravel.

3.5.9 The intake structure itself will be constructed from reinforced concrete on a foundation of crushed stone, with glass reinforced plastic meshed screens providing protection against the entrapment of marine wildlife. The mesh size will seek to limit the intake velocity of the water to less than 0.2 m / s to prevent fish entrainment on the screens.

3.5.10 The final discharge location will be located approximately 600 m offshore, discharging the combined Project effluent to the Atlantic Ocean. The discharge pipeline is anticipated to be of a similar construction to the intake pipeline and will be laid along the same route; AEL is currently processing the permit from the Ghana Maritime

Authority. The discharge infrastructure may include diffusers to accelerate the mixing of the combined Project effluent with the receiving sea water.

Figure 3.5 – Bathymetric Survey Area for proposed pipelines



Site Access Road

3.5.11 An access road currently exists from the highway to the VRA Takoradi Power Plants, which will be extended by 2 km to provide access to the south of the Project site. Part of this route is already used as a construction road for current works to the VRA Plants. The remainder is currently an access track along the coast.

3.5.12 The road will be utilised for permanent access as well as for the movement of vehicles during construction and will be constructed of material suitable for the intended use of the movement of large construction vehicles.

3.5.13 The access road route will run to the north of the beach to the south of the site (see Figure 3.1).

Overhead Transmission Line

3.5.14 Export of electricity from the power plant will be via two sets of new overhead lines, totalling approximately 1.3km in length. This will be achieved by diversion of the existing 330 kV lines coming from Tema in the East via the new AEL switchyard, requiring a 600 m set of new lines and then connecting into the existing 330 kV VRA Takoradi substation to the north east of the proposed HV switchyard, requiring a 700 m set of new lines. This connection is under the remit of GRIDCo and is not part of the AEL Project.

3.6 Project Alternatives

3.6.1 The Project site is largely dictated by the source of fuel (LCO) currently delivered by ship tanker to the existing VRA Takoradi Power Plants via the SPM (located approximately 4.5 km offshore). It is also dependent on the potential for future supply of gas from the Jubilee Fields via the West African Gas Pipeline (WAGP) which supplies the VRA Takoradi Power Plants, in addition to GRIDCo connection to the existing sub-station at the Takoradi Plants.

3.6.2 In designing the site layout, a number of considerations were taken into account:

- A large portion of the western side of the plant site is currently unusable owing to the River Anankwari cutting through this area. As a result, the Project site layout was designed to factor in the 20m buffer between the river and the site boundary;
- An existing small stream which accommodates the drainage outfall from the VRA Takoradi Power Plant also runs directly across the site. This stream will need to be diverted to accommodate the plant;
- The marshy ground conditions and risk of flooding from the river suggest a cut and fill operation will be required to raise the plant grade level by approximately 4m (in line with the VRA Takoradi Power Plants); and
- There is an existing access road from the highway to the VRA Takoradi Power Plants which AEL will extend approximately 2 km to provide access to the AEL site. This road will be utilised for permanent access as well as for the movement of vehicles during construction.

3.7 Phases of Plant Development

3.7.1 The following sections provide an overview of the processes which will be followed to construct and operate the plant.

<u>Construction</u>

3.7.2 Studies examining soil composition and contamination (pre-construction contaminated land survey) will be undertaken by the construction contractors, using the results of site investigations carried out during the development phase of the Project as a starting point.

3.7.3 Excavations will be required to construct foundations, culverts, buried services and basement structures. Excavation activities create the potential risk of disturbing and hence releasing contaminants into the surrounding environment. Current studies suggest that there may be some level of contamination encountered beneath the surface of the site, however it is currently considered unlikely to be significant and is possibly naturally occurring; further discussion is provided in Section 10.

3.7.4 In addition it will be necessary to undertake piling for some of the foundations where the heavier plant equipment will be located.

3.7.5 The major activities during the construction phase of the Project will include, for the civil works:

a preparation of site works;

b construction of foundations; and

c construction of buildings.

3.7.6 Site preparation work will comprise the levelling and / or raising of the site, earthworks, and the excavations for foundations. Trenching, installation of underground services and provision of temporary construction facilities and services will then take place.

3.7.7 It is likely that piling will be required for the HRSG, gas turbine, steam turbine, and generator foundations due to the heavy loading and the tight tolerance on settlement. The remaining foundations, for the turbine building, skids, pumps, water treatment package and the like, are likely to be spread footings and slabs of various thickness to suit the structural needs.

3.7.8 Three potential areas for the laydown and storage of plant and equipment have been identified within the site boundary and will be used, as appropriate, for the duration of the construction period (labelled Phase 2 Development in Figure 3.1). These areas will be available for any fabrication that may be necessary during the construction works. An area will also be set aside for car parking and office accommodation. These areas are identified as the areas of the site that would be developed should the Project be extended in the future therefore, whilst they are likely to be cleared, it is not intended to reinstate these areas (e.g. hardstanding or similar would help to restrict potential pathways for ground contamination that would require remediation should the Project be extended later).

3.7.9 At the peak of construction, approximately 50 heavy goods vehicles per day may travel to and from the construction site.

3.7.10 The programme for the mechanical and electrical plant can be considered in terms of the following activities:

a steam turbine and HRSG manufacture;

b gas turbine manufacture;

c gas turbine plant installation;

d gas turbine plant commissioning;

e HRSG installation;

f HRSG commissioning;

g plant take-over;

h power plant commercial operation; and

i guarantee period.

3.7.11 The total construction workforce for all components of the Project (i.e. plant and ancillary development) will likely peak at about 700, with an average of 300–350. It is anticipates that the workforce will primarily be sourced from the local area, however specialist expertise may come from further afield; it is envisaged that approximately 10 per cent of the workforce will comprise of expatriate workers. There will be no on-site accommodation for workers.

3.7.12 Construction of the ancillary structures (LCO pipeline, discharge and intake water pipeline, and road) will begin with the construction of the access road, which will facilitate the construction of the mechanical and electrical plant described above. The rest of the ancillary structures will be constructed during the construction period for the rest of the mechanical and electrical plant.

3.7.13 The overhead transmission line will be constructed by GRIDCo, and it is expected that this will be undertaken at the same time as the main plant.

3.7.14 The construction period will be approximately 27.5 months duration, including commissioning.

3.7.15 Commissioning of the gas turbine unit will take of the order of 16 weeks and will be progressive from final erection checks, pre-commissioning and setting to work of individual component parts through to the overall testing to prove the technical acceptance of the plant. Tests on completion will demonstrate the fitness for purpose of the plant prior to commercial operation. Performance tests will demonstrate that the plant complies with the performance guarantees. Reliability will be demonstrated by operating the plant under commercial conditions for a period without major repair to any item of plant or equipment.

3.7.16 Construction of the new plant is expected to commence in the third quarter of 2015. The target date for operation is late 2017.

Operation

3.7.17 It is expected that for the majority of its life, the plant will operate in various running modes including full load (operation at the maximum continuous rating) and cycling (flexible operation at a variety of different generation loads in response to requests from the transmission network operator).

3.7.18 The plant will occasionally be shut down for essential maintenance and statutory inspections. Minor outages (of the order of 2 to 4 weeks) are expected to occur every year. Major outages (of the order of 6 weeks) are expected to occur every four years in the following sequence: minor outage 2 weeks, minor outage 4 weeks, minor outage 2 weeks, major outage 6 weeks etc. It should be noted that major outages will be planned on a long term basis, with intermediate stoppages being infrequent and of short duration only.

3.7.19 Miscellaneous materials such as oils, greases, cleaning substances and materials, laboratory chemicals etc., will be stored in appropriately bunded and secure areas within the on-site stores.

3.7.20 Lubricating oils will be supplied to the gas and steam turbine equipment and generator bearings and will also be supplied for the turbine control and hydraulic oil systems. The lubricating oils will be stored within tanks in an impermeable bund sized to contain 110 per cent of the contents of each tank. Used lubricating oils will also be stored on the site for re-use or will be disposed of, off-site, by an approved and licensed contractor in accordance with applicable regulations.

3.7.21 Transformers will be provided on site to allow the plant to be connected to the wider national grid. All transformers will be oil filled and each transformer will be provided with a containment bund that will be capable of containing 110 per cent of the oil content of the transformer.

3.7.22 Pumps will drain the areas used for the storage of oil to an oil separator which in turn will discharge to the site drainage system. The sumps will be installed with high level alarms to avoid overflow.

3.7.23 A water treatment plant will be installed on-site to treat raw river or mains water to the appropriate quality for use within the Project. A demineralised water storage tank will

be provided on-site to provide virtually pure water for the HRSG. The demineralised water for this tank will be supplied from the water treatment plant.

3.7.24 A compressed air system will be provided to compress and deliver air of a quantity and quality suitable for all general, instrument and control purposes at all appropriate points in the Project.

3.7.25 Storage facilities will also be provided for the small quantities of sodium phosphate, oxygen scavenger, ammonia and other chemicals used in boiler water dosing and water treatment. All such chemicals will be retained in suitable containment areas on the site. All chemicals and dosing systems will be shielded from the atmosphere. Air discharged from the ammonia and other process dosing chemicals will pass through a device such as a common water seal and an active carbon filter, where appropriate, in order to avoid the uncontrolled release of these chemicals to the atmosphere.

3.7.26 There will be appropriate means of drainage within the various storage bunds and all valves and couplings will be within the bunded area. In the event of leakage or spillage from any oil storage tank any oil will be contained within the bund surrounding the tank. Any oil found in a bund will be removed and disposed of by a suitably licensed contractor.

3.7.27 Sufficient spares will be held on-site to ensure reliable operation of the Project. The design of buildings, enclosures and equipment will also minimise regular and long term maintenance. Materials and finishes will be selected to meet this objective and to ensure that the appearance of the Project does not deteriorate materially over its operating lifetime.

3.7.28 The Project will require 30- 40 on-site staff at any one time, with between 60 – 80 staff, in total, employed during operations. The bulk of the operational workforce will be subject to a shift system; administrative roles for the Project will be subject to normal office hours.

3.7.29 The overhead transmission line will be owned and operated by GRIDCc and its inspection and maintenance will be the responsibility of this third party. As for the ancillary developments which are the responsibility of AEL (namely the LCO pipeline, discharge and water intake pipelines, and access roads), this will be designed to the relative maintenance free and the operational work would likely be limited to visual inspections.

3.7.30 The target date for operation of the Project is late 2017. The operational life time of the Project will be of the order of 30 years.

Decommissioning

3.7.31 At the end of the useful life of the Project the plant will be decommissioned in accordance with legislative guidelines current at that time. Alternatively, if market conditions and / or electricity supply constraints at that time indicate that it would be appropriate to extend the life of the Project, then decommissioning may be deferred to a later date. In order to ensure continuing adequate condition and environmental performance, the Project would be re-engineered and re-permitted as required, dependent on the legislative requirements at that time.

3.7.32 Independently validated plant closure / demolition methodologies have been developed for power plants that are at the end of their useful life. The methodologies cover demolition of the equipment and buildings and removal of any contaminated

and hazardous material from the site. When demolishing the Project, it will be a matter of policy to ensure that the site is left with no environmental risks.

3.7.33 In order to facilitate decommissioning much of the plant on site will be made of materials suitable for recycling. In addition a large proportion of the buildings will be constructed of pre-fabricated steel and will therefore also be of interest to a scrap metal merchant. After the removal of the main items of plant and steel buildings the remaining buildings will be demolished to ground level. All underground structures will either be removed or made safe. All debris to be removed offsite will be sent to a licensed disposal facility.

3.7.34 The results of the pre-construction contaminated land survey will be used as a basis for a further contaminated land survey to be performed when the plant is closed to assess whether or not any contamination of the site has taken place during the lifetime of the plant. The site will be returned to a condition suitable for reuse.

3.7.35 During decommissioning all reasonable measures required to prevent any future pollution of the site will be carried out. This will include measures such as:

a the emptying / cleaning and removal of storage tanks; and

b the removal from site of all materials / liquids liable to cause contamination.

3.7.36 The surface water drainage system for plant will continue to operate through the decommissioning phase. Any areas where oil spillage could occur will continue to drain to an oil interceptor, which will continue to be maintained.

3.7.37 The decommissioning phase is likely to take place over several months.

3.7.38 The site's subsequent use would be discussed with the relevant authorities as part of the decommissioning process.

SECTION 4

ESIA METHODOLOGY

4 ESIA METHODOLOGY

4.1 Introduction

4.1.1 This Section outlines the methodology that the ESIA has used to determine the potential impacts and (as appropriate) mitigation measures for the Project.

4.2 Scoping and Licencing Process

4.2.1 The ESIA was preceded in 2013 by an ESIA Scoping and Terms of Reference stage, in accordance with EIA Regulations. AEL commissioned an ESIA that focussed on the key issues, concerns and decision areas of all relevant stakeholders that were identified during the ESIA scoping process.

4.2.2 The results of the original ESIA were presented in an Environmental and Social Impact Statement, of which a draft was submitted to the EPA in April 2014. Following a review by the EPA, AEL received comments on the draft document in June 2014. AEL and its consultants undertook the relevant amendments based on the comments of the EPA and submitted the Revised Environmental and Social Impact Statement. In July 2014, the EPA confirmed that the revised document was satisfactory and an Environmental Permit was issued.

4.2.3 An addendum to the EPA approved ESIA, containing the updated information supplemented in this report, will be submitted to EPA in due course. This document represents the consolidated updated ESIA.

4.3 Study Area

4.3.1 The general study area for the Project is shown in Figure 4.1, as well as the ancillary development which extend beyond the plant site. Where this is the case, it is described within the individual environmental sections later in this document.

4.4 Environmental and Social Baseline

4.4.1 The ESIA provides a description of the Project site and the surrounding environment including specifying any information necessary to identify and assess the environmental and social effects of the Project.

4.4.2 Baseline data collection used a combination of desk-based sources and surveys, depending on the topic.

4.5 Impact Identification and Characterisation

4.5.1 For each environmental and social topic, impacts will be identified and characterised.

4.5.2 Impacts can be defined as a physical or measurable change in the environment which results from the Project. Impacts for the purposes of the ESIA are defined as set out in Table 4.1.

Table 4.1: Definition of Potential Impact Types

Term	Definition
Beneficial / Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Adverse / Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Direct	Impacts that arise directly from activities that form an integral part of the Project (e.g. new infrastructure).
Indirect	Impacts that arise indirectly from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road traffic resulting from the operation of Project).
Secondary	Secondary or induced impacts caused by a change in the Project environment (e.g. employment opportunities created by the supply chain requirements).
Cumulative	Impacts arising from the combination of multiple impacts from existing projects, the Project and / or future projects.
Transboundary	Impacts that extend to multiple countries, but are not global in nature (e.g. air pollution extending to neighbour countries and use or pollution of international waterways).
Global	Impacts that, when taken together with impacts created by other human activities, can become nationally, regionally or globally significant.

4.5.3 Further information on some of these definitions is given below.

4.5.4 A number of the potential effects identified as arising from the Project are likely to cut across the topic areas identified, either intrinsically or in terms of secondary or indirect impacts.

Cumulative Impacts

4.5.5 The IFC PS 1: Social and Environmental Assessment and its Guidance Note, define cumulative impacts as “the combination of multiple impacts from existing projects, the Project, and / or anticipated future projects may result in significant adverse and / or beneficial impacts that would not be expected in case of a stand-alone project”. This guidance will be applied during the assessment of cumulative impacts.

4.5.6 The Equator Principles Exhibit II also states that the Social and Environmental Assessment need to address cumulative impacts of existing projects, the Project and future projects.

4.5.7 The ESIA considers cumulative impacts of the Project from existing and proposed developments. These are presented in the Cumulative Impacts sub-section of each topic chapter.

Transboundary Impacts

4.5.8 Transboundary impacts are defined by the IFC PS 1 as impacts that extend to multiple countries, but are not global in nature. It is not anticipated that the Project will give rise to any transboundary impacts.

Global Impacts

4.5.9 IFC PS 1 identifies that while individual project impacts on climate change, ozone layer, biodiversity or similar environmental issues may not be significant, when taken together with impacts created by other human activities, they can become nationally, regionally or globally significant.

4.5.10 An assessment of the global warming potential of the Project is included in Section 5 of this document. No other potential impact from the Project is considered to represent a 'global impact'.

4.6 Assessment of Impacts and Identification of Significant Effects

4.6.1 For each of the baseline topics covered, the significance of potential impacts will be assessed.

4.6.2 The determination and assessment of impacts will be based on the following criteria:

a Magnitude: to what extent environmental resources are going to be affected;

b Extent: how much area will be adversely or positively affected by the project;

c Significance: what value in terms of costs and benefits does society place on the resources and the different impacts affecting the resource(s); and

d Special sensitivity: which impacts are significant in the specific local economic, social and ecological setting.

4.6.3 Following international best practice, significant effects will be determined by consideration of the following:

a Sensitivity of the resource or receptor (rated as high, medium and low) by considering the importance of the receiving environment (international, national, regional, district and local), rarity of the receiving environment, benefits or services provided by the environmental resources and perception of the resource or receptor); and

b Severity of the impact, measured by the importance of the consequences of change (high, medium, low, negligible) by considering inter alia magnitude, duration, intensity, likelihood, frequency and reversibility of the change.

4.6.4 The following criteria are used to determine the sensitivity of the receptor / resource and severity of the impact. It should be noted that the definitions given are for guidance only, and not all the definitions will apply to all of the environmental/social receptors and resources being assessed. Therefore, the assessment will be further justified within each topic, referring to those tables where definitions are applicable.

Table 4.2: Determination of Receptor Sensitivity

	High	Medium	Low
Guideline definitions	Receptor is rare, legally protected, of international or national designation. Population rely on resource for health, subsistence or livelihood, or receptor is of high cultural value. Human receptors – vulnerable groups, Project Affected People (PAPs).	Receptor is of regional importance. Resource may benefit the local population, but they do not rely on it for health, subsistence or livelihood. Receptor is of some cultural value.	Receptor is common, or of local importance. Resource is not used or is of no value to the population.

Table 4.3: Determination of Impact Severity

	High	Medium	Low	Very low
Guideline definitions	Effect is trans-boundary or national. Effect exceeds a national or international standard, >75 per cent of receptor / resource is affected. Effect is long-term (>10 yrs), permanent and irreversible.	Effect is regional, 25-75 per cent of a receptor/ resource is affected. Effect is medium term (2-10 yrs) and reversible.	Effect is local, 10-25 per cent of a receptor/ resource is affected. Effect is short term (<2 yrs) and reversible.	Effect is too small to be measured. <10 per cent of a receptor/ resource is affected. Effect is confined to construction period, or is intermittent.

4.6.5 The sensitivity of the receptor and the severity of the effect are used to determine the significance of the impact. The determination of impact significance, for both positive and negative effects is set out in Table 4.4 below.

Table 4.4: Illustrative Determination of Significance Criteria

Effect		RECEPTOR/ RESOURCE SENSITIVITY		
		High	**Medium**	**Low**
IMPACT SEVERITY	High	Major	Major	Moderate
	Medium	Major	Moderate	Minor
	Low	Moderate	Minor	Minor
	Very low	Minor	Insignificant	Insignificant
	No change	None	None	None

4.7 Cumulative Effects

4.7.1 The AEL Project is one of a number of IPP projects being developed in this area, so there is potential for a number of cumulative effects.

4.7.2 The programme for the development of the AEL Project is ahead of the other plants. Although some limited information has been obtained for other plants, in most cases, there is currently no ESIA information on which to base cumulative effects. Therefore the following assumptions have been made:

- Impacts on receptors and their magnitude will be similar to those predicted for AEL.
- It assumed that similar mitigation and compensation will be required through Ghanaian National Legislation and international/IFC requirements.
- The programme for development of other power plants has been set out to the best available knowledge at the time of writing. In some cases a precautionary principal has been applied, e.g. overlap of construction periods so that a worst case scenario can be assessed.

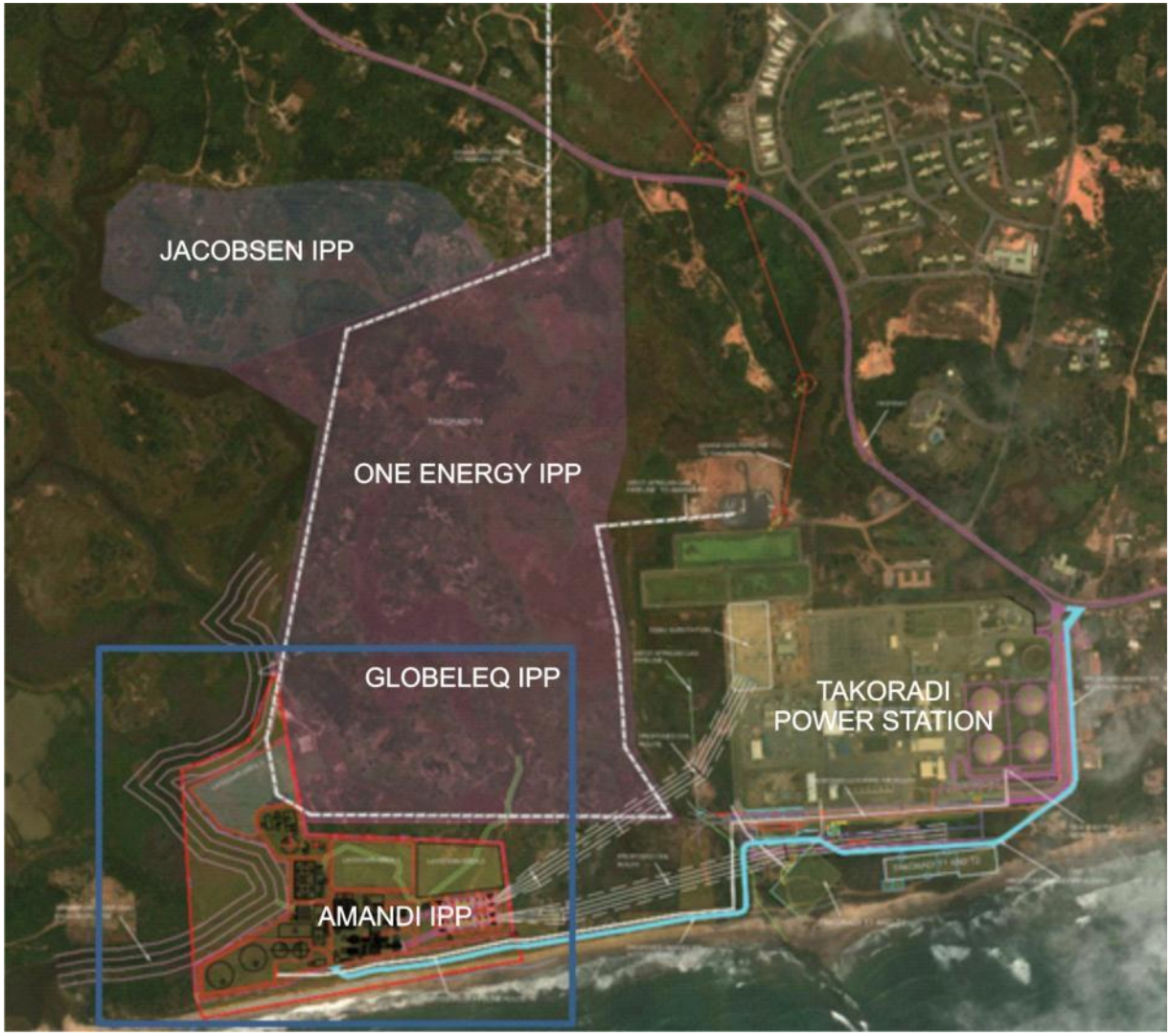
4.7.3 The impacts assessed are also largely qualitative in nature rather than quantitative, due to the lack of raw data from other developments at this stage. It is acknowledged that there is some uncertainty associated with cumulative effects assessment, however it does ensure that cumulative effects are captured as part of the ESIA process.

4.7.4 A cumulative impact assessment has been undertaken within each topic chapter and covers two aspects:

1) Total effects – this is the total effect of the AEL Project with all the other IPP development. This approach ensures that the total impact of the development of all the plants.

2) Additional effects – this is the contribution the AEL Project alone will make to the total effects above.

Figure 4.1 Other Development at the Takoradi Power Enclave



4.8 Other Proposed Developments in the Vicinity of the Project

VRA T4

4.8.1 At present there are three power stations in operation within the enclave - T1, T2 and T3 (collectively the existing VRA Takoradi Power Plants) - which are all located to the east of the AEL Project site.

4.8.2 VRA advises that the T4 plant will be an LCO-fired CCGT power plant, consisting of one gas turbine, HRSG and steam turbine. It will have an electrical generating capacity equivalent to the Project (i.e. c.190 MW).

4.8.3 The T4 site is approximately 1.8ha and is to be located to the immediate east of the existing T3 plant, approximately 400 m from the Project site (and north east of the T1 and T2 complex). As per the existing VRA Takoradi Power Plants, T4 will be owned and operated by VRA.

4.8.4 The gas turbine unit will be capable of dual-fuel operation (natural gas / LCO) with LCO delivered to site via the shared SPM (that will also be source of the LCO for the Project).

4.8.5 It is understood that the T4 condenser system will utilise wet-based from a newly built mechanical draft cooling tower. Makeup water for the cooling tower will be sea water from the existing seawater intake for the VRA Takoradi Power Plants.

4.8.6 It is also understood that electricity will exported from T4 by the extension of the existing 161 kV substation that serves T3.

4.8.7 The project is in the process of looking for financing; construction has been estimated to commence in June 2015. T4 is assumed to be operational in January 2018.

Globeleq IPP

4.8.8 The Globeleq project is in the early stages of development of a new power plant with a proposed generating capacity of approximately 400 MW. A site of approximately 25 acres of undeveloped land has been allocated 200 m north of the AEL Project site.

4.8.9 Globeleq is understood to be in the ‘project definition’ phase and therefore the technology to be utilised is not confirmed. However, it is reasonable to assume (as per other proposed development) that the technology selection will come down to reciprocating engines (as per the Jacobsen IPP) or CCGT (as per the remainder of the identified projects).

4.8.10 From an emissions perspective, CCGT is ‘cleaner’ than the use of engines and, given the potential for high cumulative impacts, it is considered that CCGT is likely to be the preferred option for Globeleq.

4.8.11 The assumed programme for development is construction to begin in September 2016, with completion in 2019.

One Energy IPP

4.8.12 The One Energy project, also known as “Ghana 1000”, is for a CCGT power plant with a total anticipated electrical generating capacity of up to 1,000 MW, to be located 450 m north of the Project site.

4.8.13 It will be built done in phases. Phase 1 is 125 MW to start construction next year. Then after one year, another 125; and after another year, another 250; the next 250 MW will be added a few years later. One Energy is currently looking to finance no more than 750 MW.

4.8.14 It will fire on liquid natural gas (LNG) as its main fuel. The LNG will be sourced from a floating storage regasification unit moored at an offshore location close to Aboadze / Takoradi.

4.8.15 It is understood that One Energy will also be capable of firing on LCO, as a backup to the principal LNG fuel. It will incorporate LCO storage facilities suitable for the storage of LCO sufficient for operation of the project for up to 30 days.

4.8.16 The site covers approximately 30ha and it is assumed construction will commence in Spring/Summer 2016 and be complete by the end of 2018. The first gas turbine is expected to commence open cycle generation in Autumn 2016 and with additional generators coming online in Summer/ Autumn 2017. Combined cycle generation will commence in Autumn/ Winter 2018.

Jacobsen IPP

4.8.17 The Jacobsen IPP project is expected to consist of up to 20 dual-fuel reciprocating engines (each with associated heat recovery boilers) and a steam turbine.

4.8.18 The plant is proposed with a nominal generating capacity of 360 MW by Jacobsen Elektro Limited, who will own and operate the project.

4.8.19 The Jacobsen IPP will be located approximately 1 km to the north of AEL's Project site.

4.8.20 The proposed engines will be capable of dual-fuel operation however the route of the LCO supply pipeline is not currently known. It is, however expected that the plant will share the usage of the existing SPM.

4.8.21 Power will be evacuated from the plant from a new 330 kV substation within the boundary of the Jacobsen IPP. Details of the substation arrangement and connection to the new 330 kV lines are currently not known.

4.8.22 The site is approximately 19ha and for the purposes of the cumulative effects assessment it is assumed that the construction period will be the same as the T4 project. The actual programme for the delivery of this project is unknown at this time.

Other Development

4.8.23 Due to the development of this power enclave in the Project vicinity, it is anticipated that there will be a range of associated development. This includes the proposed site for Abengoa Water on the north part of AEL site. Abengoa Water is running the feasibility studies for a BOO desalination plant that could provide fresh water to meet the enclave's water needs. All Services Group (ASG) is also proposing a 191 MW CCGT power plant (to be located 1.5 km to the north of the site; however it is in the very early stages of concept/design. There is also a proposal for a gas storage site, JACHFAM, 400m to the northeast of the AEL site; however again it is a very early concept phase and land has not been secured. Consequently, these projects have not been factored in to the cumulative impacts.

4.9 Mitigation and Enhancement Measures

4.9.1 For any significant negative impacts identified as a result of the Project, mitigation measures are proposed to ensure compliance with applicable Ghanaian acts and regulations, and meet the requirements of international standards, including the IFC PS 1 through 8. Mitigation is considered under the following classifications:

- Avoidance – avoiding environmental damage at source through design;
- Minimise – lessening the severity of an impact which cannot be avoided entirely;
- Mitigation and compensation – acknowledges that some negative consequences will stem from development, but provides means by which the conditions can be compensated for or improved; and
- Enhancement – increasing the effects of positive impacts.

4.10 Environmental and Social Management System

4.10.1 AEL has commenced developing an Environmental and Social Management System (ESMS). An ESMS comprises of an assessment of the environmental and social impacts, policies, an Environmental and Social Management Plan (ESMP) and specific management plans (as required). AEL has developed an ESMP (presented in Appendix X), which will provide a framework from which the contractor will be tasked with producing a site-specific Contractor Environmental and Social Management Plan (CESMP) for their work.

4.10.2 AEL is committed to the principle of sustainability with regard to its management of the environment and the highest social, health and safety standards. AEL believes that workplace injuries and occupational diseases are preventable through good planning, careful oversight, training and staff responsibility in carrying out work in a safe manner. Notable issues such as job hazards, fire prevention, evacuation plans, emergency preparedness plans and health of employees as well as providing up to the task safety training for all staff will be included in the management system.

4.10.3 Four key elements guide the ESMS development and implementation and assist staff to achieve continual improvement in environmental performance as outlined below:

a Environmental, Social, Health and Safety Planning

b Checking and Corrective

c Management Review and

d Implementation and Operation.

4.10.4 The ESMS elements are cyclic in nature in the sense that the outcomes from the implementation and operation culminate in a continual review to further improve efficiency.

4.10.5 The ESMP will comply with IFC PS 1: Social and Environmental Assessment and Management Systems and Equator Principle 4: Action Plan and Management System, with full accordance required by AEL in the CESMP that will be developed by the construction contractor.

4.10.6 The ESMP will also consider the operational environmental and health risks and hazards of the Project. An operations ESMP will be developed by AEL or its designated contractor in accordance with the principles and measures provided in the

ESMP ahead of operations commencing. A decommission plan will also be drafted ahead of any decommissioning activities to the satisfaction of AEL.

4.11 Public Participation, Consultation and Disclosure

4.11.1 Public participation is an opportunity to present the baseline study, the identification of the potential impacts identified and importantly the mitigation measures.

4.11.2 Public participation and stakeholder engagement requirements will follow the IFC Good Practice Manual Doing Better Business through Effective Public Consultation and Disclosure (1998).

4.11.3 A Stakeholder Engagement Plan (SEP) has been prepared to record the methodology and outcomes of both the ESIA and wider project stakeholder engagement process. It will also set out proposals for future stakeholder engagement and participatory methods for communication and feedback.

4.12 Subsequent Structure of this Document

4.12.1 A full description of the Project, including background details on the proposed site and its surroundings, are provided in Section 3. The range of potential impacts assessed as part of the ESIA and presented in this document, is:

- Air Quality
- Noise and Vibration
- Water Quality and Resources
- Ecology
- Socio-Economics
- Soils and Geology
- Waste.

4.12.2 Further details on specific aspects of the Project, as well as the cumulative impacts, are included in the respective Sections of this document, as relevant and as required.

<u>Presentation of the Impact Assessment</u>

4.12.3 Sections 5 to 10 of this document assess the likely direct impacts associated with the development of the Project. Each Section has been broken down to include a number of sub-sections. These are:

- Introduction

  This sub-section will provide details of the key issues with regard to the specific environmental impacts being considered.

- Assessment Methodology

  This sub-section will provide details of the assessment methodology adopted for the purposes of the ESIA. The assessment methodology chosen reflects the relevant guidelines and legislative standards. In addition, significance criteria used to quantify the extent of the environmental impact of the Project are identified and related to the generic criteria set out above.

- Existing Environment

This sub-section will identify the study area for each specific impact topic and will describe and discuss the environmental baseline conditions, and provide, as appropriate, justification for the selection of receptors to be considered within the analysis of the impact of the Project.

- Environmental Impact

  This sub-section will discuss the findings of the ESIA studies, and will take into consideration the potential construction / operation timeline for the Project. Where relevant it will also address decommissioning. In undertaking these assessments, quantitative and qualitative evaluations are applied, in varying degrees, depending on the nature of the environmental impact being assessed. The significance of the environmental impacts identified is addressed as appropriate with reference to the established significance criteria.

- Mitigation

  This sub-section will provide details of the emerging mitigation measures that are proposed to ensure that any potential adverse environmental impacts are either minimised or, wherever possible, avoided altogether. Where relevant, monitoring may be identified to allow it to be demonstrated that the mitigation measures employed are effective.

- Residual Impacts

  This sub-section discusses the potential environmental impact of the Project following the successful implementation of the mitigation / management techniques considered appropriate and outlined above.

- Cumulative Impacts

  This sub-section will identify the potential for impacts, as relevant to the respective environmental aspect being considered, between the construction, operation and decommissioning of the Project in conjunction with the relevant phases of other identified ancillary development. Where specific details of proposed mitigation for other projects are not available, assumptions will be made in line with industry standards / best practice measures.

  Where the potential for cumulative impacts is identified, the methodology outlined for assessment of the Project in isolation will be applied to all relevant projects in order to determine the potential cumulative impact.

- Impact Summary

  The impacts and mitigation are summarised according to the methodology described above and presented in impact summary tables.

4.12.4 Section 11 considers the environmental issues regarding waste generated by the Project. This Section outlines the overall approach to the handling, storage and disposal of wastes that will be adopted by AEL. This section also assesses the cumulative impacts and provides an impact summary.

4.12.5 Section 12 provides a summary and the conclusion of the ESIA.

SECTION 5

AIR QUALITY

5 AIR QUALITY

5.1 Introduction

5.1.1 This Section addresses the specific effects upon air quality that may result from the implementation and operation of the works proposed for the Project.

5.1.2 The construction, operation and demolition of the Project all have the potential to impact on local air quality. During construction and decommissioning, all elements of the Project have the potential to generate air emissions and thus impact on local air quality and therefore have been assessed within the ESIA. During operation, the potentially significant emissions sources will be limited to the power generating plant and, in particular, the Project stack.

Table 5.1: Potential Air Quality Impacts

Source	Potential Pollutant(s)	Pathway(s)	Receptor(s)
Construction / Decommissioning			
On-site civil works	Dust	Wind blow across the construction / demolition site carrying airborne particulate matter	Neighbouring industrial development; Ecological receptors.
Works traffic	Oxides of nitrogen	Localised short-term contributions to concentrations in ambient air	Residential settlements along the route to site.
Operation			
Project stack	Oxides of nitrogen, carbon monoxide, sulphur dioxide, particulate matter	Dispersion of flue gases in atmosphere	Outside Project boundary (10 km); Residential settlements; Regional climate change.

5.1.3 This Section presents the air quality impact assessment for the Project and includes:

- The assessment methodology adopted for this Updated ESIA including the identification of specific sensitive receptors;
- Significance criteria;
- The existing baseline conditions against which the assessment are made;
- The assessment of the impacts of the Project;
- Proposals for the mitigation of any anticipated significant environmental impacts, as appropriate; and
- Residual effects after mitigation.

5.2 Methodology

5.2.1 The assessment methodology set out below is applicable to each of the construction, operation and decommissioning phases. It addresses the way in which the

assessment is carried out and the technical approach to assessment that has been used.

Construction / Demolition

5.2.2 The assessment of air quality impacts during construction follows the recent guidance published by the UK's Institute of Air Quality Management (IAQM) '*Guidance on the assessment of dust from demolition and construction*' (February 2014). The guidance provides distance-based criteria for qualitatively assessing dust/particulate matter impacts from construction activities and their significance. The assessment criteria consider the scale and nature of the works, classed as small, medium or large, as well as the proximity of the receptors. Four different types of activities on construction sites can be assessed, these are:

- demolition;
- earthworks;
- construction; and
- trackout (the movement of dust/mud offsite on haulage vehicles wheels and bodies onto the public road network where it may be re-suspended by other vehicles).

5.2.3 Following the guidance, this assessment has considered two separate effects arising from construction phase, namely:

- Annoyance/ loss of amenity/ecological damage due to dust soiling; and
- The risk to health due to an increase in exposure to particulate matter with less than 10 microns diameter (PM_{10}).

5.2.4 The assessment has five steps:

1. Definition of the Potential Dust Emission Magnitude for the works (termed dust emissions class);
2. Definition of the sensitivity of the area - Identification of specific sensitivities, the proximity and number of receptors (human and ecological), background PM_{10} concentrations and site specific factors;
3. Assessment of the potential risks of impacts in the absence of mitigation;
4. Definition of site-specific mitigation measures; and
5. Assessment of whether significant effects are likely following mitigation

5.2.5 The criteria used to assess the dust emissions classes for the various phases of works and the risks prior to mitigation are shown in Appendix 5A. They take into account, the scale and nature of the works and the proximity and number of potential receptors. For ecological receptors, the criteria consider whether they are designated / protected at local, national or international level and whether they contain features that are likely to be sensitive to dust deposition.

5.2.6 For the purposes of this assessment, it is assumed that earthworks are undertaken simultaneously across all of the land to be developed as part of the Project. The works for the construction of the Project or its ancillary development may be undertaken in stages such that all of the land will not be affected at once.

5.2.7 It is important to note that the dust emissions magnitude for earthworks is based on the total area of the potential construction site and that this assumption inherently results in a dust emissions magnitude that may be greater than that which will actually be achieved. This ensures a robust and worst-case approach to the assessment to air quality impacts during construction.

5.2.8 The standard methodology employed to assess the significance of effects, as set in Section 4 of this ESIA, is based on an assessment of the magnitude or severity of an impact or effect, typically with embedded mitigation in place, and an assessment of the sensitivity of the receptor. This process is then repeated to assess residual significance following the application of bespoke / project specific mitigation measures. The IAQM guidance explicitly recommends that significance is only assigned to the effect after considering the construction activity with mitigation measures in place, whether embedded or bespoke. The air quality assessment presented in this chapter follows the IAQM guidance.

5.2.9 Therefore, in the assessment of air quality during the construction phase of the Project, this chapter presents the *risk of effects* assessed at Step 3 above i.e. risks in the absence of mitigation and then presents the significance of residual effects with all specified mitigation measures in place i.e. measures implemented through a Dust Management Plan (DMP) to be incorporated into the CESMP.

5.2.10 The IAQM guidance states that experience has shown that the implementation of effective embedded mitigation will be sufficient to ensure that effects from construction dust and particulate matter are not significant under normal circumstances. Therefore, the assessment of whether any residual significant effects are likely, following mitigation should normally be “not significant”. Nevertheless, it is important to present the initial assessment of the risk of effects prior to mitigation to demonstrate the process by which the DMP / CESMP mitigation measures were derived i.e. IAQM guidance states which mitigation measures should be considered as a function of the risk of effects. Moreover, it is also important to consider any specific characteristics of the Project site and the surrounding area to ensure a robust assessment of dust impacts in relation to this conclusion

Operation

5.2.11 The Project will produce up to 190MW of power using initially LCO as fuel. The combustion of LCO will result in emission of combustion products, primarily NO_x, CO, SO_2 and PM_{10}. All pollutants have the potential to generate health impacts through either chronic and/or acute exposure, although the significance of such effect is determined by the actual level of exposure. The assessment considers both the long term (chronic) and short term (acute) potential impacts from the operation of the facility.

Dispersion Model and Inputs

5.2.12 The methodology used to assess the operational impacts of the Project is based on the AERMOD air dispersion modelling software developed by the US Environmental Protection Agency. The model predicts the Project contribution to ambient pollutant concentrations at potential receptors, taking into account the effects of nearby buildings and variations in meteorological data.

5.2.13 The meteorological data used for this modelling exercise were taken from two sources: hourly surface data from the monitoring station at Takoradi Airport together with concurrent upper air sounding data from Abidjan Airport. These data are

representative of the conditions likely to be experienced at the Project in the future. That is to say, the surface data are taken from a site in proximity to the Project (c.15 km), with no significant terrain/elevation/exposure difference. Furthermore, whilst Abidjan Airport is located approximately 260 km to the west of the site, upper atmospheric conditions are less spatially variable than surface conditions, since they are most strongly influenced by meso- and synoptic scale weather systems with fewer local influences. Therefore, regional upper air sounding data are appropriate for modelling purposes.

5.2.14 The 5 years of meteorological data assessed ran from 2008 to 2012. Takoradi Airport wind roses for these years are shown in Figure 5.1. The prevailing wind is south westerly in all years.

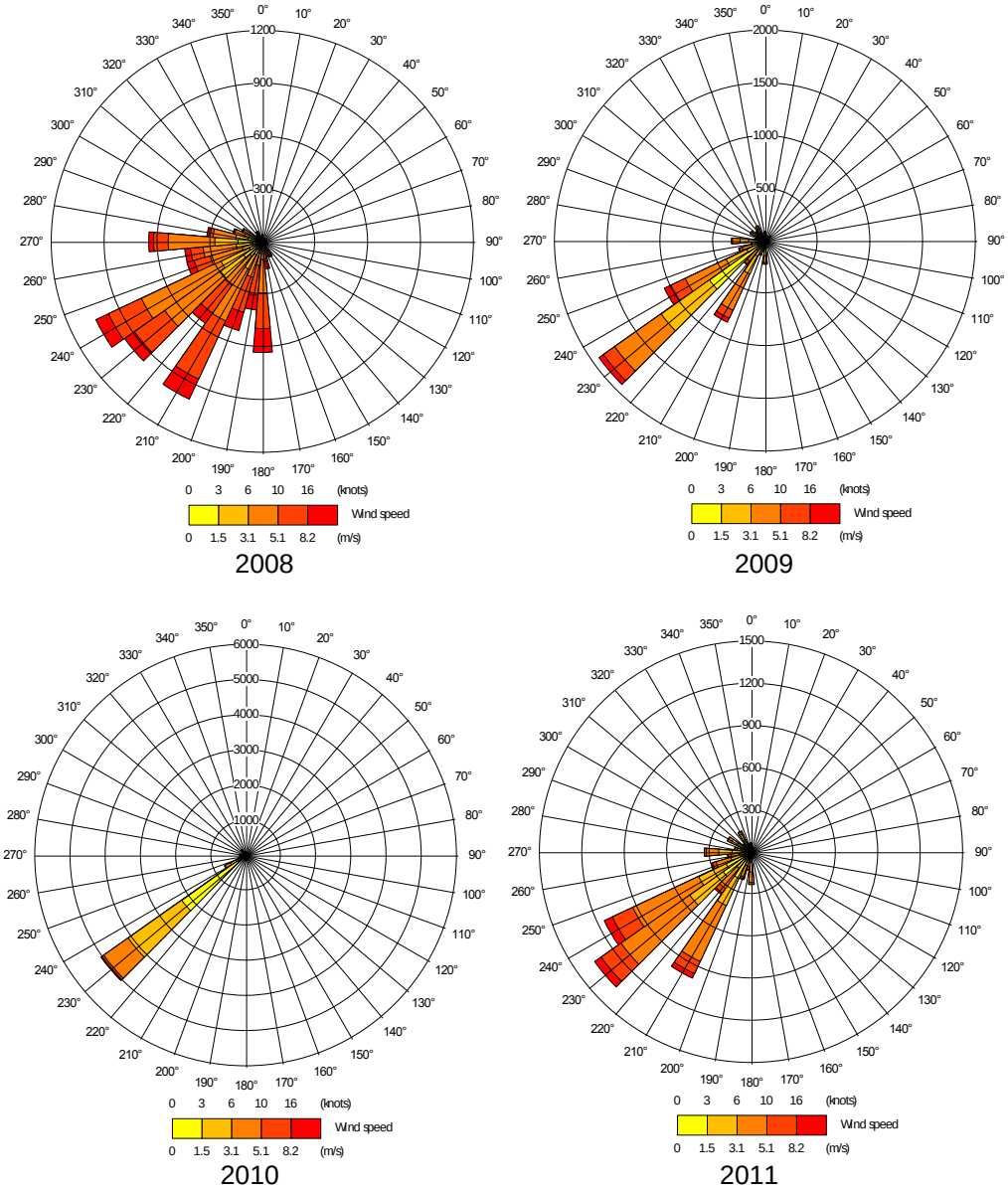
Building Downwash

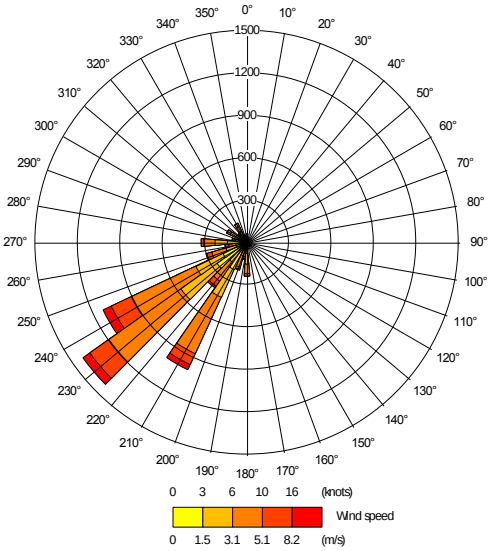
5.2.15 Building downwash is the term used to describe the effects of buildings near an emission source on the dispersion of pollutants. Turbulent eddies are generated as wind flows across buildings. If the plume from an emission source encounters these eddies, then their effect is to mix the plume (and it pollutants) down to ground level more rapidly than would be the case if the building were absent. In this way, building downwash can increase the concentration of pollutants downwind of a building. The effect is only noticeable in the immediate vicinity of the emission source, when the plume is elevated. Once the pollutants are well mixed in the vertical, the turbulent eddies have no effect i.e. further mixing of a well mixed plume does not change ground level concentrations.

5.2.16 Initial modelling, including a stack height assessment, was undertaken on the basis of buildings defined by envelopes to cover the likely scale of buildings on site. This was a conservative approach, since the actual buildings were likely to be smaller and to generate less building downwash. This modelling was then refined with design parameters based on information provided by preferred bidders. The principal buildings that were included in the initial and refined dispersion modelling are shown in Table 5.2.

5.2.17 It is a limitation of dispersion modelling that buildings must be represented by relatively basic shaped e.g. primarily cuboid or circular structures. Therefore, in both the initial and refined modelling, buildings are defined to be representative of the likely effects of the building on wind flow and will, of necessity, be a simplification of the actual dimensions of individual buildings.

Figure 5.1 Wind Roses for 2008 – 2012 (left to right); Observed Winds at Takoradi Airport





2012

Table 5.2: Building Dimensions used in Modelling (m)

Building	Number	Height	Length	Width
Building Envelopes Used In Stack Height Assessment / Initial Modelling				
Turbine Halls	1	30	112	42
LCO Storage (untreated)	2	30	50 (diameter)	
LCO Storage (treated)	2	20	30 (diameter)	
Admin / Control	1	20	45	20
Warehouse / Workshop	1	20	45	25
Refined Building Dimensions based on Preferred Bidder design				
Gas Turbine	1	21	24	33
Steam Turbine	1	27	26	19
Control Building	1	18	16	35
LCO Storage (untreated)	2	16	50 (diameter)	
LCO Storage (treated)	2	15	30 (diameter)	
Admin	1	5	45	20
Warehouse / Workshop	1	5	30	20

Receptors and Additional Model Data

5.2.18 The AERMOD model calculates time averaged ground level concentrations over any set of distances from the source. This study has used a combination of nested Cartesian grids and individual sensitive receptors to predict the process contribution to ground level concentrations.

5.2.19 Two grids were used in the model, a 20km x 20km grid and a 5km x 5km grid, both centred at the proposed stack location. The spatial resolution of the grids was 200m for the large (20km) grid and 50m for the smaller (5km) grid. With a proposed stack height of 65m, the 50m resolution grid is fine enough to ensure the point of maximum impact of the plume is well resolved in the modelling. Furthermore, outside of the

20km x 20km grid, impacts will be imperceptibly small and there is no requirement to model to greater distance.

5.2.20 The specific receptors used in the modelling are listed in Table 5.3. They were selected to be representative of potential exposure at locations within Figure 5.2 and also the locations of baseline air quality monitoring. The table provides information of the receptor locations, including distance from the Project stack. The locations are also shown in Figure 5.2. It is emphasised, however, that the receptors are selected to be representative of exposure but that the overall impact of the operation of the Project is assessed with reference to concentrations *anywhere* within the model domain i.e. within the 20km x 20km air quality "study area".

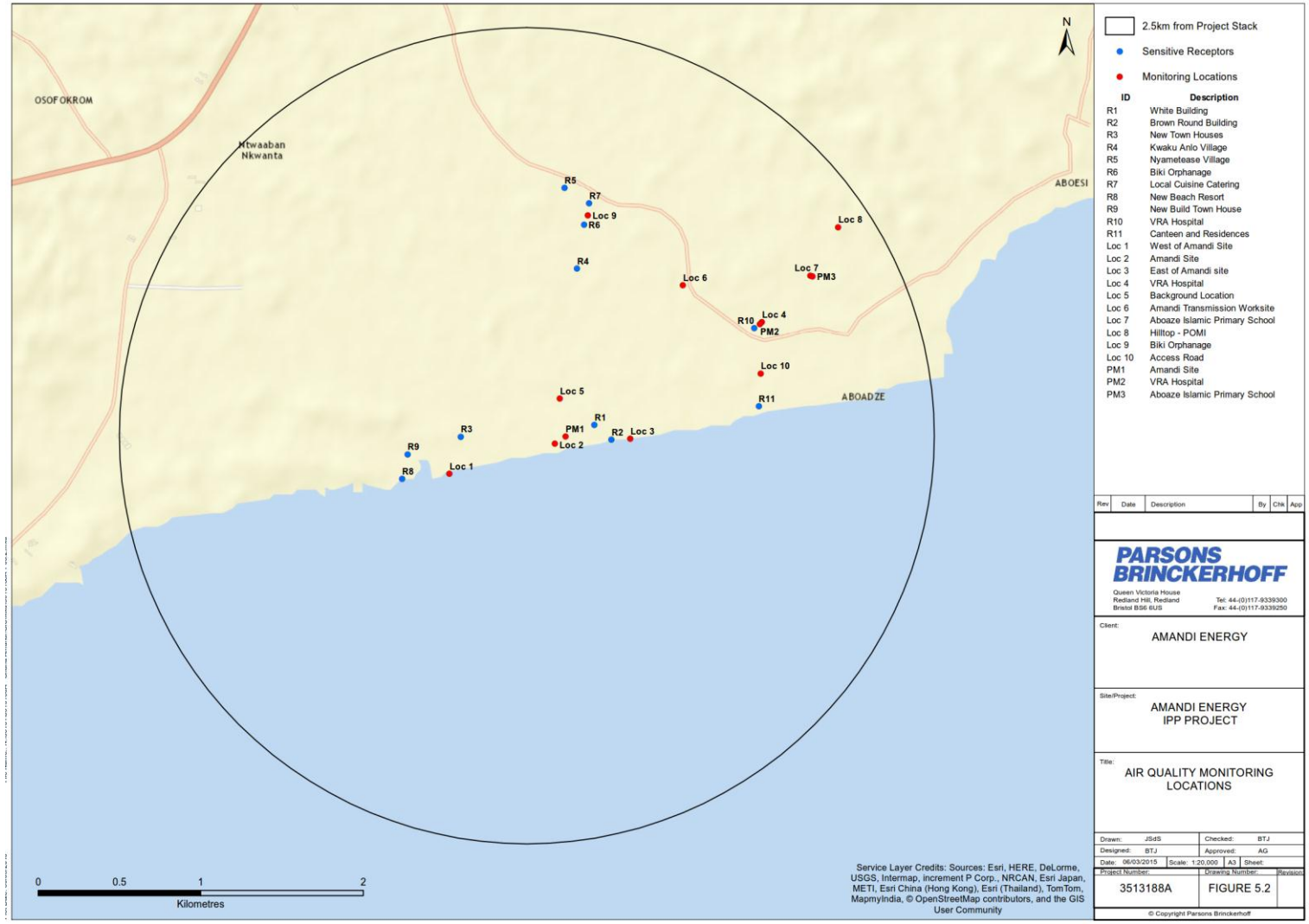
5.2.21 Variations in terrain can also have an impact on dispersion. However, any effects are only significant where there is 'significant' terrain within the study area. In the context of dispersion modelling, this is defined as large scale topography with gradients in excess of 10%. The coastal terrain in the vicinity of the Project is relatively low lying and without significant slopes. As a result, there is no requirement to include terrain in the dispersion modelling.

Table 5.3: Selected Receptors for Assessment, including distance from Project stack.

ID	Name	Character	Lat	Long	Comment including distance & direction from Project stack
	Illustrative Sensitive Receptors				
R1	White Building	Rural Background	4°58'8.74"N	1°39'50.16"W	0.4km east
R2	Brown Round Building	Rural Background	4°58'5.81"N	1°39'46.75"W	0.5km east
R3	New Town Houses	Rural Background	4°58'6.38"N	1°40'16.77"W	0.4km west
R4	Kwaku Anlo Village	Rural Background	4°58'39.91"N	1°39'53.61"W	1km north
R5	Nyametease Village	Urban Background	4°58'56.01"N	1°39'56.11"W	1.6km north
R6	Biki Orphanage	Urban Background	4°58'48.62"N	1°39'52.21"W	1.4km north
R7	Local Cuisine Catering	Urban Background	4°58'52.90"N	1°39'51.20"W	1.5km north
R8	New Beach Resort	Rural Background	4°57'57.97"N	1°40'28.44"W	0.8km west
R9	New Build Town House	Rural Background	4°58'2.87"N	1°40'27.37"W	0.8km west
R10	VRA Hospital	Urban Background	4°58'28.00"N	1°39'18.29"W	1.6km northeast
R11	Canteen and Residential unit at Seawater Inlet Works	Urban Background	4°58'12.47"N	1°39'17.37"W	1.4km east
	Monitoring Locations				
Loc 1	West of AEL Site	Background	4°57'59.00"N	1°40'19.00"W	0.5km west on western boundary of AEL site
Loc 2	Amandi Site	Site - central location	4°58'5.00"N	1°39'58.00"W	0.1km east , within proposed AEL site boundary
Loc 3	East of AEL site	Industrial	4°58'6.00"N	1°39'43.00"W	0.6km east , on eastern boundary of

ID	Name	Character	Lat	Long	Comment including distance & direction from Project stack
					AEL site
Loc 4	VRA Hospital	Urban Background	4°58'29.25"N	1°39'16.79"W	1.6km north-east , back of the hospital grounds
Loc 5	Background Location	Rural Background	4°58'14.00"N	1°39'57.00"W	0.3km north , background location on farmland
Loc 6	AEL Transmission Worksite	Roadside	4°58'36.60"N	1°39'32.50"W	1.3km north-east , next to AEL Transmission site
Loc 7	Aboadze Islamic Primary School	Urban Zone	4°58'38.50"N	1°39'7.10"W	2km east north-east , southwest of school buildings
Loc 8	Hilltop – Point Of Maximum Impact	Urban Zone	4°58'48.14"N	1°39'1.60"W	2.3km east north-east, close to likely point of maximum impact from VRA plant
Loc 9	Biki Orphanage	Urban Background	4°58'50.50"N	1°39'51.43"W	1.4km north
Loc 10	Access Road	Industrial	4°58'19.00"N	1°39'17.00"W	1.5km east, access road on eastern boundary of VRA plant
PM1	AEL Site	Background	4°58'6.41"N	1°39'55.87"W	0.2km east , within proposed AEL site boundary
PM2	VRA Hospital	Urban Background	4°58'28.83"N	1°39'17.14"W	1.6km north-east , back of the hospital grounds
PM3	Aboadze Islamic Primary School	Urban Zone	4°58'38.35"N	1°39'6.67"W	2km east north-east

Figure 5.2 - Selected Receptors used for Baseline Monitoring and Modelling



Fuel-specific Dispersion Model Inputs

5.2.22 The dispersion modelling study has considered the Project firing on LCO as its principal fuel. For the purposes of this study it is assumed that the Project will operate continuously, at full load, throughout its operational lifetime. The Project is designed as a dual fuel project, with the potential to switch to firing on gas. Emissions from the combustion of gaseous fuels are lower than LCO and, therefore, this assessment represents a worst case.

5.2.23 The dispersion modelling inputs for LCO are shown in Table 5.4.

Table 5.4: Typical Flue Gas Parameters for Full Load Operation using LCO as Fuel

Parameter	Units	Value (LCO)
Normal flue gas flow rate	Nm^3/s	335.2
NO_x emission level	mg/Nm^3	152
NO_x flow rate	g / s	50.9
CO emission level	mg/Nm^3	100
CO emission rate	g / s	33.5
SO_2 emission level	mg/Nm^3	-
SO_2 flow rate	g / s	35.8 **
Particulate emission level	mg/Nm^3	50
Particulate emission rate	g / s	16.8
Temperature	°C	138
Actual flue gas volume	m^3/s	479.3
Oxygen content	% volume, dry	12.74
Water content	% volume	9.32
Flue gas velocity	m / s	18.1
Stack diameter	m	5.8
Stack Height	m	65

** Normalised volumes corrected to 273.15 K, 1 atm and 15 per cent oxygen w / w (dry)*

*** Calculated based on combustion of LCO with a sulphur content of 0.2% w / w*

5.2.24 The emission concentrations (and associated sulphur content of fuel) shown in Table 5.4 are compliant with IFC/WB guidelines (Table 6(B), EHS Guidelines for Thermal Power Plants, 2008) for emissions in non-degraded airsheds. As will be shown in the assessment of baseline air quality, the air quality in the vicinity of the plant does not exceed Ghanaian ambient air quality standards and as such the air-shed is considered non degraded.[1]

5.2.25 Table 5.4 shows a stack height of 65m. This height was determined by testing the sensitivity of the model results to the height of the stack, with heights ranging from 40m to 90m tested. All model input parameters, with the exception of the stack

[1] An airshed for a facility is the volume of the atmosphere into which its emissions disperse. IFC/WB Guidelines define a degraded airshed to be one in which air quality standards are significantly exceeded.

height, were held constant across the stack height sensitivity tests. The results of the tests are shown in Section 5.4.

Conversion of Oxides of Nitrogen to Nitrogen Dioxide (NO_2)

5.2.26 NO_x emissions from the Project will consist of the gases NO and NO_2. It is only NO_2 that is of concern in terms of direct health effects; however NO is a source of NO_2 in the atmosphere. The gases are in equilibrium in the air, with NO predominating at the stack exit. The equilibrium changes as the plume disperses and is exposed to oxidants, such as atmospheric ozone. The rate of conversion of NO to NO_2 increases with rising ozone concentration and wind speed (turbulence and mixing effects) whilst the level of solar radiation controls the rate of the reverse dissociation reaction of NO_2 to NO.

5.2.27 In assessing the impacts on air quality of emissions to atmosphere from sources such as power stations, it is important, therefore, that realistic estimates are made of how much NO would be oxidised to NO_2 at all receptors considered.

5.2.28 A number of methodologies exist for the estimation of the conversion ratio of NO to NO_2. These range from the complex, with a requirement for detailed information on ozone concentrations and other pollutant concentrations in air, to simple, spatially constant ratios. This assessment has taken a conservative approach to the conversion and used the 'worst case' factors recommended by the UK's Environment Agency[2]. These ratios are widely used in dispersion studies and assume that 35% and 70% of NOx are in the form of NO_2 for the calculation of short term (hourly and daily) and long-term process contributions respectively.

Estimation of Concentrations at Very Short Timescales

5.2.29 The dispersion model uses hourly meteorological data and, as a result, it is not possible to explicitly model concentrations at timescales less than 1 hour. However, air quality standards exist for certain pollutant at timescales of 10, 15 and 30 minutes, and concentrations at these averaging periods have been estimated using the methodology set out in Turner (1994)[3]. Turner recommends a general power law for the ratio of concentrations at different averaging times, such that

$$\frac{C_a}{C_b} = \left(\frac{T_b}{T_a}\right)^{0.2}$$

5.2.30 Where C_a and C_b are the concentrations at averaging times T_a and T_b respectively. This relationship is based on the observed spectrum of turbulence in the atmosphere and implies, for instance that peak concentrations at 15 minute averaging period will be higher than the peak hourly concentrations by a factor of 1.32 (=$(60/15)^{0.2}$).

Ambient Air Quality and the Protection of Human Health

5.2.31 The Ghanaian EPA Ambient Air Quality Guidelines (AAQG) specify a series of standards and objectives for air quality in Ghana. The Ghanaian objectives relevant to the study are summarised in Table 5.5, together with those specified in the World Health Organsiation (WHO) Air Quality Guidelines and/or European Union (EU) Air

[2] UK Environment Agency Air Quality Modelling and Assessment Unit (2006) Guidance Note on 'Conversion Ratios for NOx and NO_2'
[3] D.B.Turner (1994) Workbook of Atmospheric Dispersion estimates, CRC Press

Quality Directives. The WHO/EU guideline and limit values are referenced by IFC/WB EHS Guidelines as appropriate examples of international air quality standards.

Table 5.5: Ambient Air Quality Guidelines

Pollutant	Location	Averaging Period	Ghanaian Ambient Air Quality Standards (as time-weighted average) (µg/m^3)	WHO/EU Ambient Air Quality Guidelines (µg/m^3)
Nitrogen dioxide	Industrial	1-hour	400	-
		24-hour	150	-
		Annual	-	-
	Residential	1-hour	200	200
		24-hour	60	-
		Annual	-	40
Carbon monoxide	Industrial / Residential	15-minute	100,000	-
		30-minute	60,000	-
		1-hour	30,000	-
		8-hr	10,000	10,000
Sulphur dioxide	Industrial	10-minute	-	-
		1-hour	900	-
		24-hour	150	-
		Annual	80	-
	Residential	10-minute	-	500
		1-hour	700	350[c]
		24-hour	100	125[a,c] / 50[b]
		Annual	50	-
Particulate matter	Industrial / Residential	24- hour	70	150[a] / 50[b,c]
		Annual	-	70[a] / 40[c] / 20[b]

a. WHO Interim Target Level
b. WHO Guideline
c. EU Ambient Air Quality Directive Limit Value

5.2.32 The Ghanaian Environmental Permit for the Project has concluded that the area is to be classed as industrial for the purposes of assessing ambient air quality in the vicinity of the Project. Therefore, the relevant standards shown above have been used as the formal basis for the assessment of emissions for the operation phase, with the standards for residential areas and WHO/EU standards/limit values used for illustrative purposes.

Significance Criteria

5.2.33 The consideration of whether the impact of emissions from the proposed scheme is significant depends on the magnitude of the impact, the importance of the affected resource or population group (receptors), and the background pollution levels. Even a small impact on a valuable receptor, such as a residential property, may be

considered significant, particularly where background pollution levels are already high.

5.2.34 Details of the general approach to the control of air quality provided in the '*EHS Guidelines*' (World Bank / IFC, April 2007) have been used to define the significance criteria for this study. For the purposes of this assessment it has been assumed that the process contributions as a result of the emissions from the Project can be considered acceptable if:

a A process contribution is <25% of the applicable air quality standards; and

b The process contribution does not result in predicted environmental concentrations (i.e. the sum of the process contribution and the existing background concentration) that exceed the appropriate standard.

5.2.35 Moreover, the Guidelines state that pollutant concentrations should be assessed by applying national legislated standards or, in their absence, the current WHO guidelines or other internationally recognized sources. Therefore, as stated above, the approach taken for this assessment is to assess the impact of the Project against Ghanaian standards, which exist for all potentially significant pollutants from the Project, but to refer to WHO/EU standards to ensure a precautionary approach is taken.

5.2.36 The WorldBank/IFC guidelines' use of 25% to define a 'significant portion' of the air quality standard has been specified on a pragmatic basis to allow further development within the same airshed as the process under consideration. Criterion 'a' above, which requires process contributions to be less than 25% of the standard, was the principal driver for setting an appropriate stack height for the Project.

5.3 Existing Environment

Study Area

5.3.2 The project is located in a semi-rural setting on the western edge of industrial development, with:

- Atlantic Ocean to the south;
- Sparsely populated Kojokrom area to the west;
- Undeveloped farmland and marsh immediately to the north, with the VRA township 1.7 km away from the project boundary;
- VRA industrial development to the east and beyond that the township of Aboadze 2 km to the east.

5.3.3 The specific receptors identified for the assessment of impacts were outlined in Table 5.3.

5.3.4 For construction impacts, the IAQM Guidance states the "study area" should be defined as the area within 350m of the site boundary and 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s). The construction impacts study area therefore includes areas of mangroves immediately to the west of the site and a limited number of properties, namely Town Houses (R3) around 200m west of the site boundary, and the White House (R1), 90m

east of the site, and the Round House (R2) 180m east of the site. The remaining area is undeveloped farmland and marsh.

5.3.5 For operational impacts, as noted previously, the model results are provided as a maximum anywhere within the 20km study area, irrespective of the presence of receptors at that location. The closest sensitive receptors are the properties listed within the study area, namely R1 – R3, which lie to the east and west of the Project stack. Given the prevailing south-westerly winds, none of these receptors are directly downwind of the prevailing south westerly winds. The closest sensitive receptor to the north-east of the Project stack is the VRA Hospital (R10) which lies 1.6 km away. To the north of the stack, the closest receptor is Kwaku Anlo Village (R5) which lies 1km from the stack.

Baseline Conditions

Air Quality Monitoring

5.3.6 In the absence of quality assured continuous monitoring of ambient air quality, a short term field survey was carried out at a number of locations onsite and in the area surrounding the site. The survey was undertaken from 1st February to 14th February 2015 and included the principal pollutants of concern for combustion sources and ambient air quality, namely NO_2, SO_2 and PM_{10}.

5.3.7 NO_2 and SO_2 were monitored using diffusion tube samplers design for the passive sampling of gaseous airborne pollutants, deployed at 10 locations (Table 5.3, Loc1 – Loc 10, Figure 5.2). Two sets of duplicate tubes were installed at each location, with each set installed for a duration of approximately 1 week each. The results are presented as the average of the duplicate tubes for each week and as an overall average for the monitoring period.

5.3.8 The results of the monitoring for gaseous emission parameters are presented in Tables 5.6 and 5.7. In the absence of results from a year-long monitoring programme, it is assumed that the sampling period average is representative of longer term conditions and, therefore, suitable for comparison with annual mean criteria.

5.3.9 The results of the survey for NO_2 demonstrate that long term baseline concentrations are well below the WHO Guideline. (There is no Ghanaian standard for annual mean nitrogen dioxide). Concentrations are lowest at the rural background site (Loc 5, 11.7µg/m^3, immediately to the north of the site) and highest at the industrial site (Loc 10, 20µg/m^3, to the east of the site). The latter location is adjacent to the access road to the VRA site and concentrations are likely to be influenced by emissions from heavy duty vehicles.

5.3.10 Weekly average concentrations of NO_2were markedly higher in week 1 of the survey than week 2, and the maximum weekly concentration was 23.1µg/m^3, at Location 10. This is just 15% of the daily standard. Whilst it is not possible to directly compare the diffusion tube results for nitrogen dioxide to the Ghanaian AAQS for daily mean or hourly mean nitrogen dioxide, the weekly concentration is such a low proportion of the daily standard, it is reasonable to infer that maximum daily mean concentrations within the survey period were well below the applicable standard of 150µg/m^3 for industrial areas and, indeed, below the standard of 60µg/m^3 for residential areas.

5.3.11 The results of the survey for SO_2 demonstrate that baseline concentrations of SO_2 are very low, and in the majority of cases below the limit of detection for the diffusion

tubes (<5 - 7µg/m^3 depending on exposure period). This concentration is well below the Ghanaian AAQS for annual mean sulphur dioxide (in both industrial and residential settings).

5.3.12 Locations 4, 7 and 8 are located downwind of the existing VRA Takoradi Power Plants (T1 – T3), but there is no indication in the baseline monitoring that this facility is having a significant impact on NO_2 (14.5 – 16.3µg/m^3) or SO_2 concentrations.

5.3.13 Overall, the results of the survey suggest that the airshed in the vicinity of the Project is non-degraded in relation to gaseous pollutants.

Table 5.6: Baseline monitoring for nitrogen dioxide, as µg/m^3.

ID	Site Name	Description	Week 1 Average (01/02/2015 – 08/02/2015)	Week 2 Average (08/02/2015 – 14/02/2015)	Period Average
Ghanian AAQS (daily mean) WHO Guideline (annual mean)			150 µg/m^3 40 µg/m^3		
Loc 1	West of Amandi Site	Background	18.7	9.7	14.2
Loc 2	Amandi Site	Site - central location	17.1	9.1	13.1
Loc 3	East of Amandi site	Industrial	15.8	9.6	12.7
Loc 4	VRA Hospital	Urban Background	17.0	12.1	14.5
Loc 5	Background Location	Rural Background	15.7	7.6	11.7
Loc 6	Amandi Worksite	Roadside	17.0	10.9	14.0
Loc 7	Aboadze Primary School	Urban Zone	19.7	13.0	16.3
Loc 8	Hilltop - POMI	Urban Zone	18.3	13.2	15.7
Loc 9	Biki Orphanage	Urban Background	15.7	9.5	12.6
Loc 10	Access Road	Industrial	23.1	16.9	20.0

Table 5.7: Baseline monitoring for sulphur dioxide, as µg/m^3.

ID	Site Name	Description	Week 1 Average (01/02/2015 – 08/02/2015)	Week 2 Average (08/02/2015 – 14/02/2015)	Period Average
Ghanian AAQS (annual mean) WHO Guideline (daily mean)			80 µg/m^3 125 µg/m^3		
Loc 1	West of Amandi Site	Background	<5.2	<5.8	5.5
Loc 2	Amandi Site	Site - central location	<5.2	<5.8	5.5
Loc 3	East of Amandi site	Industrial	<5.2	<5.9	5.5
Loc 4	VRA Hospital	Urban Background	7.8	<5.9	6.8
Loc 5	Background Location	Rural Background	<5.1	<5.9	5.5
Loc 6	Amandi Worksite	Roadside	<5.2	<5.9	5.5
Loc 7	Aboadze Primary School	Urban Zone	<7.0	6.0	6.5
Loc 8	Hilltop - POMI	Urban Zone	<7.0	6.0	6.5

Loc 9	Biki Orphanage	Urban Background	<7.3	<5.9	6.6
Loc 10	Access Road	Industrial	5.4	13.5	9.4

5.3.14 The baseline survey also included a 10 day survey of particulate matter, as PM_{10}, monitored using a DM11™ instrument, which is a real-time, optical particulate matter monitor. They survey included a minimum of 72 hours monitoring at each of 3 locations (Table 5.3, PM1 – PM3, Figure 5.2).

5.3.15 Table 5.8 shows the monitored daily mean particulate matter concentrations. All monitored concentrations are below both the Ghanaian AAQS and WHO Guideline. Concentrations were highest at PM1 and decreasing to PM3. However it is not possible to ascertain whether this is a result of a regional decrease in particulate matter pollution across the study period or a reflection of local sources at each of the sites.

5.3.16 Therefore, as for gaseous pollutants, the baseline monitoring indicates that the airshed in the vicinity of the Project is non-degraded for particulate matter. It is important to note that the IFC guidelines define a degraded airshed as one in which the AAQS are "exceeded significantly".

Table 5.8: Baseline monitoring for daily mean particulate matter as PM_{10}, µg/m^3. Measurements marked with a * are based on <24 hours data.

<table>
<tr><th rowspan="2">Site / Date</th><th>PM1</th><th>PM2</th><th>PM3</th></tr>
<tr><th>Background</th><th>Urban Background</th><th>Urban Zone</th></tr>
<tr><td>Ghanaian AAQS
WHO/EU</td><td colspan="3">70 µg/m^3
50 µg/m^3</td></tr>
<tr><td>05/02/2015</td><td>37.9*</td><td rowspan="3">Not monitored</td><td rowspan="6">Not monitored</td></tr>
<tr><td>06/02/2015</td><td>34.3</td></tr>
<tr><td>07/02/2015</td><td>39.6</td></tr>
<tr><td>08/02/2015</td><td>36.1*</td><td>22.0*</td></tr>
<tr><td>09/02/2015</td><td rowspan="6">Not monitored</td><td>21.3</td></tr>
<tr><td>10/02/2015</td><td>23.3</td></tr>
<tr><td>11/02/2015</td><td>31.4*</td><td>17.5*</td></tr>
<tr><td>12/02/2015</td><td rowspan="3">Not monitored</td><td>17.4</td></tr>
<tr><td>13/02/2015</td><td>16.8</td></tr>
<tr><td>14/02/2015</td><td>17.8*</td></tr>
<tr><td>Period Average</td><td>36.9</td><td>23.6</td><td>17.3</td></tr>
</table>

5.3.17 It is acknowledged, however, that whilst the baseline monitoring was robust and undertaken to strict quality assurance procedures, it was of limited duration and may not reflect maximum possible pollutant concentrations.

5.3.18 There are no known seasonal patterns in NO_2 and SO_2 concentrations and, given the headroom between the annual standards and the monitored concentrations, the

monitoring is sufficiently robust to conclude that the airshed is non-degraded for these pollutants. However, during Harmattan[4] wind episodes, particulate matter pollution is known to increase substantially albeit from natural sources. Such episodes are unpredictable but of limited duration and, as such, further ambient air monitoring will be undertaken prior to and during operation of the Project. This monitoring will be undertaken using continuous analysers to ensure all averaging periods used in Ghanaian AAQS can be resolved explicitly.

5.4 Environmental Impact

5.4.1 This section describes the potential impacts of the Project, set out for the construction phase (with decommissioning assumed to have similar impacts) and operational Phase.

Construction / Decommissioning

5.4.2 Construction activities can give rise to emissions of dust/particulate matter. For larger particles (>75µm), these emissions can give rise to nuisance dust soiling effects on property and effects on ecological receptors. The small particles (<10µm) can give rise to effects on human health when inhaled.

Dust Emission Magnitude

5.4.3 As set out in the methodology, the assessment of potential dust impacts requires the assessment of the potential for particulate emissions from the different aspects of construction activities. Table 5.9 sets out the assessment of dust emission magnitude from demolition activities, earthworks, construction and trackout. The criteria against which the activities are assessed are provided in Appendix 5A.

Table 5.9: Summary of assessment of potential for dust emission for all construction activities without mitigation

Activity	Dust Emission Magnitude	Commentary
Demolition	Not applicable (N/A)	No demolition is expected
Earthworks	Large	Site area is ~252,000 m^2, the amount of material to be moved is greater than 100,000 tonnes with more than 10 earthmoving vehicles estimated working at any one time, stockpiles of earth >8m and potentially dry conditions
Track-out	Large	It was assumed that the extent of unconsolidated surfaces and roads is >100 m with high levels of offsite heavy good vehicle movements (>50 per day as a peak)
Construction	Large	Installation volume is large >100,000m^3 with construction involving activities such as on-site concrete batching, piling, use of concrete and potential burning of waste materials

5.4.4 The dust emission potential for construction of the proposed development is assessed as being large for all relevant categories of activities. This high rating is primarily due to the scale of the development area and facility.

[4] Harmattan Winds are a cold-dry and dusty trade wind blowing over the West African subregion from the northeast. On their passage over the Sahara, they pick up fine dust and sand particles (between 0.5 and 10 micrometres).

Area Sensitivity

5.4.5 Following the IAQM guidance, the assessment of construction impacts considers sensitive receptors within 350 m of the boundary of the site and/or within 100 m of the routes used by construction vehicles on the public highway, up to 500 m from the site entrance. The area sensitivity is judged with reference to the sensitivity of individual receptors and their number and distance from dust generating activities.

5.4.6 The sensitivity of the area is judged to be low in relation to dust and particulate matter effects on human receptors. Whilst individual residential properties have potentially high sensitivity to dust and/or health effects from particulate matter, there are relatively few properties within the construction dust assessment study area and the closest properties lie between 50 and 100m from the site boundary. The majority of the area is either industrial in character or undeveloped farmland. Using the IAQM criteria, the area sensitivity is, therefore, set to low.

5.4.7 In relation to ecological impacts, there are areas of mangrove on site (which will be removed during construction) but also on the boundary of the site, within a protected buffer zone along the river. The habitat is not designated at international level, but is in the IUCN red list of threatened species and has high ecological value. As such the sensitivity of the area to ecological impacts from construction dust is high.

Definition of Risk

5.4.8 Table 5.10 sets out the risk category associated with each phase of the construction activities. Following IAQM guidance, the risk assessment is based on the dust emission potential, and the sensitivity of the surrounding area.

5.4.9 In the absence of mitigation, the risk of /particulate matter effects on human receptors is low, but the risks to ecological receptors are high.

5.4.10 However standard mitigation measures will be implemented to ensure that no effects on the surrounding population arise and that any effects on ecological receptors are slight adverse at worst. Appropriate measures are detailed in Section 5.5.

Table 5.10: Summary of assessment of risks associated with construction dust, assessed without mitigation

Activity	Emission Magnitude	Distance to Nearest Receptor	Risk	Commentary
Demolition	N/A	N/A	Negligible	No demolition activities expected
Earthworks	Large	>50m (humans) <20m (ecological)	Low (humans) High (ecology)	With few residential properties downwind of the site, the risk of the earthworks is low even with a large dust emission magnitude; however, the risk of impacts on mangrove is high.
Track-out	Large	>350m	Low	There are no sensitive receptors, whether human or ecological, within 500m of the haul route which passes through the current construction area.
Construction	Large	>50m (humans) <20m (ecological)	Low (humans) High (ecology)	The scale of works and the likely movement of vehicles during construction has significant potential for impacts, although only on ecological receptors due to their proximity to

				potential works.

Operation

5.4.11 This section describes the results of initial modelling to define an appropriate height for the Project stack and then detailed modelling of impacts at specific receptors. The model input parameters, in terms of stack exhaust parameters reflect the design and guarantees of the preferred bidder (Table 5.4). Exhaust emissions are compliant with all relevant IFC guidelines on emission concentrations.

5.4.12 It is reiterated that assessment considers the maximum modelled concentrations, anywhere within the study area, and, for impacts at averaging periods less than 1 year, the maximum concentration in any hour or day over a year. Typically impacts, both in terms of spatial and temporal distribution, will be significantly lower.

Operational Impacts - Stack Height Assessment

5.4.13 Stack sensitivity testing was undertaken using meteorological data from 2010. As will be shown later, this year produces the maximum impacts at short and long term averaging periods.

5.4.14 Dispersion model runs were undertaken for various stack heights between 40m and 90m. The appropriate stack height was determined using the following criteria:

5.4.15 The maximum process contribution should be less than 25% of any Ghanaian AAQS;

5.4.16 Further increases in stack height provide no significant benefit in terms of maximum ground level impacts.

5.4.17 At this stage, and to ensure a conservative final assessment, the model results were assessed against Ghanaian standards for residential areas. This is a conservative approach since the applicable standards are, in a strict sense, the standards to be applied in industrial areas.

5.4.18 Table 5.11 and Figures 5.3 – 5.5 show the results of the stack height sensitivity testing. Compliance with the hourly and daily mean standards, and the criteria above, was assessed against the maximum modelled concentration anywhere within the study area. The critical metrics in the specification of the stack height were hourly and daily mean NO_2 and SO_2.

5.4.19 Figures 5.3 and 5.4, and Table 5.11, show the impact of stack height on maximum predicted concentrations of NO_2 and SO_2 for both hourly and daily means. Significant benefits are seen as the stack height increases from 40m to 60m. Beyond this height, both the above criteria are met and as a result, the recommended stack is 65m. Data for annual mean sulphur dioxide (not shown) demonstrate that, with a 65m stack, maximum impacts are less than 5% of the Ghanaian AAQS.

5.4.20 For particulate matter, as PM_{10} (Figure 5.5), with a 65m stack, maximum daily mean impacts are less than 5% of the applicable standard of 70µg/m3. This is well below the criteria of 25% of the standard and is an appropriate level of impact where there is some uncertainty over the definition of the airshed as non-degraded due to the seasonal influence of Harmattan winds.

5.4.21 As will be shown in the following section, with the process contribution meeting the above criteria for all pollutants with a stack height of 65m, the total predicted

environmental contribution (process contribution plus background concentration) is also within Ghanaian AAQS.

Table 5.11: Stack Height Sensitivity Testing Results (process contribution only, in µg/m^3)

Stack Height (m)	Nitrogen Dioxide		Particulate Matter (PM_{10})	Sulphur Dioxide	
	Hourly	Daily	Daily	Hourly	Daily
Ghanaian AAQS (µg/m^3)	200	60	70	700	100
40	139.9	40.8	38.4	280.9	81.9
45	95.9	24.9	23.4	192.6	50.0
50	58.4	14.4	13.5	117.2	28.8
55	47.1	8.1	7.7	94.7	16.4
60	41.1	4.3	4.1	82.5	8.7
65	39.2	3.7	3.5	78.6	7.4
70	37.3	3.6	3.4	74.8	7.2
75	35.7	3.5	3.2	71.6	6.9
80	34.2	3.4	3.2	68.8	6.7
85	32.9	3.3	3.1	66.1	6.6
90	31.7	3.2	3.0	63.6	6.4

Figure 5.3 Stack Height Sensitivity Testing Results for Hourly and Daily Mean Nitrogen Dioxide

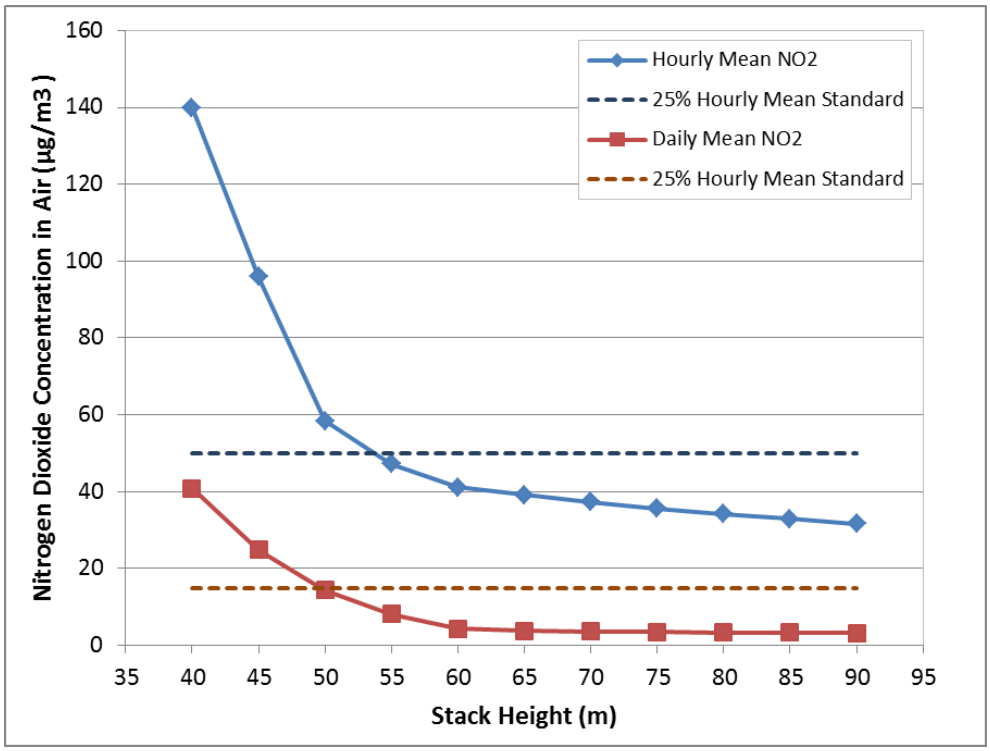


Figure 5.4 Stack Height Sensitivity Testing Results for Hourly and Daily Mean Sulphur Dioxide

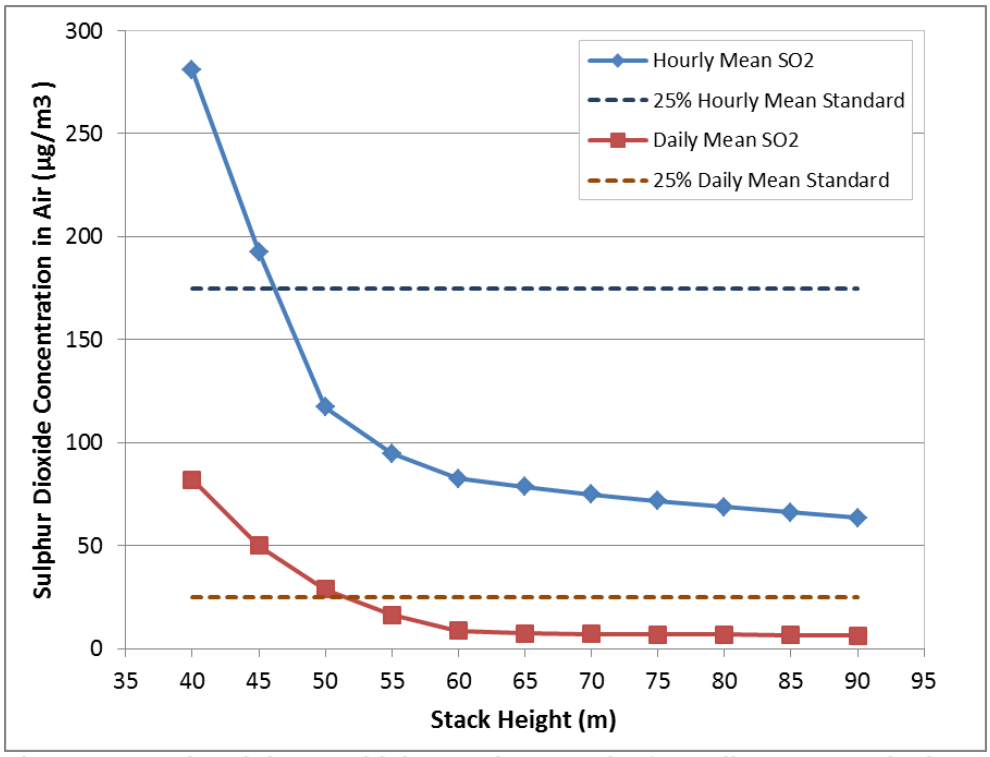
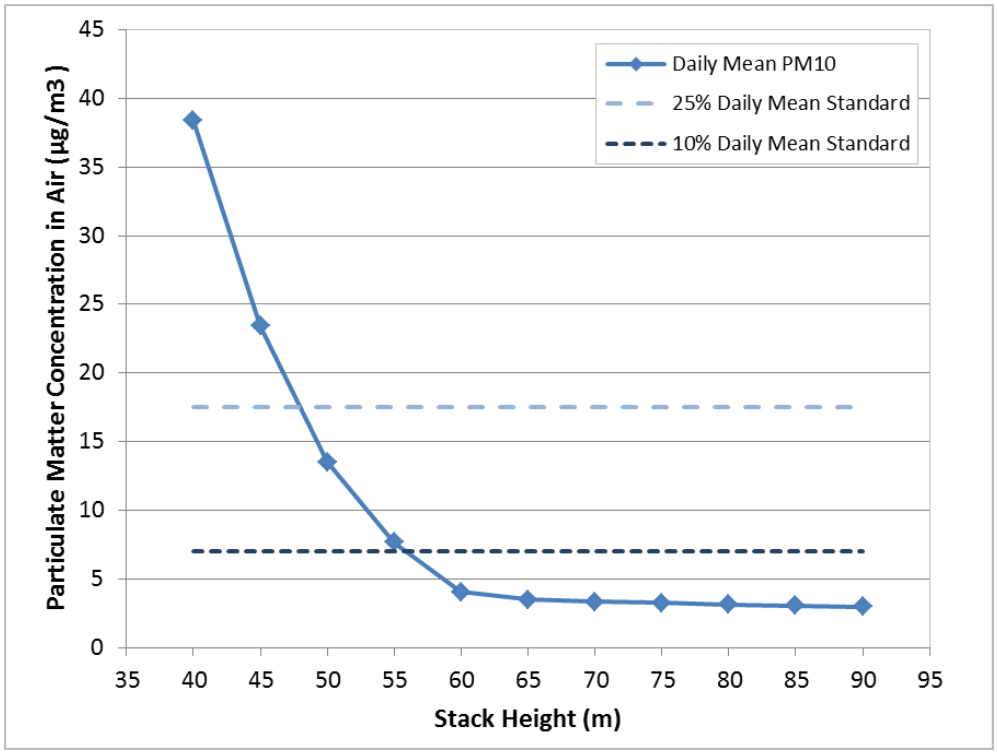


Figure 5.5Stack Height Sensitivity Testing Results for Daily Mean Particulate Matter (as PM_{10})



Operational Impacts with a 65m stack

5.4.22 Before setting out the operational impacts of the Project, it is necessary to define the background pollutant concentrations to be added to the contribution of the Project to calculate the predicted environment concentration (process contribution plus background concentration). In this study, the background concentrations have been derived from the baseline monitoring using the following assumptions:

5.4.23 Daily and annual mean background concentrations are assumed equal to the maximum period mean values, at any location, in the baseline survey

5.4.24 Short term (hourly and sub-hourly) background concentrations are assumed equal to twice the maximum period means, at any location, in the baseline survey

5.4.25 This method follows that recommended by UK's Environment Agency as a pragmatic approach where detailed background information is unavailable[5]. The daily and annual mean concentrations are set to the maximum period mean values in the survey. For daily mean concentration in particular, this may not capture maximum background pollutant concentrations. This is acceptable however, since it is unlikely that the conditions leading to maximum process contributions from an elevated stack will routinely coincide with maximum background pollutant concentrations. Similarly, the assumption that the background concentration for short term averages equates to double the annual mean background reflects the relatively low probability of the coincidence of high background pollutant concentrations with maximum process contribution. This approach is widely used in EIA. The derived background pollutant concentrations are provided in Table 5.12.

Table 5.12: Derived Background Pollutant Concentrations

Pollutant	Averaging Period	Ghanaian AAQS µg/m^3	Specified Background Pollutant Concentration	Reasoning
NO2	1hr	200	40	Concentration equates to 2 x maximum period mean in monitoring
	24hr	60	20.0	Concentration equates to period mean in monitoring
SO2	1hr	700	18.8	Concentration equates to 2 x maximum period mean in monitoring
	24hr	100	9.4	Concentration equates to period mean in monitoring
	Annual	50	9.4	Concentration equates to period mean in monitoring
CO	1hr	30000	Not assessed	It is unnecessary to assess background concentrations of CO since the modelled contribution of the Project is <0.2% of AAQS and imperceptible
	8hr	10000		
PM	24hr	70	36.9	Concentration equates to maximum period mean in monitoring

[5] UK Environment Agency, Horizontal Guidance H1, Annex F, Air Emissions, 2011.

5.4.26 The model results for all pollutants are shown in Tables 5.13 to 5.16.

5.4.27 Table 5.13 shows the maximum process contributions and total predicted environmental concentrations for NO_2, as a function of meteorological year over the 5 years tested. The data shown are the maximum concentrations anywhere within the study area.

5.4.28 The maximum process contributions are less than 25% of all Ghanaian and international air quality standards, and the maximum predicted environmental concentrations are well below the standards. This applies whether Ghanaian standards for industrial or residential areas are applied, or whether WHO/EU guidelines are used. For NO_2, the maximum process contribution (when assessed as a percentage of the standard) occurs for hourly mean concentrations. For this metric, the impact of the Project equates to less than 10% of the Ghanaian AAQS in industrial areas, and less than 20% of the AAQS in residential areas. The total predicted environmental concentration is less than 40% of the Ghanaian standard for residential areas. Furthermore, the total predicted annual mean concentration of $NO_2$is predicted to be 56% of the WHO Guideline.

5.4.29 The inter-annual variability in predicted impacts is significant, with a variation of up to +/-30% about the average impact. However, in comparison to the air quality standards, the interannual variability amounts to less than +/-5% of the standard. Nevertheless, since the assessment is based on the concentrations in the worst meteorological year, it is robust.

Table 5.13: Maximum modelled impacts of the Project on nitrogen dioxide (µg/m^3). Impacts are shown as a function of meteorological year used in the modelling

Metric/Year	Process Contribution (µg/m^3)			Total Predicted Environmental Concentration (µg/m^3)		
	Hourly	Daily	Annual Mean	Hourly	Daily	Annual Mean
2008	36.5	3.1	1.46	76.5	23.1	21.5
2009	26.0	3.3	1.75	66.0	23.3	21.7
2010	39.2	3.7	2.32	79.2	23.7	22.3
2011	28.2	2.8	1.67	68.2	22.8	21.7
2012	22.2	2.5	1.73	62.2	22.5	21.7
Maximum over all years	39.2	3.7	2.32	79.2	23.7	22.3
Ghanaian AAQS (Industrial)	400	150	-	400	150	-
Maximum as % of AAQS	9.8%	2.5%	-	19.8%	15.8%	-
Ghanaian AAQS (Residential)	200	60	-	200	60	-
Maximum as % of AAQS	19.6%	6.2%	-	39.6%	39.5%	-
WHO/EU Guidelines / Limit Values	200	-	40	200	-	40
Maximum as % of	19.6%	-	5.8%	39.6%	-	55.8%

AAQS						

5.4.30 Table 5.14 shows the maximum process contributions and total predicted environmental concentrations for SO_2, as a function of meteorological year over the 5 years tested.

5.4.31 The maximum process contributions are less than 25% of all Ghanaian and international air quality standards, and the maximum predicted environmental concentrations are well below the standards. This applies whether Ghanaian standards for industrial or residential areas are applied, or whether WHO/EU guidelines are used.

5.4.32 For SO_2, the maximum process contribution (when assessed as a percentage of the standard) occurs for hourly mean concentrations. For this metric, the impact of the Project equates to less than 9% of the Ghanaian AAQS in industrial areas, and less than 12% of the AAQS in residential areas. The total predicted environmental concentration is less than 14% of the Ghanaian standard for residential areas. Furthermore, the total predicted hourly mean concentration of nitrogen dioxide is predicted to be 30% of the WHO Guideline, and the daily mean is less than 40% of the guideline.

Table 5.14: Maximum modelled impacts of the Project on sulphur dioxide (µg/m^3). Impacts are shown as a function of meteorological year used in the modelling

Metric/Year	Process Contribution (µg/m^3)			Total Predicted Environmental Concentration (µg/m^3)		
	Hourly	Daily	Annual Mean	Hourly	Daily	Annual Mean
2008	73.3	6.3	1.5	92.1	15.7	10.9
2009	52.2	6.7	1.8	71.0	16.1	11.2
2010	78.6	7.4	2.3	97.4	16.8	11.7
2011	56.6	5.7	1.7	75.4	15.1	11.1
2012	44.5	5.0	1.7	63.3	14.4	11.1
Maximum over all years	78.6	7.4	2.33	97.4	16.8	11.7
Ghanaian AAQS (Industrial)	900	150	80	900	150	80
Maximum as % of AAQS	8.7%	5.0%	2.9%	10.8%	11.2%	14.7%
Ghanaian AAQS (Residential)	700	100	50	700	100	50
Maximum as % of AAQS	11.2%	7.4%	4.7%	13.9%	16.8%	23.5%
WHO/EU Guidelines / Limit Values	350	50	-	350	50	-
Maximum as % of AAQS	22.5%	14.9%	-	27.8%	33.7%	-

5.4.33 Table 5.15 shows the maximum process contributions and total predicted environmental concentrations for PM_{10}, as a function of meteorological year over the 5 years tested.

5.4.34 The maximum process contributions are less than 5% of all Ghanaian and less than 7% of all international air quality standards. The maximum environmental concentration is less than 60% of the Ghanaian AQS but reaches 95% of (although does not exceed) the WHO guidelines/ EU Directive for annual mean PM_{10}. However, given the relatively low process contribution, it is evident that maximum environmental concentrations are dominated by background sources rather than the Project itself.

5.4.35 Table 5.16 shows the maximum process contributions and total predicted environmental concentrations for carbon monoxide, as a function of meteorological year over the 5 years tested. The process contribution is less than 25% of the Ghanaian AAQS for all metrics. An impact at this level can be considered imperceptible and does not warrant further assessment.

Table 5.15: Maximum modelled impacts of the Project on particulate matter, PM_{10} (µg/m^3). Impacts are shown as a function of meteorological year used in the modelling

Metric/Year	Process Contribution (µg/m^3)		Total Predicted Environmental Concentration (µg/m^3)	
	Daily	Annual Mean	Daily	Annual Mean
2008	3.0	0.7	39.9	37.6
2009	3.1	0.8	40.0	37.7
2010	3.5	1.1	40.4	38.0
2011	2.7	0.8	39.6	37.7
2012	2.3	0.8	39.2	37.7
Maximum over all years	3.5	1.09	40.4	38.0
Ghanaian AAQS (Industrial)	70	-	70	-
Maximum as % of AAQS	5.0%	-	57.7%	-
Ghanaian AAQS (Residential)	70	-	70	-
Maximum as % of AAQS	5.0%	-	57.7%	-
WHO/EU Guidelines / Limit Values	50	40	50	40
Maximum as % of AAQS	7.0%	2.7%	80.8%	95.0%

Table 5.16: Maximum modelled impacts of the Project on carbon monoxide (µg/m^3). Impacts are shown as a function of meteorological year used in the modelling

Metric/Year	Process Contribution (µg/m^3)			
	15 minute	30 minute	1 hour	8 hour
2008	90.5	78.8	68.6	11.8
2009	64.5	56.2	48.9	16.8
2010	97.1	84.6	73.6	14.7
2011	69.9	60.8	53.0	13.2
2012	55.0	47.9	41.7	12.2
Maximum over all years	97.1	84.6	73.6	16.8
Ghanaian AAQS	100000	60000	30000	10000
Maximum as % of AAQS	0.1%	0.1%	0.2%	0.2%

5.4.36 As stated in the methodology, initial modelling, including the stack height assessment was based on model runs with buildings defined as envelopes within which the actual buildings would be situated. Table 5.17 presents a comparison of the model results, modelled using the initial building layout and with the layout based on the preferred bidders design (Table 5.2). There are no perceptible differences between the model results and it can be concluded that building downwash effects are not significant for the current design and that the data presented in Table 5.13 to 5.17 are representative of maximum impacts with the preferred bidders design.

Table 5.17: Comparison of Model Runs with Buildings defined as envelopes and with detailed design parameters from preferred bidder. Data shown are maximum concentrations for model runs using meteorological data from 2010, and a 65m stack

Model Run	Nitrogen Dioxide		Particulate Matter (PM_{10})	Sulphur Dioxide	
	Hourly	Daily	Daily	Hourly	Daily
Ghanaian AAQS (µg/m^3)	200	60	70	700	100
Initial Indicative Modelling	39.2	3.7	3.5	78.6	7.4
Refined Modelling	39.2	3.7	3.5	78.6	7.4

5.4.37 Table 5.18 to 5.20 show the impacts of the Project at the selected sensitive receptors together with, for comparison, the maximum impact in the study area. The concentrations shown are the maximum modelled concentrations over the 5 years of meteorological data. Maximum concentrations occur at the VRA Hospital (R8). This location lies to the north-east of the stack and, therefore, downwind of the Project stack for the predominant south-westerly winds.

5.4.38 The contribution of the Project to ambient pollutant concentrations is small at all receptors. For all pollutants and metrics, the maximum process contributions are less than 10% of the most stringent Ghanaian standards (set for residential areas).

Moreover, for all metrics except hourly mean nitrogen dioxide, the contribution of the Project is less than 5% of the AAQS.

5.4.39 Total predicted environmental concentrations are within all of the air quality standards considered in this assessment, whether national or international. Indeed, concentrations are well below all Ghanaian AAQS.

5.4.40 The metric at greatest risk of exceeding an international standard is annual mean PM_{10}. This is due to the relatively high background concentration rather than to the process itself. The latter contributes less than 1.5% of the PM_{10} annual mean standard at all selected receptors.

5.4.41 No significant effects on human health at sensitive receptors are, therefore, expected as a result of the operation of the Project.

Table 5.18: Maximum modelled impacts of the Project on nitrogen dioxide (µg/m^3) at Sensitive Receptors. Impacts are shown the maximum impact over all meteorological years tested

Receptor	Process Contribution (µg/m^3)			Total Predicted Environmental Concentration (µg/m^3)		
	Hourly	Daily	Annual Mean	Hourly	Daily	Annual Mean
Ghanaian AAQS (Resi) WHO Guideline	200	60	40	200	60	40
Maximum in Study Area	39.2	3.7	2.0	79.2	23.7	22.0
R1: White Building	13.6	1.6	1.3	53.6	21.6	21.3
R2: Brown Round Bld	17.6	2.4	1.3	57.6	22.4	21.3
R3: New Town Houses	6.7	1.2	0.6	46.7	21.2	20.6
R4: Kwaku Anlo Vil.	9.8	1.3	0.7	49.8	21.3	20.7
R5: Nyametease Vil.	15.3	1.2	0.5	55.3	21.2	20.5
R6: Biki Orphanage	11.8	1.2	0.6	51.8	21.2	20.6
R7: Local Cuisine	12.3	1.2	0.6	52.3	21.2	20.6
R8: New Beach Resort	8.6	1.2	0.5	48.6	21.2	20.5
R9: New Build Town Hse	7.9	1.2	0.5	47.9	21.2	20.5
R10: VRA Hospital	17.2	2.3	1.3	57.2	22.3	21.3
R11: Canteen and Residential unit at Seawater inlet	9.3	2.0	1.0	49.3	22.0	21.0

Table 5.19: Maximum modelled impacts of the Project on sulphur dioxide (µg/m^3) at Sensitive Receptors. Impacts are shown the maximum impact over all meteorological years tested

Receptor	Process	Total Predicted

	Contribution (µg/m^3)			Environmental Concentration (µg/m^3)		
	Hourly	Daily	Annual Mean	Hourly	Daily	Annual Mean
Ghanaian AAQS (Resi)	700	100	50	700	100	50
Maximum in Study Area	78.6	7.4	2.0	97.4	16.8	11.4
R1: White Building	27.3	3.3	1.3	46.1	12.7	10.7
R2: Brown Round Bld	35.4	4.8	1.3	54.2	14.2	10.7
R3: New Town Houses	13.4	2.4	0.6	32.2	11.8	10.0
R4: Kwaku Anlo Vil.	19.7	2.7	0.7	38.5	12.1	10.1
R5: Nyametease Vil.	30.8	2.4	0.5	49.6	11.8	9.9
R6: Biki Orphanage	23.8	2.5	0.6	42.6	11.9	10.0
R7: Local Cuisine	24.8	2.4	0.6	43.6	11.8	10.0
R8: New Beach Resort	17.2	2.4	0.5	36.0	11.8	9.9
R9: New Build Town Hse	16.0	2.4	0.5	34.8	11.8	9.9
R10: VRA Hospital	34.5	4.6	1.3	53.3	14.0	10.7
R11: Canteen and Residential unit at Seawater inlet	18.7	4.1	1.0	37.5	13.5	10.4

Table 5.20: Maximum modelled impacts of the Project on PM_{10} (µg/m^3) at Sensitive Receptors. Impacts are shown the maximum impact over all meteorological years tested

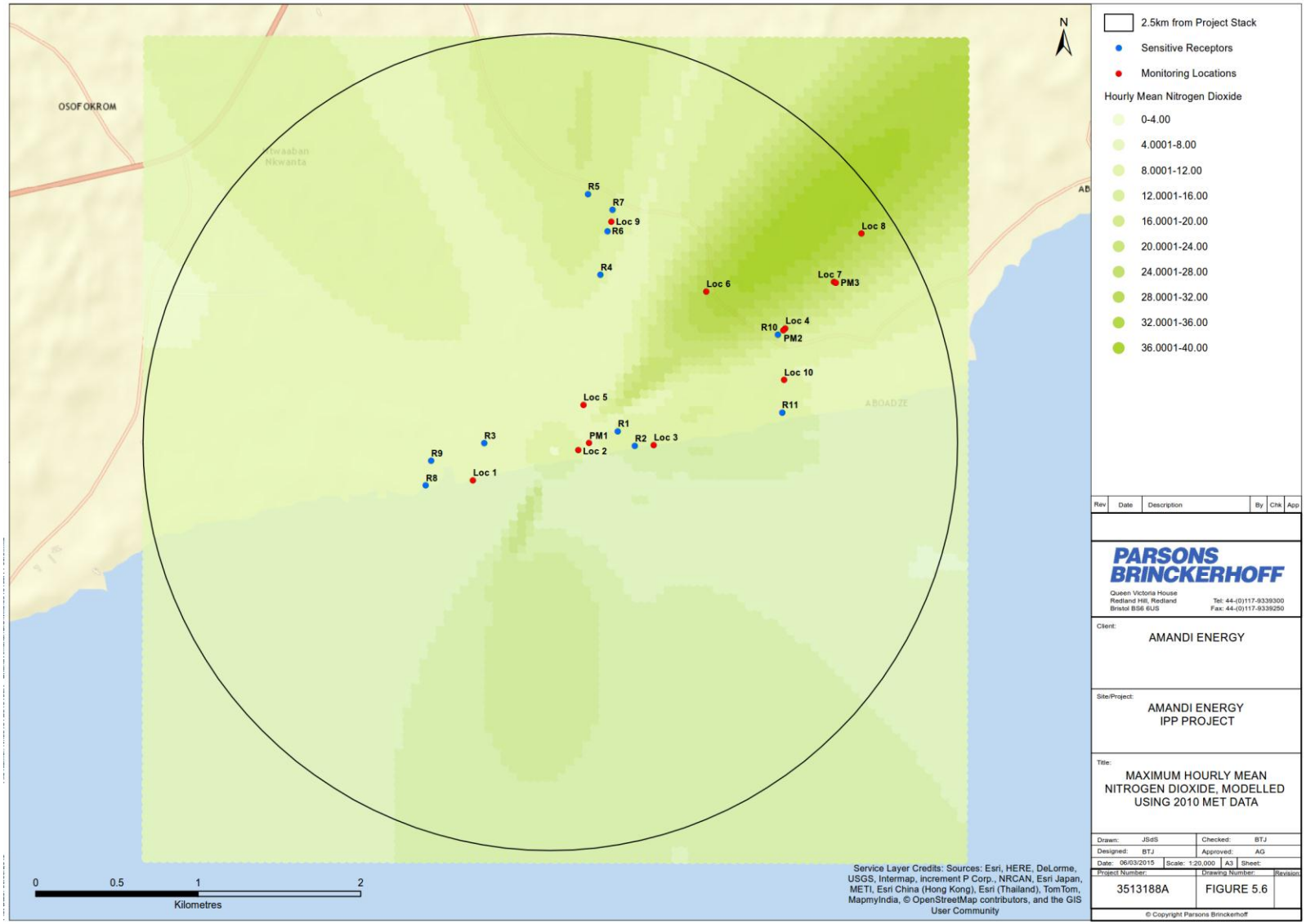
Receptor	Process Contribution (µg/m^3)		Total Predicted Environmental Concentration (µg/m^3)	
	Daily	Annual Mean	Daily	Annual Mean
Ghanaian AAQS WHO Guideline	70	 40	70	 40
Maximum in Study Area	3.48	0.92	40.4	37.8
R1: White Building	1.53	0.63	38.4	37.5
R2: Brown Round Bld	2.25	0.59	39.2	37.5
R3: New Town Houses	1.13	0.30	38.0	37.2
R4: Kwaku Anlo Vil.	1.25	0.32	38.1	37.2
R5: Nyametease Vil.	1.13	0.23	38.0	37.1
R6: Biki Orphanage	1.17	0.28	38.1	37.2
R7: Local Cuisine	1.12	0.26	38.0	37.2

R8: New Beach Resort	1.11	0.24	38.0	37.1
R9: New Build Town Hse	1.13	0.25	38.0	37.1
R10: VRA Hospital	2.14	0.62	39.0	37.5
R11: Canteen and Residential unit at Seawater inlet	1.93	0.47	38.8	37.4

5.4.42 Isopleths have been prepared for the metrics for nitrogen dioxide, sulphur dioxide and PM_{10} for which there are Ghanaian standards (Figures 5.6 to 5.11), modelled using meteorological data from 2010. Whilst 2010 is the worst case year, the spatial distribution is similar in all years, with the maximum impacts occurring within 2km of the facility. The maximum impacts follow the prevailing south-westerly winds and as a consequence are located to the north east of the site, for all metrics.

5.4.43 Maximum short term impacts occur around 2km northeast of the stack, with maximum long term impacts occurring around 850m northeast of the stack. However it should be noted that in any particular year, the point of maximum impact will be dependent on the wind statistics, and is not fixed in space and time. In general, maximum impacts will occur within +/-100m of the UTM coordinates given below:

- Short term impacts: UTM 649222, 550608, zone 30N
- Long Term Impacts: UTM 648397, 549833 zone 30N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2.5km from Project Stack
Sensitive Receptors
Monitoring Locations
Hourly Mean Nitrogen Dioxide
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Queen Victoria House
Redland Hill, Redland
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Fax: 44-(0)117-9339250
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Site/Project:
AMANDI ENERGY
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Title:
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Checked: BTJ
Designed: BTJ
Approved: AG
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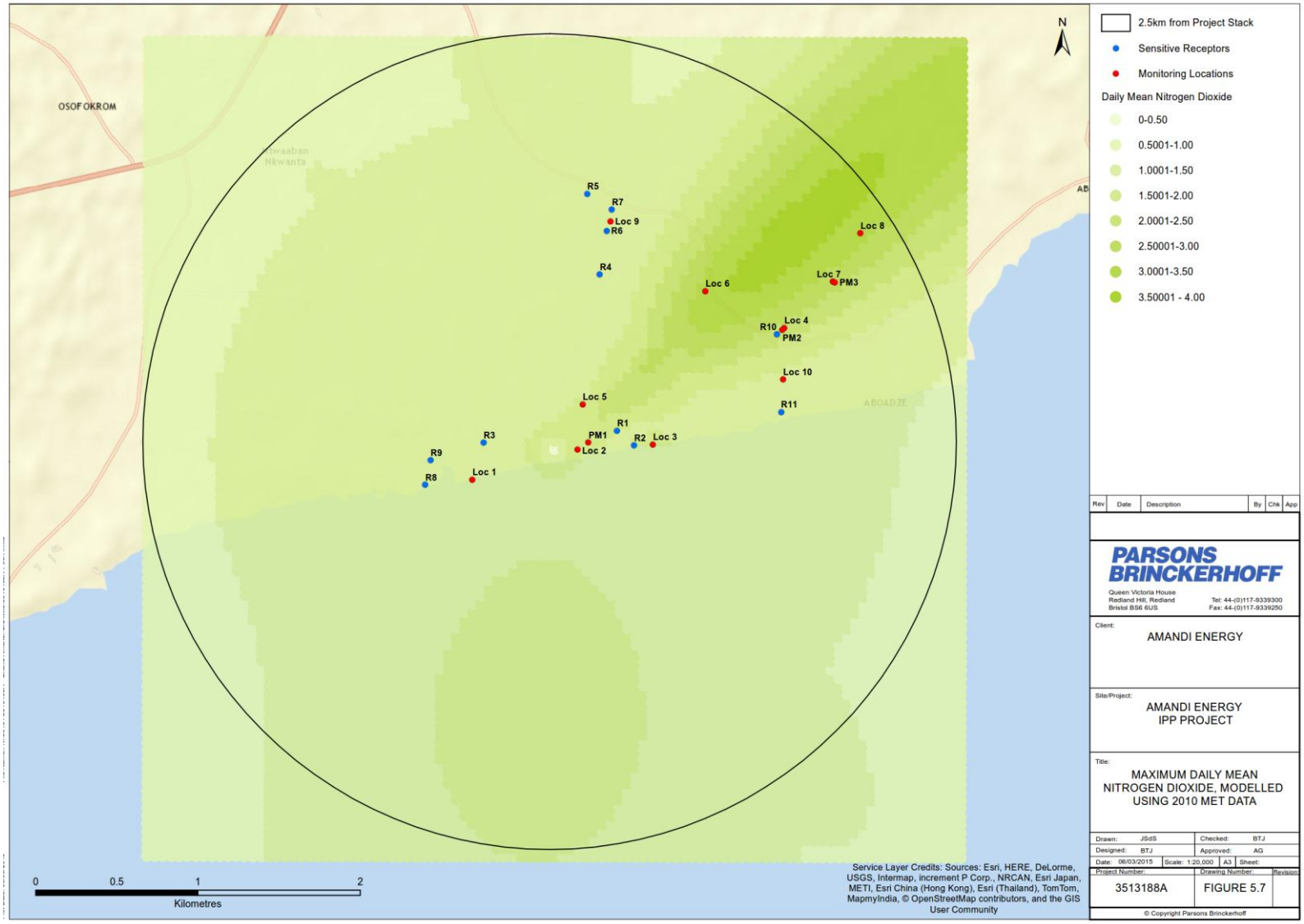
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2.5km from Project Stack
Sensitive Receptors
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Daily Mean Nitrogen Dioxide
0-0.50
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1.0001-1.50
1.5001-2.00
2.0001-2.50
2.50001-3.00
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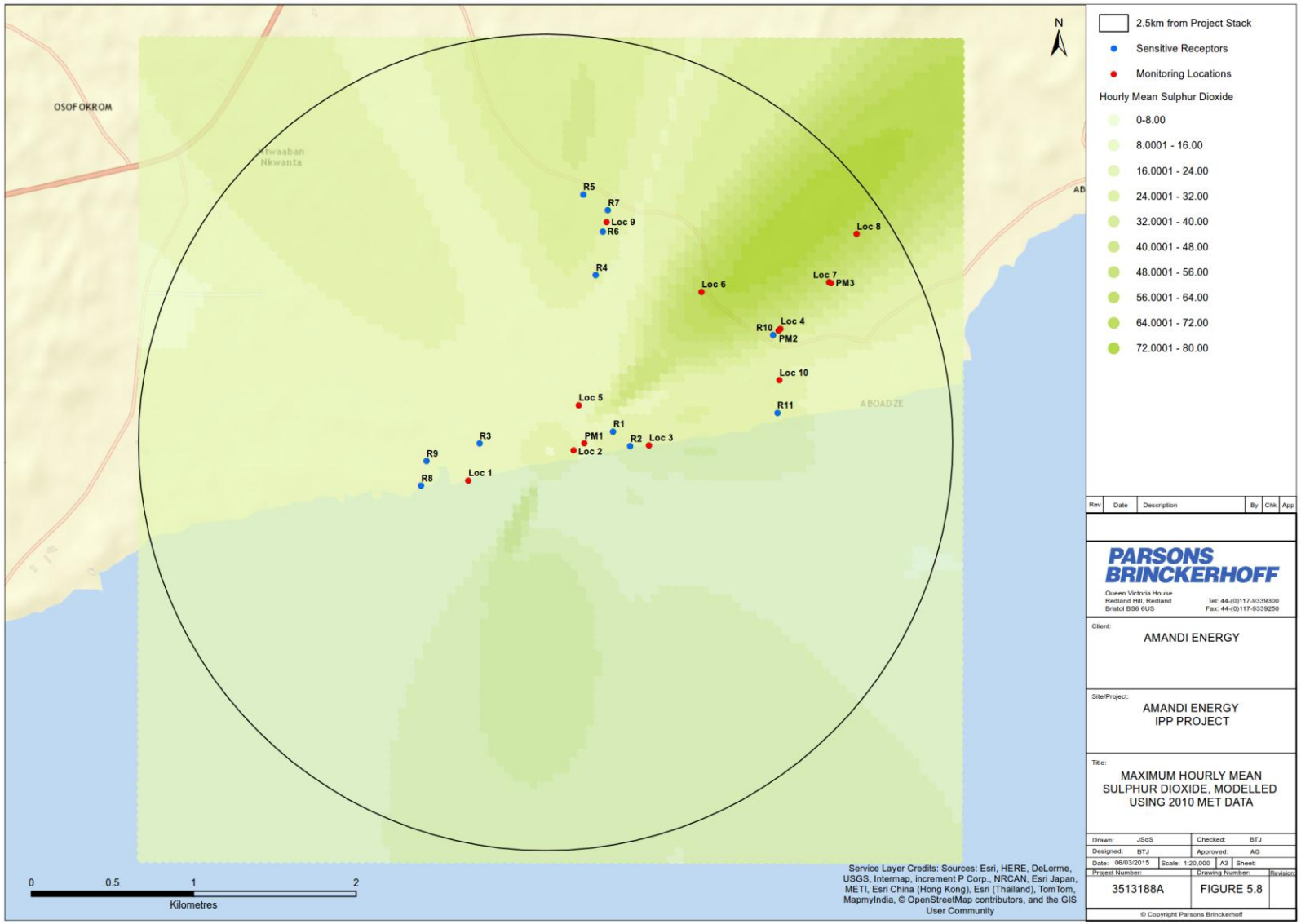
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2.5km from Project Stack
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Monitoring Locations
Hourly Mean Sulphur Dioxide
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8.0001 - 16.00
16.0001 - 24.00
24.0001 - 32.00
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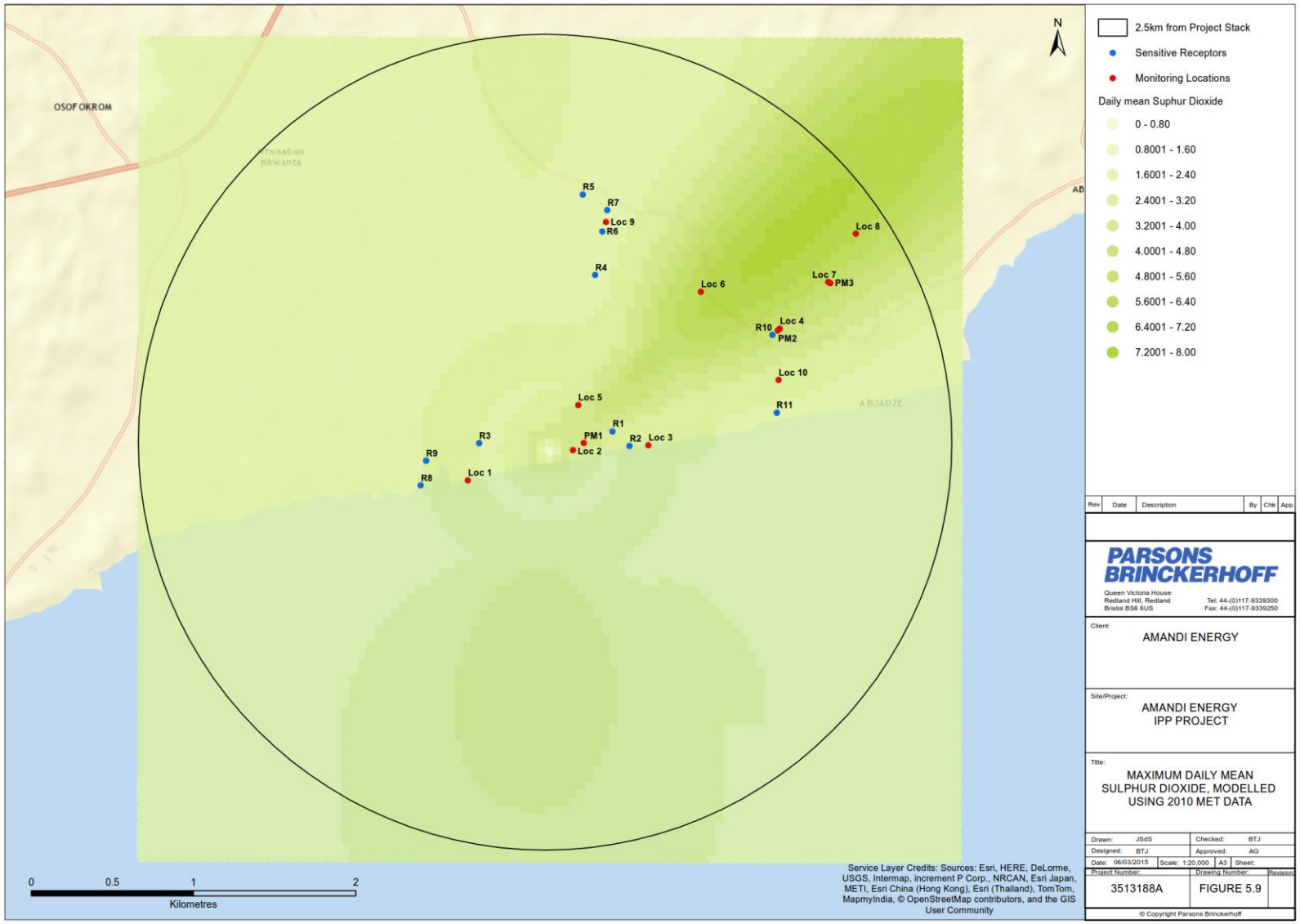
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2.5km from Project Stack
Sensitive Receptors
Monitoring Locations
Daily mean Suphur Dioxide
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1.6001 - 2.40
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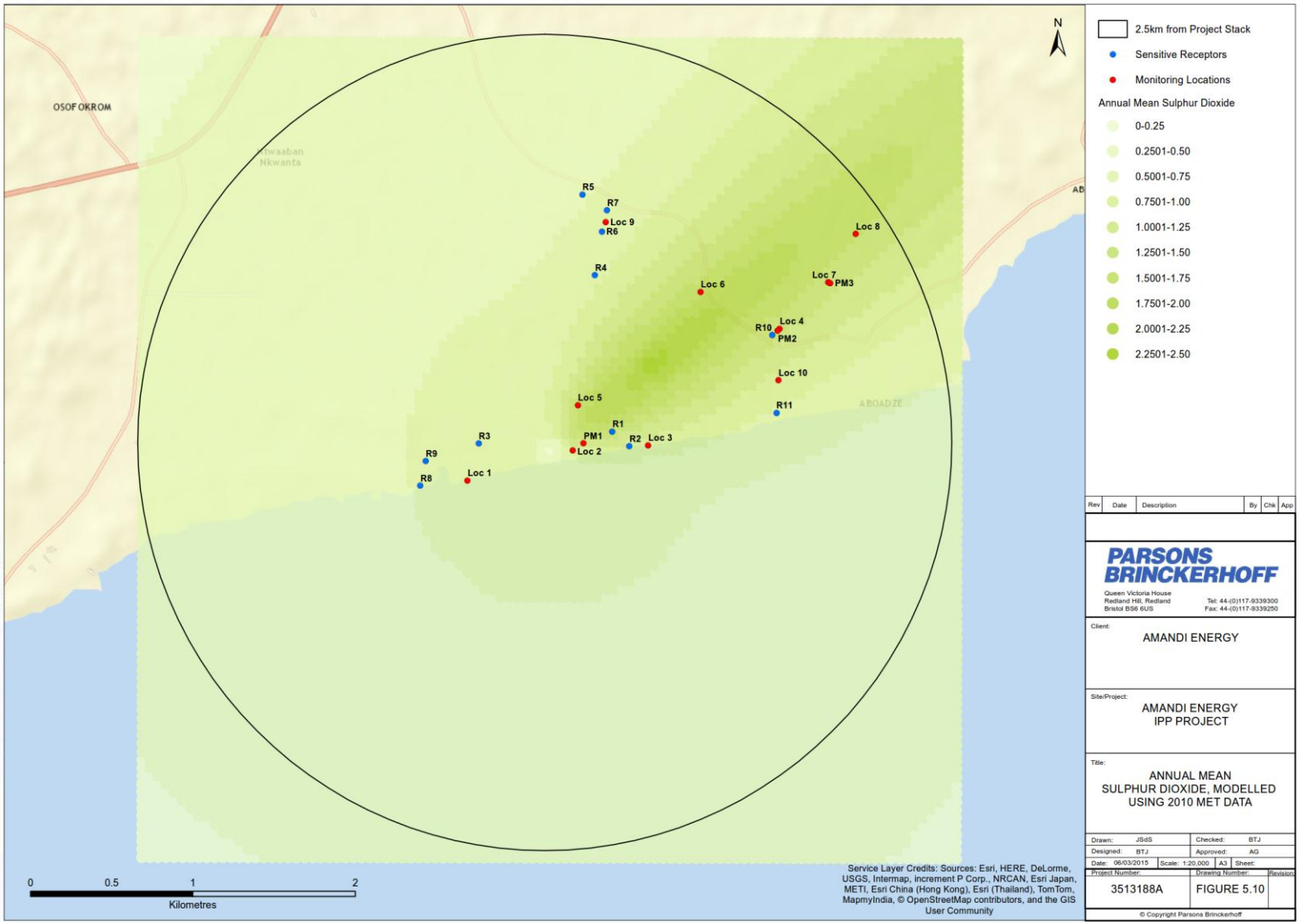
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Kilometres
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2.5km from Project Stack
Sensitive Receptors
Monitoring Locations
Annual Mean Sulphur Dioxide
0-0.25
0.2501-0.50
0.5001-0.75
0.7501-1.00
1.0001-1.25
1.2501-1.50
1.5001-1.75
1.7501-2.00
2.0001-2.25
2.2501-2.50
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Date
Description
By
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Tel: 44-(0)117-9339300
Fax: 44-(0)117-9339250
Client:
AMANDI ENERGY
Site/Project:
AMANDI ENERGY
IPP PROJECT
Title:
ANNUAL MEAN
SULPHUR DIOXIDE, MODELLED
USING 2010 MET DATA
Drawn: JSdS
Checked: BTJ
Designed: BTJ
Approved: AG
Date: 06/03/2015
Scale: 1:20,000
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Sheet:
Project Number:
Drawing Number:
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FIGURE 5.10
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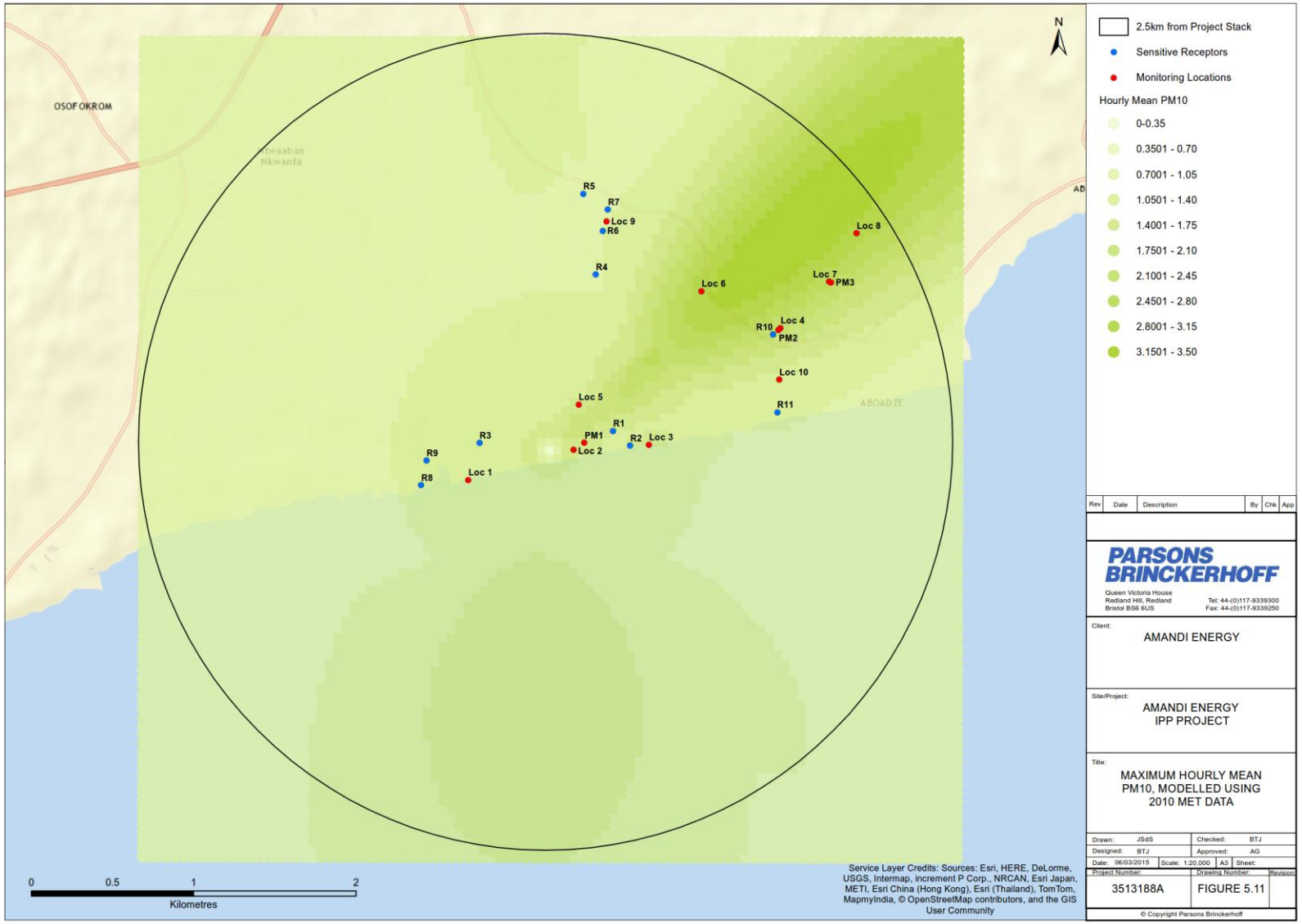
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Kilometres
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2.5km from Project Stack
Sensitive Receptors
Monitoring Locations
Hourly Mean PM10
0-0.35
0.3501 - 0.70
0.7001 - 1.05
1.0501 - 1.40
1.4001 - 1.75
1.7501 - 2.10
2.1001 - 2.45
2.4501 - 2.80
2.8001 - 3.15
3.1501 - 3.50
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AMANDI ENERGY
IPP PROJECT
Title:
MAXIMUM HOURLY MEAN
PM10, MODELLED USING
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FIGURE 5.11
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5.5 Mitigation

Construction

5.5.1 Subject to the above on-going works, this subsection presents a summary of the mitigation measures that could be implemented for the Project by AEL / the contractor in order to control and minimise emissions from the construction phase:

a Communications

i AEL will develop and implement a SEP that includes community engagement before work commences on site.

ii Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary (this may be the environment manager / engineer or the site manager).

iii Display the head or regional office contact information.

b Dust Management

i AEL will consider the development and implementation of a DMP (either as a standalone plan or as part of the overall CESMP), which may include measures to control other emissions. The DMP may include monitoring of dust deposition, dust flux, real-time PM_{10} continuous monitoring and / or visual inspections (as appropriate to the potential risks to receptors).

c Site Management

i Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.

ii Record any exceptional incidents that cause dust and / or air emissions, either on- or off-site, and the action taken to resolve the situation in the log book.

iii Hold regular liaison meetings with other local construction sites to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport / deliveries which might be using the same strategic road network routes.

d Monitoring

i Carry out regular site inspections to monitor compliance with the CESMP / DMP, record inspection results, and make an inspection log available to the relevant authority when asked.

ii Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.

e Preparing and Maintaining the Site

i Erect solid screens or barriers around dusty activities on the site boundary that are at least as high as any stockpiles on site.

ii Avoid site runoff of water or mud as far as is reasonably practicable.

f Operating Vehicle / Machinery and Sustainable Travel

i Ensure all vehicles switch off engines when stationary - no idling vehicles.

g Operations

i Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.

ii Ensure an adequate water supply on the site for effective dust / particulate matter suppression / mitigation, using non-potable water where possible and appropriate.

iii Use enclosed chutes and conveyors and covered skips.

iv Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.

h Waste Management

i Avoid bonfires and burning of waste materials.

5.5.2 This range of mitigation measures will be developed as the results of the on-going works are available and the assessment works are completed.

Operation

5.5.3 The stack height has been optimised to represent the best cost-benefit solution for the Project. The incremental environmental benefit that may result from a greater stack height is not anticipated to be sufficient to make a significant difference to the potential impacts of the dispersed flue gases.

5.5.4 The Project will (as required) utilise water injection to reduce the combustion temperature within the gas turbine in order to control the production of NO_x and its emission to atmosphere.

5.5.5 The emissions of CO and particulate matter will be minimised by the use advanced process control systems and monitoring if the combustion process in order to maximise its efficiency.

5.5.6 Emissions of SO_2 will be limited by the Project only accepting LCO (and / or DFO) that has a fuel sulphur content of less than 0.2 per cent (w / w).

Decommissioning

5.5.7 The potential impacts during decommissioning are anticipated to be similar to those expected for the construction phase. As such it is considered that the application of the above mitigation measures will be appropriate for use during the decommissioning phase.

5.6 Residual Impact

Construction

5.6.2 The above mitigation measures will be suitable for the control of airborne particulate matter and the control of emissions from construction vehicles, noting that the range of mitigation measures may be further by the contractor. The efficiency of the dust

mitigation measures is critically dependent on the operation of a robust system for monitoring the application of mitigation.

Operation

5.6.3 It is considered that the (embedded) mitigation measures including in the preferred bidder's design, will enable AEL to control the emissions from the Project such that the residual impact will not be significant.

Decommissioning

5.6.4 The above mitigation measures will be suitable for the control of airborne particulate matter and the control of emissions from construction vehicles, noting that range of mitigation measures may be further developed as the results of the on-going works are available.

5.7 Cumulative Impact

5.7.1 There is definite potential for cumulative impacts to air quality as a result of the construction, operation and decommissioning of the Project in conjunction with those phases of other identified developments in the vicinity of the Project.

5.7.2 The construction of the Project is likely to coincide with construction works or site preparation works for other industrial developments, primarily power plant, in the region. Cumulative impacts are unlikely to arise due to on-site works, whether earthworks or construction activities. This is because, significant impacts tend to be local to the dust generating event and dependent on the level of activity and meteorological conditions on a particular day. In general, rather than increasing the magnitude of an individual dust event, the cumulative effect of multiple developments is to increase the likelihood of occurrence of an event.

5.7.3 However, the application of mitigation measures should reduce impacts from all sites and minimise the risk of effects from construction dust.

5.7.4 It is also possible that cumulative impacts could occur during construction as a result of construction traffic. However, given the relatively low roadside concentrations monitored in the baseline survey, it is unlikely that roadside pollutant concentrations would exceed Ghanaian and WHO/EU standards and so no significant health effects are anticipated.

5.7.5 The most significant potential cumulative impacts arise from the operation of multiple power plant, both existing and planned, in the region. Whilst it has not been possible to gather sufficiently detailed information on each proposed power facility listed in Section 4.8, it has been possible to undertake a screening assessment of the likely impacts. In undertaking this assessment it has been assumed that:

5.7.6 The impacts from additional power facilities will be proportional to the impacts of the Project itself, and dependent on the power output

5.7.7 The location of maximum impacts from all additional power facilities coincide in time and space

5.7.8 The first assumption is robust in that the proposed facilities are either due to fire on the same fuel as the Project, LCO, or to fire on gas/LNG. Emissions from the combustion of gas are generally lower than those for the combustion of gaseous fuels

and, therefore, assuming impacts are proportional to the impacts of the Project is likely to be a conservative assumption.

5.7.9 The second assumption is appropriate for a screening exercise, but is highly conservative. The proposed facilities will be situated at distances of the order of several hundred metres from the Project. This implies that their points of maximum impacts will be similarly offset in space, whereas we have assumed the impacts to be coincident in space. Furthermore, maximum impacts in the short term rely on winds blowing directly from emission source to receptor. It would simply not be possible for winds to blow directly to a receptor from all proposed plant at the same time (to give cumulative short term impacts). As such, it is considered that the screening assessment is highly conservative.

5.7.10 Table 5.21 shows the screening assessment calculations. The Project has a capacity of 190MW; of the proposed facilities, Takoradi T4 is also 190MW, Jacobsen is 360MW, Globeleq is 400MW and One Energy is a potential of up to 1,000MW. This is an additional 1950MW, which is 10.3 times the capacity of the Project. The impacts of these additional processes are, therefore, considered to be 10.3 x the impact of the Project. In this case, impacts are assessed against Ghanaian AAQS for an industrial zone since the area would be heavily developed.

Table 5.21: Screening Assessment for Cumulative Impacts

Metric	Nitrogen Dioxide (µg/m^3)		Particulate Matter, PM10, (µg/m^3)	Sulphur Dioxide (µg/m3)		
	Hourly	Daily	Daily	Hourly	Daily	Annual Mean
Ghanaian AAQS (µg/m3)	400	150	70	900	150	80
Maximum Impact from Project	39.2	3.7	3.5	78.6	7.4	2.0
Maximum Impact from Proposed Facilities (10.3 x Project Impact)	402.0	38.0	35.7	807.1	76.2	20.1
Total Process Contribution	441.2	41.7	39.2	885.7	83.6	22.1
Background Concentration	40	20	36.9	18.8	9.4	9.4
Total Environmental Concentration	481.2	61.7	76.1	904.5	93.0	31.5
Total Environmental Concentration as % of AAQS	120.3%	41.1%	108.6%	100.5%	62.0%	39.3%

5.7.11 The table shows that, in the screening assessment, the pollutant at greatest risk of exceeding an AAQS is hourly mean NO_2, with lesser risks of exceedence for daily mean particulate matter and hourly mean SO_2. Furthermore, the exceedence is not substantial. However, taking into account the degree of conservatism built into the assessment, it is considered highly unlikely that impacts would, in reality, exceed the standard. Aside from the issue of temporal and spatial coincidence, for NO_2 it is assumed that 35% of NO_x are in the form of NO_2– at the point of maximum impact this is a likely overestimate; for particulate matter, all future facilities are assumed to emit PM_{10} whereas those firing on gas will have negligible particulate emissions; and for

SO_2, all fuel is assumed to have 0.2% v/v sulphur at all times, whereas this is the maximum permissible sulphur content.

5.7.12 In summary therefore, whilst it is concluded that there is significant potential for cumulative impacts during the operation of all planned power facilities in the area, it is also concluded that the developments are unlikely to lead to an exceedence of Ghanaian AAQS for industrial areas. Moreover, future plants will, as they undergo detailed design be required to take into account the impacts of the Project on air quality which will result in the specification of stack heights appropriate to provide adequate dispersion.

5.7.13 It has also been demonstrated that the proposed stack height for the Project is appropriate to allow further development within the local airshed as required by IFC guidelines i.e. impacts are less than 25% of Ghanaian AAQS.

5.8 Greenhouse Gases / Climate Change

5.8.1 All fossil fuel-fired (thermal) power stations generate emissions of CO_2 as a result of the combustion of any carbon present in the fuel. The emissions of CO_2 are directly proportional to the carbon content of the fuel (on a mass percentage basis) and the amount of fuel utilised.

5.8.2 The assessment of the emissions of CO_2 emissions from the Project is approached differently from the emissions of NO_x, SO_2 and PM_{10}. There are currently no air quality objectives for ground level concentrations of CO_2 and no emissions limit values prescribed under legislation or guidelines. Air dispersion modelling requires that both these conditions / limits exist such that the process contribution from operation of the Project can be calculated and compared directly to a performance standard in order to determine the significance of any impact. It is therefore considered that air dispersion modelling is not appropriate for the purposes of assessing the emissions of CO_2 from the Project.

<u>CO_2 Emissions</u>

5.8.3 The emissions of CO_2 from thermal power stations are a function of the carbon content of the fuel and the rate of fuel combustion. The rate of combustion is controlled by the calorific value of the fuel and the overall efficiency of the Project.

5.8.4 During CCGT operation, the Project will, in the short-term, use LCO as its principal fuel. The anticipated typical carbon content of the LCO is approximately 84.5 per cent. The lower heating value will be approximately 43.2 MJ/kg. The efficiency of the Project will be approximately 49 per cent (conservatively estimated operational average). CO_2 is anticipated to be emitted at a rate of approximately 29 kg/s, at full load (approximately 530 kg/MWh).

5.8.5 The annual CO_2 release from the Project could be up to approximately 902,700 tonnes per annum[6] as a result of continuous, full load, operation.

5.9 Summary and Conclusions

5.9.1 A baseline air quality survey was completed at sensitive receptor locations and in areas likely to be affected by existing emission sources surrounding the Project Site.

[6] From preferred bidder data, Exhaust Gas mass flow rate of 1453 tonnes/hr at 4.58% CO_2 by volume.

The survey was undertaken for a period of 14 days in February 2015, using passive diffusion tubes for nitrogen dioxide and sulphur dioxide and continuous optical measurements for particulate matter.

5.9.2 The Project has the potential to generate air quality impacts during construction, operation and decommissioning. The assessment of impacts has involved a qualitative, risk based assessment of impacts during construction/decommissioning and a quantitative assessment of impacts during operation using detailed dispersion modelling.

5.9.3 Impacts during construction and decommissioning include nuisance dust deposition, health effects and dust deposition of ecological receptors. With the implementation of mitigation measures, impacts on human receptors are considered to be negligible whilst impacts on the retained sensitive mangrove habitats surrounding the site are slight adverse but temporary.

5.9.4 The results of the dispersion modelling of exhaust emissions have been compared to Ghanaian ambient air quality standards and to international standards and guidelines (WHO/EU). An initial modelling exercise was used to determine an appropriate height for the Project stack (65m). With the stack at this height, the impact of the Project is less than the IFC guideline of 25% of national standards for acceptable impacts and total pollutant concentrations, taking into account background concentrations are below the Ghanaian standards for all pollutants.

5.9.5 In summary, the results of the atmospheric dispersion modelling have been compared to the Ghanaian AAQS. The key findings from the assessment of the Project during full load operations are:

- Taking into consideration existing, baseline pollutant concentrations and the maximum contribution from the Project, no exceedences of *any* ambient air quality standards were modelled (whether national or international);
- No significant health effects are anticipated as a result of the operation of the Project;
- Maximum process contributions are less than 10% of all relevant Ghanaian AAQS for industrial areas and less than 20% for residential areas, in all years;
- Maximum short term predicted environmental concentrations are dominated by the contribution from the Project; maximum long term concentrations are dominated by the contribution from background/baseline air quality;
- The critical metrics are, for short timescales, hourly mean NO_2 and, for long timescales, annual mean particulate matter. The latter is dominated by high background concentrations; and
- The maximum contributions of the Project to ambient pollutant concentrations at selected sensitive receptors are less than 5% of all relevant air quality standards, with the exception of hourly mean NO_2 for which they are less than 10% of the standards, including both Ghanaian national standards and more stringent international and WHO guidelines.

5.9.6 As such no health effects from emissions to air are expected with the operation of the Project.

Table 5.22. Potential Air quality impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Local communities (High)	Health effects from increased particulate matter pollution	Low	Minor Adverse	ESMP	Negligible
Ecological Receptors (High)	Adverse impacts due to deposition of dust on vegetation surface	Low	Minor Adverse	ESMP	Negligible

Table 5.23. Potential Air Quality impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Local communities (High)	Health effects from increased airborne pollution	Low	Minor Adverse	Stack height set to ensure adequate dispersion; abatement of NO_X emissions through diluent injection; combustion optimisation; use of low Sulphur content fuel	Negligible

SECTION 6

NOISE AND VIBRATION

6 NOISE AND VIBRATION

6.1 Introduction

6.1.1 This section presents the noise and vibration assessment for the Project and includes:

a The existing baseline conditions against which the assessment will be made;

b The assessment methodology adopted for the ESIA including the identification of specific sensitive receptors;

c Significance criteria;

d The potential impacts of the Project;

e Mitigation of any anticipated significant environmental impacts, as appropriate; and;

f Residual effects remaining after mitigation.

6.1.2 During construction, operation and decommissioning, all elements of the Project have the potential to generate noise and vibration, which may impact on local ambient noise levels and sensitive receptors (e.g. residential settlements).

6.1.3 The following text discusses elements of the Project that are scoped out of the noise and vibration assessment:

Noise from Construction Traffic

6.1.4 There will be noise generated by construction traffic. However, it is noted that any increases in noise levels will represent a temporary increase, and will be restricted to the duration of the construction activities. The noise generated by construction traffic will also vary day-to-day due to the phasing of works and progress on-site.

6.1.5 It is anticipated that most of the construction activities will take place during the day therefore the potential for disturbance to local residential or other sensitive receptor during the most sensitive periods (e.g. evening and at night) is limited.

6.1.6 Given that noise from construction traffic will be of short duration and temporary, it is not considered further as part of this assessment.

Vibration from Construction Activities

6.1.7 The identified construction plant/equipment items used in this assessment are not recognised as sources of high levels of vibration. Indeed, even at a close distance of 10 m, peak particle velocity (PPV) levels significantly less than 1 mm/s are generated. For example, a bulldozer would typically generate a PPV of approximately 0.6 mm/s and a "heavy lorry on poor road surface" would generate a PPV of less than 0.1 mm/s. These values are well below limits at which cosmetic building damage becomes likely (15 mm/s). As such, vibration impacts from construction activities are considered to be negligible and are not assessed further in this study. The plant information used in this assessment is listed in the Appendix 6A. This assessment assumes all construction plant items are used/ in operation simultaneously to provide a worst case noise impact assessment. This is very unlikely to occur in reality.

Operational Vibration

6.1.8 It is predicted that the principal on-site vibration sources during operation will be:

a Balanced rotating equipment, such as turbines; and

b Wind induced vibrations in the stack and condenser structures, which would be transmitted to the foundations.

6.1.9 The level of ground borne vibration from these sources is expected to be imperceptibly low, and to not have a significant effect on structures or humans in the study area. The study area for the noise and vibration assessment is the area included within a radius of 1km from the centre of the Project site. Therefore this assessment does not consider operational vibration further.

6.2 Methodology

6.2.1 The assessment of noise impacts has been undertaken in accordance with the following standards:

Establishing the Baseline

6.2.2 ISO 1996-2:2007 '*Description and Measurement of Environmental Noise*' defines and prescribes best practice during recording and reporting of environmental noise. This standard should be applied in all instances when undertaking environmental noise measurements.

6.2.3 The assessment of potential noise impacts as a result of all stages of the Project requires the identification of specific noise sensitive receptors (NSR) in the vicinity of the site that could be close enough to potentially be significantly affected by noise from the Project.

6.2.4 For the purposes of this assessment, daytime and nigh time noise measurements undertaken as follows:

a An attended survey at relevant locations, using 2 x 30 minute (daytime) and 2 x 15 minute (night time) measurements at each location

b Noise measurements are collected using a pre-calibrated Class 1 hand held sound level meter mounted on a tripod

6.2.5 Attended noise surveys allow for the identification of what is principally contributing to the baseline noise at each receptor. Records of weather (e.g. precipitation, wind speed) are recorded in order to demonstrate that the prevailing conditions are suitable for taking noise measurements on each occasion and at each location.

Significance Criteria

Construction / Decommissioning

6.2.6 The Ghanaian EPA - Ambient Noise Level Guidelines (ANLG) set out noise limits based on the sensitivity of the receptor and its location, such as residential, healthcare, light industrial areas and heavy industrial areas. However, the ANLG does not specifically set out noise limits relating to construction activities. As such, this assessment uses the guidance of British Standard (BS) 5228:2009 '*Noise and vibration control on construction and open sites*' to assess noise from the construction phase.

6.2.7 BS 5228:2009 gives recommendations for basic methods of noise and vibration control relating to construction sites and other open sites where construction activities are carried out. It offers a methodology to predict noise levels from construction sites, and methods for assessing its impact on those exposed to it. BS 5228 is an industry approved code of practice.

6.2.8 A prediction of the impact during construction / demolition is undertaken for each NSR and information regarding the noise output of specific items of plant has been taken from the BS 5228 database. The noise assessment procedure, as set out in BS 5228 is described below:

6.2.9 Stage 1 - Obtain an activity L_{Aeq} by direct measurement of similar plant in the same mode of operation, or use the indicative plant noise sound pressure values provided in Annexes C and D of BS 5228, these values have been measured at a distance of 10m.

6.2.10 Stage 2 - If the distance R, in metres (m) from the point of interest to the geometric centre of the plant or activity is other than 10m subtract from the L_{Aeq} obtained in stage 1 using the following equation:

6.2.11 $$L_2 = L_1 - 20Log_{10}\frac{R}{10}$$

Where:

L1 = Measured plant noise level at 10m distance

L2 = Predicted plant noise level at assessment location (NSR)

R = Distance between geometrical centre of noise source and assessment location (NSR)

6.2.12 The equation identified in stage 2 of the BS 5228 noise assessment method has been used to calculate each separate identified plant noise source. This method predicts the total potential sound pressure level at each NSR as a result of construction activities. Each plant noise source has been calculated as being the shortest distance between the Project site and each NSR.

6.2.13 The noise impacts during the decommissioning phase will use similar plant items, and as such noise levels are anticipated to be similar to those assessed for the construction of the Project. The assessment for decommissioning will therefore be carried out on the same basis for those arising from construction activities.

6.2.14 Table 6.1 sets out the construction noise significance threshold taken from the ABC method in BS 5228 for day, night, and evening and weekend periods.

Table 6.1: Construction Noise Significance Threshold (dB)

Period	BS 5228 Threshold Level ($L_{Aeq,T}$) *
Night-time	45
Evening & Weekends	55
Daytime	65

** Averaging periods, T: Night-time 23:00 – 07:00; Daytime (07.00−19.00) and Saturdays (07.00−13.00); and Evenings & Weekends 19.00 – 23.00 weekdays*

6.2.15 The BS 5228 threshold levels are free field levels expressed in terms of a L_{Aeq} at 1 m from the façade of an NSR. The L_{Aeq} metric is the equivalent continuous sound level expressed in "A weighted" decibel terms and is, in general, used as a description of environmental noise. It represents the steady sound level, which would produce the same energy as a fluctuating sound, over the same period of time.

6.2.16 The core working hours for the construction phase should be limited by a requirement in the ESMP) to the daytime period only. Any works undertaken outside of these hours should be agreed with written consent from the Local Authority, this is discussed further is Section 6.6 Mitigation.

Operation

6.2.17 The computer noise modelling software CadnaA (Version 4.5), which uses the ISO 9613 propagation algorithms has been used to undertake noise calculations. The model estimates the contribution to noise levels at each NSR location, and has been created using typical values for each of the major proposed plant items.

6.2.18 NSR locations outside the Project boundary, such as residential, educational and healthcare buildings are all classed as sensitive.

6.2.19 The operational noise limits for the project have been taken from the World Bank / IFC (WB/IFC) Guidelines and the Ghanaian EPA Ambient Noise Level Guidelines (ANLG) for sensitive receptors. These noise limits are compared in Table 6.2

Table 6.2 – World Bank / IFC Noise and Ghanaian ANLG Noise Limits Comparison

Receptor	Measured Noise Level, dB $L_{Aeq\ 1hr}$	
	Day (07:00 - 22:00)	Night (23:00-07:00)
World Bank / IFC	55	45
Ghanaian EPA Ambient Noise Level Guidelines	55	48

6.2.20 Summary Table 6.2 identifies that the daytime limits are the same, but during the night time period the World Bank / IFC noise limits are marginally lower. In order to preserve low ambient noise levels at NSR locations this assessment uses the WB / IFC limits as the threshold limits for the Project.

6.2.21 The World Bank / IFC allows for an increase of up to 3 dB above the existing background levels outside the Project boundary. As such, in the instance where the measured background noise level is already higher than the World Bank / IFC limit,

the design limit for the plant will then be the measured ambient noise level $L_{Aeq,\ T}$ +3dB.

6.3 Significance Criteria

Construction

6.3.1 The significance criteria for construction noise have been derived from BS 5228. An adapted scale for the description of the significance of construction and decommissioning noise is shown in Table 6.3. All receptors in the study area are treated as having a high sensitivity to noise.

Table 6.3: Significance of Construction and Decommissioning Noise

Impact Category	Noise	Significance Criteria
Negligible	Daytime noise levels < ambient L_{Aeq}	Not Significant
Minor Adverse	Daytime noise levels ≥ ambient L_{Aeq} but < 64 dB L_{Aeq}.	Significant
Moderate Adverse	Daytime noise levels ≥ 65 dB L_{Aeq} but < 69 dB L_{Aeq}.	Significant
Major Adverse	Daytime noise levels ≥ 70 dB L_{Aeq} but < 74 dB L_{Aeq}	Significant
Severe	Daytime noise levels ≥ 75 dB L_{Aeq}	Significant

Operation

6.3.2 The significance criteria presented in Table 6.4 has been adopted for the purposes of the assessment of operational noise from the Project.

Table 6.4: Significance of Operational Noise

Impact Category	Exceedance of Threshold Value (dB)	Significance Criteria
Negligible	< 1	Not Significant
Minor Adverse	1 to 3	Significant
Moderate Adverse	3 to 5	Significant
Major Adverse	5 to 10	Significant
Severe	> 10	Significant

6.4 Existing Environment

Baseline Conditions and Noise Sensitive Receptors

6.4.2 The baseline noise survey included measurements on the Project site, the adjacent existing power plant and at NSR locations. The study area included representative NSR locations within a radius of 1km of the Project boundary, beyond which noise impacts were considered negligible. The representative NSR locations include

residential, commercial and healthcare buildings, which are all classed as sensitive to noise.

6.4.3 Table 6.5: Summary of Measurement Locations and Noise Sensitive Receptors

Measurement Location	Description	NSR
Location 1	Open Land (site)	NO
Location 2	White Building	YES
Location 3	VRA Hospital	YES
Location 4	Brown Round Building	YES
Location 5	T2 Expansion	NO
Location 6	VRA Land (Car Park)	NO
Location 7	WAGP	NO
Location 8	Local Cuisine Restaurant	YES
Location 9	Kwaku Anlo Village	YES
Location 10	Town Houses (West of River Anankwari)	YES

6.4.4 Table 6.5 identifies that measurement locations 1, 5, 6 and 7 are not classed at noise sensitive. Measurements were undertaken at these locations for information purposes only; these locations are not included within the noise impact assessment.

6.4.5 Baseline noise measurements were undertaken during the day and night on a typical week and weekend days. The weekend measurements were carried out on 1st February and 7th to 8th February 2015. The weekday measurements were carried out on Monday 2nd February through to Thursday 5th February 2015.

6.4.6 Weather conditions were conducive to successful monitoring; with wind speeds between 0-4m/s. All roads were dry, and there was no significant rain at the time of measurement. The average ambient temperature was 32°C during the daytime (though there was a high of 38°C), reducing to around 26°C during the night-time period. Though humidity was not measured it was perceived to be high. The measurement microphones were positioned in free field at 1.4 m above ground level and more than 3.5m from any vertical reflective facades. A wind-shield was used to minimise the effects of wind noise.

6.4.7 Each measurement recorded the same five parameters (L_{90}, L_{eq}, L_{max}, L_{10}, L_{min}.)[7] in un-weighted third octave bands, with the overall figure reported using the A-weighed frequency network.

6.4.8 All monitoring was conducted using Class 1 Sound Level Meters. A field calibrator was used to calibrate and check the meter before and after the measurement period with no change in level recorded. Specific details of the equipment used, including serial numbers and calibration dates is provided in Appendix 6A

6.4.9 The full results of the baseline noise measurements are presented in the baseline noise survey report in Appendix 6A. Table 6.6 provides a summary of the L_{A90} measured levels at each NSR position during the baseline noise survey.

[7] Definitions of these abbreviations can be found in the glossary of acoustic terms in Appendix 6A.

Table 6.6: Summary of L_{A90} Background Noise Measurements at NSR Locations

NSR Location	Measured $L_{Aeq,T}$ dB			
	Weekend		Weekday	
	Daytime T=30 mins	Night Time T=15 mins	Daytime T=1 hour	Night Time T=15 mins
Location 2	45.5	51.8	46.4	56
Location 3	55.8	55.7	58.4	56
Location 4	60.5	59	61.6	60.5
Location 8	47.3	38.7	48.3	54.3
Location 9	44.4	41.8	55.3	50.9
Location 10	45.0	44.7	42.7	40.4
Location 11	45.7	46.7	45	46.2

6.4.10 It was not possible to access Location 10 during the weekend. As such, the measured noise levels from NSR locations 9 and 10 have been extrapolated to provide an estimated weekend noise level at this location.

6.5 Assessment

Construction (including Decommissioning)

6.5.1 Construction and demolition activity inevitably leads to some degree of noise disturbance at locations in close proximity to these activities. It is however a temporary source of noise. The noise levels generated by construction and demolition activities would have the potential to impact upon nearby noise sensitive receptors. Noise levels at any one location will vary as different combinations of plant machinery are used and throughout construction and demolition activities and as specific locations of these activities locations change.

6.5.2 The likely construction / demolition noise levels have been predicted using the methodology set out in BS 5228 in conjunction with general information regarding proposed activities.

6.5.3 Table 6.7 presents a results summary of the construction noise calculations. The full calculations are presented in the Appendix 6A and show; the list of plant items used in the assessment, and the sound power levels associated with each plant item / construction activity. Calculations have been undertaken to predict the likely noise level contributed by each item of plant at each NSR. The calculations are based on all identified plant items operating simultaneously at the closet point on the project boundary to any NSR locations. Also, the estimated sound pressure levels shown are worst-case estimates based on distance attenuation only and do not account for ground absorption or screening bodies. As such, the predicted construction levels shown in Table 6.7 can be considered as a worst case. In reality the noise levels experienced at NSR locations during the construction phase are likely to be lower than reported.

Table 6.7: Summary of Predicted Construction Noise Levels

Construction Area	Predicted Noise Level at NSR from Construction, dB L_{Aeq}						
	NSR 2	NSR 3	NSR 4	NSR 8	NSR 9	NSR 10	NSR 11
Power Generation Plant	61.8	49.8	60.3	49.6	52.0	60.7	54.4

6.5.4 Table 6.7 shows that noise levels are predicted not to exceed the 65dB(A) threshold at any NSR location. As such, the noise impact due to construction activities is minor. In terms of noise effects this is not significant.

6.5.5 With respect to the decommissioning phase, it is anticipated that very similar plant items and process would be used, therefore similar noise levels to the construction phase are likely to be created. It follows that the impact of noise as a result of the decommissioning phase would be minor. In terms of noise effects this is not significant.

Operation

6.5.6 For the operational noise assessment predicted noise levels for the Project are assessed against the WB / IFC noise limits (Table 6.2) at NSR locations. To provide a worst case assessment, the lowest measured ambient noise ($L_{Aeq,T}$) levels are compared to the WB/IFC limits.

6.5.7 Where background ambient noise levels exceed the WB / IFC noise limits, an increase of up to 3 dB above the existing background levels are permitted. In this instance, the noise limit for the plant at the NSR location will be the measured background level +3dB. Table 6.8 provides a summary of where the background +3dB correction is applicable, and where the fixed WB / IFC limits should be used.

Table 6.8: Summary of Applicable Noise Limits at each NSR for Daytime and Night Time

Daytime				
NSR	**Daytime Lowest Measured dB L_{Aeq}**	**World Bank / IFC Daytime Noise Limit, dB $L_{Aeq\ 1hr}$**	**3dB Correction to Background Applicable?**	**Project Operational Noise limit, dB L_{Aeq}**
2	45.5	55	NO	55
3	55.8	55	YES	58.8
4	60.5	55	YES	63.5
8	47.3	55	NO	55
9	44.4	55	NO	55
10	44.5	55	NO	55
11	45	55	NO	55
Night Time				
NSR	**Night Time Lowest Measured dB L_{Aeq}**	**World Bank / IFC Night Time Noise Limit, dB $L_{Aeq\ 1hr}$**	**3dB Correction to Background Applicable?**	**Project Operational Noise limit, dB L_{Aeq}**
2	51.8	45	YES	54.8
3	55.7	45	YES	58.7
4	59	45	YES	62
8	38.7	45	NO	45
9	41.8	45	NO	45
10	40.4	45	NO	45

11	46.2	45	YES	49.2

6.5.8 Table 6.8 identifies that during the daytime the background +3dB correction is applicable at locations NSR 3 and 4. At all other locations the fixed WB/IFC operational plant noise limit of 55 dB(A) is applicable

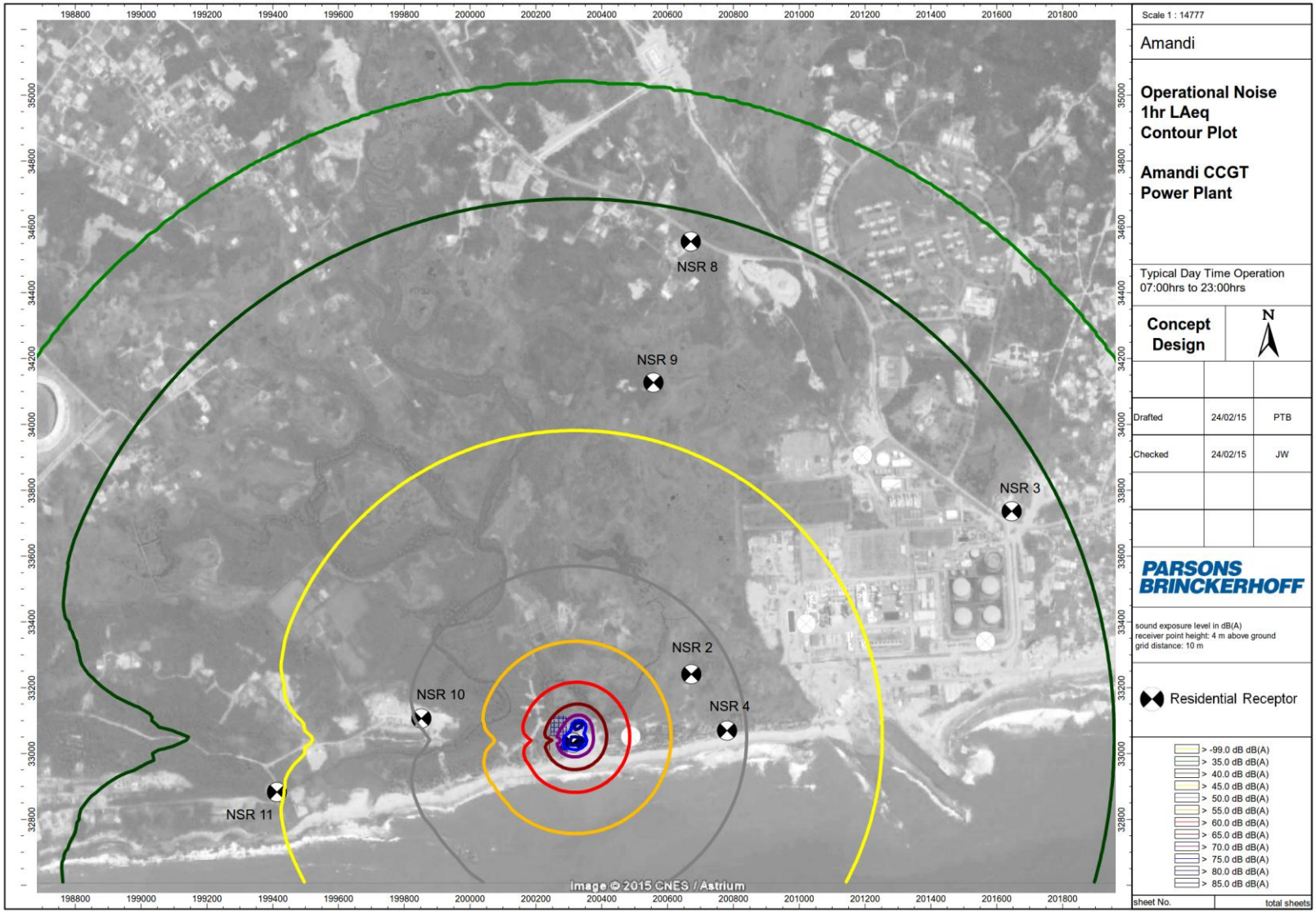
6.5.9 During the night time period, NSR locations; 2, 3, 4 and 11 are applicable for the background +3dB correction. At all other locations the fixed WB/IFC operational plant noise limit of 55 dB(A) is applicable.

6.5.10 The Cadna noise model prepared for this assessment has been based on the following information:

- The concept design plant layout used as a template;
- The sound pressure level at a distance of 1m from the generator / turbine housing has been modelled using a level of 85 dB(A);
- The sound power emission at the top of the stack has been modelled using a level of 103 dB(A).

6.5.11 A noise contour plot to show the predicted spread of noise levels in 5dB contours is provided in Figure 6.1.

Figure 6.1 Modelled Noise Levels in 5dB Contours



6.5.12 Table 6.9 presents a summary the predicted noise levels from the Project at each of the NSR locations.

Table 6.9: Predicted Plant Noise Levels at each NSR Location

Location	NSR 2	NSR 3	NSR 4	NSR 8	NSR 9	NSR 10	NSR 11
Predicted Plant Noise Level, L_{Aeq}	50.7	39.5	49.6	39.1	42.1	48.9	43.4

6.5.13 The predicted operational noise levels are assessed against the noise limits set out in Table 6.8. The results are presented in Table 6.10.

Table 6.10: Assessment Summary - Predicted Noise Levels and Noise limits

Daytime			
NSR	**Daytime Operational Noise limit, dB L_{Aeq}**	**Predicted Plant Noise Level, dB L_{Aeq}**	**Exceedance Above Limit, dB**
2	55	50.7	-4.3
3	58.8	39.5	-19.3
4	63.5	49.6	-13.9
8	55	39.1	-15.9
9	55	42.1	-12.9
10	55	48.9	-6.1
11	55	43.4	-11.6
Night Time			
NSR	**Night Time Operational Noise limit, dB L_{Aeq}**	**Predicted Plant Noise Level, dB L_{Aeq}**	**Exceedance Above Limit, dB**
2	54.8	50.7	-4.1
3	58.7	39.5	-19.2
4	62	49.6	-12.4
8	45	39.1	-5.9
9	45	42.1	-2.9
10	45	48.9	3.9
11	49.2	43.4	-5.8

6.5.14 With the exception of NSR 10, Table 6.10 identifies that the predicted operational noise levels for the Project are predicted to meet the Project noise limits at all NSR locations during the daytime and the night time. At these locations the operational noise impact can be considered as negligible, in terms of noise effects this is not significant.

6.5.15 The noise impact at NSR 10 is considered as moderate adverse. In terms of noise effects this is significant. To reduce operational noise levels at this location further mitigation options are considered in the residual impacts section.

6.5.16 The location of NSR 10 is to the west of the site at a distance of approximately 380m.

6.6 Mitigation

Construction / Decommissioning

6.6.2 In order to mitigate noise impacts from the construction phase, all construction activities would be carried out in accordance with the recommendations of BS 5228.

6.6.3 AEL will require its appointed contractor(s) to minimise the impact of construction activities through successful implementation of a relevant CESMP. The measures relevant to noise in the CESMP are expected to include:

a The appropriate selection of plant, construction methods and programming: Only plant conforming with or better than relevant national or international standards, directives or recommendations on noise or vibration emissions will be used. Construction plant will be maintained in good condition with regards to minimising noise output and workers exposed to harmful noise and vibration.

b Construction plant will be operated and maintained appropriately, having regard to the manufacturer's written recommendations or using other appropriate operation and maintenance programmes which reduce noise and vibration emissions.

c All vehicles and plant will be switched off when not in use.

d Design and use of site hoardings and screens, where necessary, to provide acoustic screening at the earliest opportunity.

e Approved routes and programming for the transport of construction materials, spoil and personnel to reduce the risk of increased noise and vibration impacts due to the construction of the project.

f Vehicle and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers, to be maintained in good working order and operated in such a manner as to minimise noise emissions. The contractor should use plant items that comply with the relevant noise limits applicable to that equipment.

g The positioning of construction plant and activities to minimise noise at sensitive locations.

h Equipment that breaks concrete by munching or similar, rather than by percussion, should be used as far as is practicable.

i The use of mufflers on pneumatic tools.

j Where practicable, rotary drills actuated by hydraulic or electrical power should be used for excavating hard materials.

k The use of non-reciprocating construction plant where ever practicable.

l The use, where necessary, of effective sound reducing enclosures.

6.6.4 In addition, core site working hours for potentially significant noise-generating activities will be considered. Should it be necessary to work outside these core hours for particular activities would require the prior written notification and agreement with the Local Authority. Specific method statements and risk assessments would be required for working outside these hours.

6.6.5 In order to minimise the likelihood of noise complaints in such instances, the contractor would also be required to advise potentially affected residents of the works to be carried out outside normal hours. Furthermore, the residents would be provided with a point of contact for any queries or complaints.

Operation

6.6.6 The following embedded mitigation will be included on the power generation plant to minimise noise during operation:

a The gas turbine, steam turbine and major compressors will be housed in individual acoustic enclosures, of heavy construction, specified at 85 dB(A) Sound Pressure Level at 1 m.

b Turbine filter and ventilation apertures are to be fitted with high performance silencers, and designed such that all sensitive receptors benefit from screening and/or directivity corrections;

c High performance silencers will be installed in the outlet duct(s) between the gas turbine and the HRSG. Due to the impracticality of screening stack noise, discharge noise will be controlled using these silencers that will be tuned to attenuate low frequencies from the gas turbine exhausts;

d Unit transformers and generator transformers will be housed in an appropriate enclosure or three sided pen, to provide full screening to noise sensitive receptors; and

e Low noise emission fans will be used on the air cooled condensers.

6.7 Residual Impact

Construction / Decommissioning

6.7.2 The mitigation measures identified for the construction and decommissioning phases represent current best practice, and will help to mitigate noise disturbance impacts as far as reasonably practicable. With the identified measures in place the noise impact is predicted to be minor, which in terms of noise effects is not significant.

6.7.3 No further mitigation measures for the construction and decommissioning phases are considered to be necessary.

Operation

6.7.4 The mitigation measures identified for operation represent current best practice. However, further mitigation is required to reduce the operational noise levels at NSR 10.

6.7.5 The most practicable option to reduce operational noise levels at NSR 10 will be to construct an acoustic screening wall on the site. The acoustic screen has been modelled running south, from the southernmost edge of the ACC's for a length of 35m. The coordinates for the screen are advised in Table 6.11.

Table 6.11: Geo Reference Coordinates for Acoustic Screen

Acoustic Screen	Coordinates

	X	Y
Northernmost Edge	200241.22	33057.36
Southernmost Edge	200241.06	33009.28

6.7.6 The acoustic screen would need to be a minimum height of 6m and be continuous with no gaps or breaks. Acoustic screens should be formed from either; close boarded timber fencing with a minimum surface mass of or concrete block construction.

6.7.7 Table 6.12 presents the results at NSR 10 with the acoustic screen in place.

Table 6.12: Operational Noise Results following Mitigation

NSR	Night Time Operational Noise limit, dB L_{Aeq}	Predicted Plant Noise Level, dB L_{Aeq}	Exceedance Above Limit, dB
10	45	44.6	-0.4

6.7.8 Table 6.12 identifies that with the proposed mitigation in place the predicted noise levels at NSR 10 meet the WB/IFC night time noise limit. In terms of noise impact this is negligible, which is not significant.

6.8 Cumulative Impacts

6.8.1 Adjacent to the Project site is the existing VRA Takoradi Power Plants, with currently 3 plants in operation; Takoradi T1, T2 and T3. These were all in operation during the baseline noise survey, as such noise produced by the VRA Takoradi Power Plants is already included in the baseline data. Therefore, noise from the Takoradi site and the Project site has been assessed cumulatively in this assessment.

6.8.2 There are four additional power plants proposed for the area:

- VRA T4;
- One Energy IPP;
- Jacobsen IPP, and;
- Globeleq IPP

6.8.3 At this stage quantitative data for the proposed power plants site is not available. Therefore, the prediction of cumulative noise effects will be qualitative. It is anticipated that the proposed power plants will use similar CCGT power generation technology as the AEL plant. It is estimated that noise levels at the NSR locations as a results of the identified power plants are likely to increase by approximately 10dB above the levels reported for the AEL power plant running in isolation.

6.8.4 Table 6.13 presents a summary of results for the predicted cumulative operational noise levels at the NSR locations.

Table 6.13: Predicted Cumulative Operational Noise Levels at NSR Locations

Night Time			
NSR	**Night Time Operational Noise limit, dB L_{Aeq}**	**Predicted Cumulative Plant Noise Level, dB L_{Aeq}**	**Exceedance Above Limit, dB**
2	54.8	60.7	5.9
3	58.7	49.5	-9.2
4	62	59.6	-2.4
8	45	49.1	4.1
9	45	52.1	7.1
10	45	55.6	10.6
11	49.2	53.4	4.2

6.8.5 Table 6.13 Identifies exceedances above the night time noise limits at NSR locations 2, 8, 9, 10 and 11, the impact of these vary between moderate to major, in terms of noise effects these increases are significant.

6.8.6 Based on this cumulative assessment, additional noise mitigation will be required at the VRA T4, One Energy, Globeleq, and Jacobsen sites to ensure existing ambient noise levels at sensitive receptor locations are maintained.

Table 6.14. Potential Noise impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Noise Sensitive Receptors	Increased ambient Noise Levels during the construction phase	Minor	Minor	Noise mitigation to follow techniques identified in ESMP	Not significant

Table 6.15. Potential Noise impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Noise Sensitive Receptors	Increased ambient Noise Levels during the operational phase	Ranges between Negligible to Moderate	Ranges between Negligible to Moderate	Embedded mitigation as identified, plus additional mitigation in the form of an acoustic screen to the west of the Project site	Negligible - Not significant

SECTION 7

WATER RESOURCES AND QUALITY

7 WATER RESOURCES AND QUALITY

7.1 Introduction

7.1.1 The construction, operation and demolition of the Project have the potential to impact on local water quality. During construction and decommissioning, all elements of the Project have the potential to generate emissions to local water courses and thus impact on local water quality. During operation, the potentially significant emissions sources will be limited to the overall Project discharge that will comprise all individual process and waste effluents from the equipment and drainage systems that will form part of the Project.

7.1.2 Whereas Section 10 of this document deals with contamination issues to ground water, and also includes an assessment of the potential impact of these pollutants on surface watercourses, the aim of this Section is to highlight the main potential impacts of the Project caused by the construction and operation of the Project on water quality and water resources through the development of, and processes used for, a CCGT power plant.

Table 7.1: Potential Water Quality Impacts

Source	Potential Pollutant(s)	Pathway(s)	Receptor(s)
Construction / Decommissioning			
On-site civil works	Silt / sediment Oils and grease	Uncontrolled surface water run-off	River Anankwari Atlantic Ocean
	Changes to surface water drainage patterns	Change of surface type Compaction of soils Creation of new drainage pathways Material stockpiling Changes to existing drainage ditches (re-routing, culverting)	
Operation			
Effluent discharge	Elevated temperature Concentration of dissolved solids present in the raw water (e.g. calcium, magnesium, chloride, sulphate)	Direct release	Atlantic Ocean
Fuel / Chemicals	LCO Other Oils Process / treatment chemicals	Uncontrolled surface water run-off	River Anankwari Atlantic Ocean

Water Resources

7.1.3 The overall water requirements for the Project, during operation, will be of the order of 1200 m^3/day (c.14 l/s) which is typical for plants of this size and type. All water required for the Project will be obtained from the Atlantic Ocean via a buried / submerged pipeline that will extend a distance of 1.2 km offshore.

7.1.4 The water requirement for the Project are minimised by the use of air-cooled condensers versus wet-cooling methods (e.g. once-through cooling or cooling towers). The principal water requirements for the Project will therefore be for emissions control within the combustion chamber of the gas turbine. Smaller volumes of water will be required for various make-up / treatment / chemical dilution requirements elsewhere within the Project.

7.1.5 It is anticipated that approximately 45 per cent of the abstracted water will be lost (e.g. evaporated and discharged from the stack as water vapour in the flue gases); the remaining 55 per cent will be returned the Atlantic Ocean (resulting in an overall net loss of approximately 6.5 l/s).

7.1.6 Given the low loss and the nature of the source of this raw water (i.e. oceanic), it is considered that there will be no significant impacts to water resources as a result of operation of the Project. Therefore, the potential impacts on water resources have not been considered further in the ESIA.

7.1.7 This Section presents the assessment of the potential impacts to water quality for the Project and includes:

a The assessment methodology adopted for the ESIA including the identification of specific sensitive receptors;

b Significance criteria;

c The existing baseline conditions against which the assessment are made;

d The assessment of the impacts of the Project;

e Proposals for the mitigation of any anticipated significant environmental impacts, as appropriate;

f Residual effects after mitigation; and

g Cumulative effects.

7.2 Methodology

7.2.1 The assessment methodology set out below is applicable to each of the construction, operation and decommissioning phases. It addresses the way in which the assessment is carried out and the technical approach to assessment that has been used.

Construction / Demolition

7.2.2 During construction and decommissioning, all elements of the Project have the potential to impact on water quality through site effluent discharges and potential changes to surface water drainage. The assessment of construction / demolition impacts is considered within Section 10, because potential impacts will, primarily, be as a result of the potential mobilisation of soils and contaminants during these phases that has the capacity to affect sensitive receptors.

7.2.3 For construction, this Section considers the works required for the installation of the water intake / discharge pipelines on water quality within the Atlantic Ocean, rerouting of the small tributary which passes east to west across the Project site, and runoff of chemicals / sediments into adjacent waterbodies during construction of the plant.

7.2.4 The excavation of a trench for the laying of such pipelines has the potential for the disturbance of the sea bed and a temporary (i.e. limited to during the construction) increase in the suspended solid content of the local waters. Demolition may result in similar impacts, should the pipelines be removed; if left in-situ following decommissioning of the plant, then no disturbance will be required.

7.2.5 Rerouting of the small tributary into an open channel to the north of the plant has the potential to temporarily disturb sediments within the channel, resulting in a temporary increase in the suspended solid content within waterbodies downstream (Anankwari River / Atlantic Ocean) ,

7.2.6 Construction of the plant also has the potential to increase suspended solid content within adjacent watercourses caused by the compaction of soils by construction vehicles, creation of new drainage pathways, and runoff from material stockpiles.

Operation

7.2.7 During operation, the principal source of potential water quality impacts will be the direct discharge of the combined Project effluent to the Atlantic Ocean. There overall effluent will be a concentrated solution of the total dissolved solids (TDS) in the raw sea water, together with some additional sodium sulphate or sodium chloride produced as a result of any effluent neutralisation requirements. In addition, the effluent may contain small amounts of ammonia and phosphate, from the blowdown, and trace amounts of oil following treatment oil interceptors.

7.2.8 The anticipated composition of the overall Project effluent has been calculated based on the anticipated concentration of the TDS, by the Project processes, between the proposed intake and the combined effluent discharge. Using the typical intake / discharge flow rates from the Indicative Operation Water Balance presented in Figure 3.4, the overall concentration factor for the Project will be approximately 2 (i.e. the concentration of TDS in the effluent will be around double that of the raw sea water).

7.2.9 As discussed in Section 7.3, the composition of the sea water has been analysed at two locations in the vicinity of the proposed sea water intake. From this data, the anticipated worst case composition (i.e. highest anticipated concentrations of TDS) of the combined Project effluent has been calculated (see Section 7.4).

7.2.10 The UK Environment Agency has published 'Horizontal Guidance Note H1 – Annex D: Discharges to Surface Water' (September 2014) (the H1 Guidance) that provides a methodology for the screening of potentially significant impacts from discharges to surface waters, where the concentrations of the various parameters within the effluents are known.

7.2.11 For discharges to coastal waters (as is proposed for the Project), a number of screening tests are provided. These are applied (as relevant to the location of the proposed discharge for the Project) in the following order:

a Does the concentration of the substance in the discharge exceed 100 per cent of the substance-specific environmental quality standard (EQS)?

b Is the discharge to a location with restricted dilution / dispersion characteristics?

c Is the discharge either to a location less than 50 m offshore from where the sea-bed is at Chart Datum[8] or to a location where the sea-bed is less than 1m below Chart Datum?

7.2.12 For the screening of the 'potential to cause pollution' from non-hazardous pollutants present in a discharge, if any of the above conditions do not apply to the Project discharge then the impact can be considered to be not significant (i.e. no deterioration of the receiving water is likely).

7.2.13 In addition to the above, and for all hazardous substances within a discharge, a further test is applied:

a Is the Significant Load exceeded?

7.2.14 The hazardous substances that may be relevant to the Project are cadmium and mercury (which may be present in small amounts in the acid or caustic used for effluent neutralisation).

Significance Criteria

7.2.15 As per Paragraph 7.2.8, if any of the screening conditions detailed in Paragraph 7.2.7 are not applicable then the potential impact in respect of that substance can be considered to be insignificant.

7.2.16 Where all of the conditions in Paragraph 7.2.7 apply, further assessment of the potential significance will be required. The severity of the potential impacts of the Project on water quality, in this case, can be assessed by the criteria defined in Table 7.2.

Table 7.2: Significance Criteria for Individual Pollutants

Impact Severity	Long-Term Process Contribution	
	Process Contribution as a percentage of relevant EQS	Predicted Environmental Concentration as a percentage of relevant EQS
Very Low	< 4%	-
Low	> 4%	< 70%
Medium	> 4%	70% < x < 100%
High	> 4%	> 100%

7.2.17 There are no current Ghanaian EQS for coastal (sea) water. Similarly, the WB / IFC EHS Guidelines do not provide such standards.

7.2.18 Therefore, for the purposes of this assessment, the EQS for 'coastal waters' as defined in the H1 Guidance have been used, where relevant to the substances within the proposed combined discharge. These EQS are presented in Table 7.3.

[8] Chart Datum, in the UK, normally refers to the level to which the lowest tides fall (lowest astronomical tide). For the purposes of this assessment, Chart Datum is taken as the Ghana National Grid Datum.

Tale7.3: Assumed EQS (µg/l)

Substance	Annual Average	Maximum Allowable Concentration
Chromium	0.6	32
Copper	5	-
Iron	1000	-
Lead	7.2	
Zinc	40	-
Cadmium	0.2	1.5
Mercury	0.05	0.07

7.2.19 Given the very small volume of water that will be discharged from the Project (with an overall concentration factor of approximately 2) and the large dilution capacity of the receiving Atlantic Ocean, it is considered that the sensitivity of the receiving water will be low.

7.2.20 Where this step of the assessment is required, the resultant significance will be assessed in accordance with the criteria presented in Table 4.4.

Hazardous Substance (Additional Assessment)

7.2.21 Similar to Paragraph 7.2.15, the Significant Load for cadmium and mercury is also based on the values provided in the H1 Guidance. If this Load (for each substance) is not exceeded then the potential impact in respect of each substance will be insignificant. The Significant Loads for cadmium and mercury are 5 kg/year and 1 kg/year, respectively

7.3 Existing Environment

Study Area

Construction / Decommissioning

7.3.2 The Project site where the main construction activities will take place is defined by an area which is approximately 600m x 300m, and made up of predominantly low lying wetland and mangrove.

7.3.3 The site is bound by the Anankwari River to the west, beach and Atlantic Ocean to the south, VRA Takoradi Power Plants to the west, and further forest and mangrove to the north. There is a sinuous watercourse flowing from east to west across the centre of the site, which discharges into the main Anankwari River.

7.3.4 During construction, in order to facilitate the construction of the power plant, this tributary to the Anankwari River will be diverted, in an open channel along the northern boundary of the project site.

7.3.5 The submerged pipelines which will supply water to the Project will be laid in an excavated channel up to 2.5 m below the sea bed. The channel will then be backfilled either with suitable excavated material or additional sand / gravel.

7.3.6 There is likely to be short-term impacts arising from higher sediment loads when the watercourse is diverted and the pipeline is laied. Indirect effects on ecology are reported within chapter 8.

Operation

7.3.7 The study area for the assessment of the potential impacts to water quality from the combined Project effluent can be defined as the area (roughly centred on the location of the discharge) within which the discharged effluent undergoes a process of dilution by the receiving water. This 'mixing zone' can be defined as the area around the discharge location within which the elevated temperature and / or concentrations can be detected.

7.3.8 The dilution factor is a function of ambient current velocity and water depth and, as such, a range of factors for the dilution of the combined Project discharge are expected over the full tidal cycle. For the purposes of this assessment, it is recognised that the worst case (i.e. the lowest dilution factor and, thus, the largest mixing zone over the full tidal cycle) will occur during low tide (slack water), when the speed of the current is effectively zero and the depth of the discharge below the surface of the receiving water will be at its minimum.

7.3.9 Previous experience of discharges from power plants to similar coastal / tidal locations have determined that, at slack water (i.e. the time where mixing effects are at their lowest), the mixing zone may extend to no more than between 100-200 m from the discharge point. Given that the discharge pipe will be approximately 600 m in length, the extent of any potential impact will be limited. The intake pipe will extend 1.2 km offshore.

Baseline Conditions

Seawater Sampling

7.3.10 To determine the composition of the raw sea water from the Atlantic Ocean (and thus the quality of the receiving surface waterbody), sea water sampling was undertaken by ESC, on behalf of AEL at locations to the east and west of the proposed route of the intake and discharge pipelines. Supplementary information in relation to the baseline conditions has been presented in Appendix 7A of this ESIA.

7.3.11 A range of substances were analysed (for samples taken across the tidal cycle). The results of the sampling, for the substances relevant to this assessment, are presented in Table 7.5.

Table 7.5: Results of ESC Sea Water Sampling (µg/l)

Substance	East		West		Assumed Baseline
	High Tide	Low Tide	High Tide	Low Tide	
Chromium	730	2170	670	1270	1210
Copper	100	200	280	400	245
Iron	130	240	160	150	170
Lead	2.9	10	3.7	2.4	4.8
Zinc	- *	10	- *	10	10

** Below detection limit*

7.3.12 The assumed baseline shown in Table 7.5 is taken as the average across the tidal cycle and between the two monitoring locations. It is noted that some of the concentrations presented in the above Table exceed the EQS presented in Table 7.4. However, the EQS have been assumed for the purposes of this assessment only (and are UK standards). Therefore no conclusion is given, or implied, on the current water quality in this location.

Ground Contamination

7.3.13 To establish the potential for contamination in soils and ground water within the Project site, an limited intrusive investigation, including soil sampling and testing was carried out across the Project site. The findings of this investigation found that arsenic is of concern within the soil.

7.3.14 Arsenic was found to exceed the intervention values within four of the seven samples analysed, and was identified at depth of between 0.5m – 2m below ground level.

7.3.15 No other contaminants of concern were identified within the soils.

7.3.16 Further details in relation to the potential impact on site workers and human health are provided in Chapter 10 (Soils and Geology).

7.4 Environmental Impact

Construction / Decommissioning

7.4.2 During construction and demolition of the plant, the key risks to the water environment include:

a Impact on local water resources for water supply;

b Contamination of surface water runoff that could pollute receiving surface water bodies; and

c Flood risk to construction workers and construction plant.

Impact on local water resources for water supply

7.4.3 A small amount of water will be required each day for the construction and demolition works and for personal hygiene. This water will likely be brought in by tanker and therefore no surface water or groundwater abstraction will be required.

7.4.4 The sensitivity of local water supply resources, including Anankwari River, Anankwari River Tributary and Atlantic Ocean, is assessed to be “high”, however the magnitude of impact is expected to be “negligible” due to the temporary nature of the affect. The impact is therefore considered to be of Neutral Significance.

7.4.5 Potential impact on groundwater resources used for water supply is considered in Chapter 10.

Contamination of surface water runoff

7.4.6 Construction and demolition activities have the potential to contaminate surface water. Risks to surface water during construction and demolition include:

a Increased sediment loads caused by site runoff containing elevated levels of suspended sediment. This can result from activities such as land clearance, excavation, dewatering of excavations, wheel washing and storage and transportation of site materials;

b The release of hydrocarbons and oils dues to increased vehicle movement on the site, leakage from oil/fuel storage tanks and accidental spillages;

c Accidental leaks of hazardous materials, particularly concrete and cement products, which can be contained in uncontrolled washdown water and surface water runoff; and

d Contaminated leachate (including arsenic) discharging to surface water bodies due to the creation of soil piles formed during excavation, levelling and other such on-site works.

7.4.7 Embedded mitigation measures will minimise the risk of contamination of surface water runoff. These measures include the implementation of a detailed mitigation measures and the use of oil interceptors to prevent hydrocarbons discharging from site. As a result of the implementation of the identified mitigation, the impact of surface water runoff is considered to be of “slight adverse significance”.

Flood Risk

7.4.8 The Project site is situated in a wetland area which has the potential to become flooded. However to mitigate this, the plant has been designed to raise the ground level of the site by approximately 4m to ensure that all plant items are above the high tide level.

7.4.9 During construction, prior to the level of the land being raised sufficiently to be above the flood level, there will be a period of time when construction staff will be required to work with this area which is potentially liable to flooding.

7.4.10 In order to address this risk, flood mitigation procedures will be developed, as part of the CESMP, following the detailed design of the plant which will identify a process for forecasting the potential risk of flooding and allocation appropriate evacuation routes / procedures etc.

7.4.11 Given that the nature of flooding in the area is likely to be a result of tidal inundation, the raising of the ground level will not result in displacement of water to other potentially sensitive areas.

<u>Operation</u>

7.4.12 During operation, the principal source of potential water quality impacts will be the direct discharge of the combined Project effluent to the Atlantic Ocean. There overall effluent will be a concentrated solution of the TDS in the raw sea water, together with some additional sodium sulphate or sodium chloride produced as a result of any effluent neutralisation requirements. In addition, the effluent may contain small amounts of ammonia and phosphate, from the blowdown, and trace amounts of oil following treatment oil interceptors.

7.4.13 The anticipated composition of the overall Project effluent has been calculated based on the anticipated concentration of the TDS, by the Project processes, between the proposed intake and the combined effluent discharge. This is presented in Table 7.6.

Table 7.6: Anticipated Composition of the Combined Project Effluent

Substance / Parameter	Value	Unit
Chromium	2541	µg/l
Copper	514.5	µg/l
Iron	357	µg/l
Lead	10	µg/l
Zinc	21	µg/l
Cadmium	1.2 *	µg/l
Mercury	1.1 *	µg/l
pH	6 – 9	-
Temperature	No more than ±3	°C (above ambient temperature)

** Cadmium and mercury content is based on the presence of trace amounts of these substances in acid or caustic required for neutralisation; wherever possible, AEL will source such chemicals that are free from cadmium and mercury.*

7.4.14 As per the first screening test outlined in Section 7.2, the levels of iron and zinc are within the EQS assumed for the purposes of this assessment. Therefore the potential impacts in respect of these two substances are considered to be insignificant.

7.4.15 For the remainder, the second screening test needs to be applied. A bathymetric survey of the proposed pipeline subsea corridor was commissioned, by AEL, and the results are published in the 'Phase II Multi-Beam Echosounding and Side-Scan Sonar Survey Report for Amandi Energy' (Envaserv, 2014).

7.4.16 The proposed discharge location will be approximately 600 m offshore in an area where the depth of water (relative to Chart Datum) is approximately 6-8 m. However, approximately 500 m further south of the proposed discharge, the seabed within the corridor rises by up to 4 m which may impact on the tidal currents (and their potential contribution to the initial dilution of the combined effluent discharge. It is not possible to determine if the proposed discharge location is in an area with restricted dilution / dispersion characteristics.

7.4.17 For the purposes of this assessment, a worst case assumption has been taken that this could be the case, therefore the third screening test is required.

7.4.18 As above, the proposed discharge location will be approximately 600 m offshore in an area where the depth of water (relative to Chart Datum) is approximately 6-8 m. Therefore the discharge location is:

a More than 50 m offshore; and

b Where the sea-bed is more than 1 m below Chart Datum.

7.4.19 As such, the potential impacts in respect of the identified substances can be considered to be insignificant.

Hazardous Substances

7.4.20 As discussed in Section 7.2, the assessment of the potential impacts of trace amounts of cadmium and mercury in the combined effluent also requires consideration of the annual mass discharge of these potential pollutants.

7.4.21 Based on the concentrations presented in Table 7.6, it is anticipated that the Project will discharge up to 255 g/year of cadmium and up to 240 g/year of mercury (where supplies of acid and caustic free of such chemicals cannot be sourced).

7.4.22 For both cadmium and mercury, the anticipated worst case annual mass discharges are significantly less than the respective Significant Load thresholds.

7.4.23 Therefore, the potential impacts to water quality from cadmium and mercury discharges are considered to be insignificant.

7.5 Mitigation

Construction / Decommissioning

7.5.2 As detailed in above, three sources of potential adverse impact on the water environment have been identified during the construction / decommissioning phase. However, this has shown that they are of negligible impact due to the inbuilt mitigation measures which will be embedded within the detailed design of the plant. As such, no further mitigation is considered necessary.

Operation

7.5.3 For the raw water abstraction infrastructure, screens will be fitted to the water inlet and the intake pipeline will be designed to prevent the entrainment of marine ecology. The abstracted water will be subject to continuous or intermittent (shock) dosing with a biocide (such as chlorine dioxide or sodium hypochlorite) to prevent bio-fouling within the intake pipework.

7.5.4 No specific significant impacts are anticipated from the combined effluent discharge, however the process effluents draining to the collection system will be monitored for various parameters, including pH, temperature and flow rate.

7.5.5 The quality of the combined effluent will be monitored and treated (e.g. neutralised) accordingly. This treated effluent will be continuously monitored and, should significant amounts of any relevant substance within the effluent be recorded, the discharge will be stopped and the water retained on-site. Correction measures will be employed in order to rectify the performance of the treatment systems prior to resuming the discharge of the combined effluent to the Atlantic Ocean.

7.5.6 In addition, the cadmium and mercury content of the combined effluent will be based on the presence (or otherwise) of trace amounts of these substances in acid or caustic required for neutralisation; wherever possible, AEL will source such chemicals that are free from cadmium and mercury.

7.5.7 All oil and chemical storage tanks and areas where drums are stored will be surrounded by an impermeable bund. Single tanks will be within bunds sized to contain 110 per cent of capacity and multiple tanks or drums will be within bunds sized to contain greater than 110 per cent of the capacity of the largest tank or 25 per cent of the total tanks contents. Permanently fixed taps, filler pipes, pumping

equipment, vents and sight glasses will also be located within the bunded area. Taps and valves will be designed to discharge downwards and will be shut and locked in that position. Manually started electrically operated pumps will remove surface water collected within the bund and its composition will be verified prior to disposal.

7.5.8 The surface water drainage system will drain areas of the site unlikely to be contaminated with oil and discharge the water to the surface water drainage system. The majority of the surface water drainage will be uncontaminated and typical of surface water run-off from general paved areas or roads.

7.5.9 An oily waste water drainage system will drain all areas where oil spillages could occur. The design will incorporate suitably sized oil interceptors and traps. The treated water will be drained to the process effluent collection systems for further treatment prior to discharge.

7.5.10 All elements of all waste water treatment systems will be regularly monitored to ensure optimum performance and maintenance. At the detailed design stage, consideration will also be given to the incorporation of rainwater harvesting, as a supplementary source of fresh water feed to the demineralisation plant. This rain water harvesting has the potential, if practicable, to reduce water consumption from other sources, adding to the sustainability of the Project.

7.6 Residual Impact

Construction / Decommissioning

7.6.2 Short-term temporary impacts are likely from offshore sediment loads during construction of the pipeline.

Operation

7.6.3 The potential impacts in respect of the identified substances can be considered to be insignificant.

7.6.4 The potential impacts to water quality from cadmium and mercury discharges (where supplies of acid and caustic cannot be sourced that are free of these substances) are considered to be insignificant.

7.7 Cumulative Impacts

7.7.1 At this stage quantitative data for the other proposed power plants in the power enclave (namely T4, One Energy IPP, Globeleq IPP and Jacobsen IPP) is not available. Therefore, the prediction of cumulative water resources impacts will be qualitative. It is anticipated that all power plants will use similar power generation technology and fuel (gas or LCO in combined cycle) as the AEL plant.

7.7.2 Using this approach, it is reasonable to assume that the water balance at these proposed adjacent plants, and method of water disposal will similar to that at the AEL Project.

7.7.3 This will likely result in an increase in the discharge of sodium sulphate or sodium chloride, ammonia and phosphate to the Atlantic Ocean. Due to the large dilution capacity of the receiving Atlantic Ocean, this is unlikely to result in significant impact on this water resource.

7.7.4 Furthermore, in relation to the hazardous substances of cadmium and mercury, given that the anticipated discharges of these chemical from the AEL plant represent just 5% and 25% of the Significant Load, it is unlikely that the Significant Load for cadmium will be exceeded by the enclave,

7.7.5 At 25% of the Significant Load for mercury, there is a possibility that the total output of mercury from the enclave could exceed the threshold. However, as stated at Table 8.6 - AEL will source such chemicals that are free from cadmium and mercury. If the same approach is taken by the other power plants in the enclave, this threshold is unlikely to be exceeded.

7.7.6 Based on this cumulative assessment, similar mitigation to that proposed at the AEL plant will be required at the VRA T4, One Energy, Globeleq and Jacobsen sites to ensure that impacts on local water resources are not significant.

Table 7.7. Potential water resources impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Local communities (High)	Pollution of watercourse	Low	Low	Best practice construction methods	Negligible
Construction Workers (High)	Pollution of watercourse	Low	Low	Best practice construction methods	Negligible
	Flooding	High	Major Adverse	Implementation of flood plan and identification of evacuation routes	Negligible

Table 7.8. Potential Water Resources Impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Atlantic Ocean (	Pollution of sea water	Low	Low	Water treatment prior to discharge	Negligible

SECTION 8

ECOLOGY

8 ECOLOGY

8.1 Introduction

8.1.1 The construction, operation and decommissioning of the Project have the potential to result in adverse impacts on ecological resources through the loss, damage or degradation of habitats and the direct or indirect mortality, injury or disturbance of protected or notable species.

8.1.2 During construction all elements of the Project have the potential to displace on-site habitats and species. Habitat loss, degradation, fragmentation and increased disturbances, such as noise and light spill are likely to result in the greatest impacts. Impacts associated with the decommissioning are envisaged to be similar to those presented under the construction phase.

8.1.3 During operation the emissions to air could impact on the air quality of ecologically sensitive sites via an increase in the ground level concentrations of certain pollutants and the associated nutrient and acid deposition. In addition, noise generated by the Project and the associated increases in movement, vibration and light could cause disturbance to local species.

8.1.4 This Section therefore assesses the significant environmental effects associated with the proposed development of the Project on the existing ecological receptors within the site and surrounding areas. The ecological impact assessment is therefore presented in this Section.

8.1.5 Where appropriate, measures to prevent / minimise / control / mitigate the effects are presented and residual effects following the adoption of those measures are assessed.

8.1.6 This Section presents the ecological impact assessment for the Project and includes:

a The assessment methodology for the ecological impact assessment including methods for the identification of specific sensitive receptors;

b Significance criteria;

c The existing baseline conditions against which the assessment has been made;

d Assessment of the likely impacts of the Project;

e Proposals for the mitigation of any anticipated significant environmental impacts, as appropriate; and

f An assessment of residual impacts.

8.2 Methodology

8.2.1 The text below confirms the different development scenarios that form the basis of this assessment, the key impacts associated with them and the impact assessment methodologies applicable to each of the construction, operation and decommissioning phases.

Construction

8.2.2 During construction the Project has the potential to result in impacts on the ecology and nature conservation receptors, as detailed in Table 8.1, particularly:

a Permanent and temporary habitat loss from all elements of the Project, including degradation and fragmentation of habitats;

b Direct mortality or injury to species during site clearance and construction from all elements of the Project within terrestrial, aquatic (freshwater and marine), intertidal and marine habitats;

c Direct and indirect disturbance from construction relating to all elements of the Project; and

d Pollution caused by hazardous materials and incidental release of chemicals, fuels, waste materials and / or excess dust relating to all elements of the Project.

8.2.3 Impacts to ecology and nature conservation will be discussed with regards to:

a Statutory and non-statutory designated sites where present;

b Habitats; and

c Flora and fauna.

Operation

8.2.4 During operation, impacts to ecology and nature conservation receptors may arise due to:

a Emissions of pollutants to the air from the Project;

b Emissions of pollutants to water from the combined waste water discharge to the Atlantic Ocean;

c Movement, noise and vibrations of site plant equipment and personnel associated with all elements of the Project;

d Lighting also associated with all elements of the Project; and

e Maintenance of the pipelines.

8.3 Ecological Impact Assessment

8.3.1 The methodology for this ecological assessment has involved the following key stages:

a Consultations;

b Baseline studies and evaluation of ecological receptors;

c Identification and characterisation of potential impacts;

d Defining significance of effect;

e Survey methodologies;

f Establishment of baseline conditions per stage of works;

g Identification of effects from potential impacts upon receptors from construction phase per stage of works;

h Identification of operational effects;

i Assessment of decommissioning effects;

j Assessment of residual effects; and

k Assessment of cumulative impacts.

Baseline studies and evaluation of ecological receptors

8.3.2 Baseline information regarding ecological features, including designated ecological sites, species populations, species assemblages and habitats, was obtained from the following principal sources:

a Existing data from published sources; and

b Terrestrial and marine ecological surveys.

Desk-Study Methodology

8.3.3 A desk study was undertaken to review previously recorded information of protected / notable species and habitats in the vicinity of the Project. Sources consulted in this regard included:

a The 1995 EIA Report for T1

b The 1999 EIA Addendum (T2 expansion);

c The 2001 EIA Supplemental Addendum (Combined Cycle addition);

d EIA for Takoradi Thermal Power Plant Expansion Project (T3), 2009

e African Environmental Research Consulting Company Ghana Limited (AERC);

f Bush Power Group LLC;

g S&W Energy Solutions;

h SGT Environment Services;

i Sound Environmental Solutions Inc;

j Hoover & Keith Inc, Acoustics and Noise Control Engineering;

k EPA approved original ESIA for the Amandi Project (2014);

l Amandi CCPP Seawater Supply Intake Project (Draft, December 2014)

m Biodiversity Threats Assessment for the Western Region of Ghana (2010); and

n Site visits by local Ghanaian consultants and AEL.

Terrestrial and marine ecological survey methodologies

8.3.4 All surveys were completed by Envaserv between 26th January and 5th February 2015 employing approved survey protocols provided in detail below. The perimeter of the study area is shown in Figure 8.1 and incorporates the entire area of the AEL owned concession, of which the construction site is only part. Species recorded within the study area were assessed for their conservation value (international & national) and ecological significances.

8.3.5 All surveys and results are summarised in this Chapter, for further details refer to Appendix 8A.

Terrestrial Habitat Survey

8.3.6 A rapid but thorough survey was carried out to assess and document the assemblage of flora in accordance with standard ecological study methods (Hawthorne and Swaine, 1981; Hawthorne and Musah, 1993).The purpose of a terrestrial habitat

survey was to identify the different types of floristic habitats found within the area and to delineate their coverage and the fauna type they support.

Vegetation and Plant Species

8.3.7 The vegetation types and plant species in the study area were inventoried with the purpose of providing information on plant species diversity and their conservation importance. Quantitative data (e.g. percentage cover) was obtained with a 10 x10m quadrat along demarcated transects lines as described in the section 8.3.8 below. Plants were assessed for their conservation value as well as their economic and medicinal value to the local communities.

Transects

8.3.8 Three line/belt transects were laid along east-west axis with Transect 1 closer to the shoreline, whilst Transect 3 was farthest (Figure 8.1). Plant species along the transect lines were identified and recorded. A series of 10 x 10m frame quadrats were laid along each transect for detailed plant species enumeration and abundance cover estimation. Plant species inside the quadrats were identified and the species percentage covers estimated.

8.3.9 The transect and quadrat locations were geo-referenced.

Geographic Information System (GIS) Analysis

8.3.10 LandSat image of the site was obtained from the Advanced Land Observation Satellite and the Astrium sateliite services. The images were geo-referenced to the coordinate system of Ghana to allow overlay of other geographic features. The plant data within the transects and quadrants were superimposed on the satellite image to provide the vegetation profile of the area in order to track future changes in the vegetation structure when the power plant facility become fully operational. All images were pre-processed by the performance of atmospheric corrections and orthographic rectification to eliminate possible image errors. This pre-processing was done using IDRISI Selva[9] and ENVI 5.0[10] software. Prior to image classification using ArcGIS 10.0[11] software, a class probability and principal component assessment were done to ascertain the possible classes and the accuracy of the digital numbers of the satellite images. The filed data was consolidated into habitat map with various legends showing the locations of different types of habitats on the map.

8.3.11 All GIS process and map composition were performed using ArcGIS 10.0 from Environmental System Research Institute, an international supplier of GIS software. A local interpolation model was used to predict the shoreline topography from recorded beach profile depths. The local polynomial interpolation was used to fit a second order polynomial using points only within the defined neighbourhood of the shoreline.

9 Integrated GIS and Image Processing software
[10] Geographical Information System Software used primarily for processing and analyzing geospatial imagery
11 Geographical Information System Software used primarily for producing and analysing spatial data.

Figure 8.1 Map showing Terrestrial Flora Sampling Points

Mammal and Herpetofauna Survey

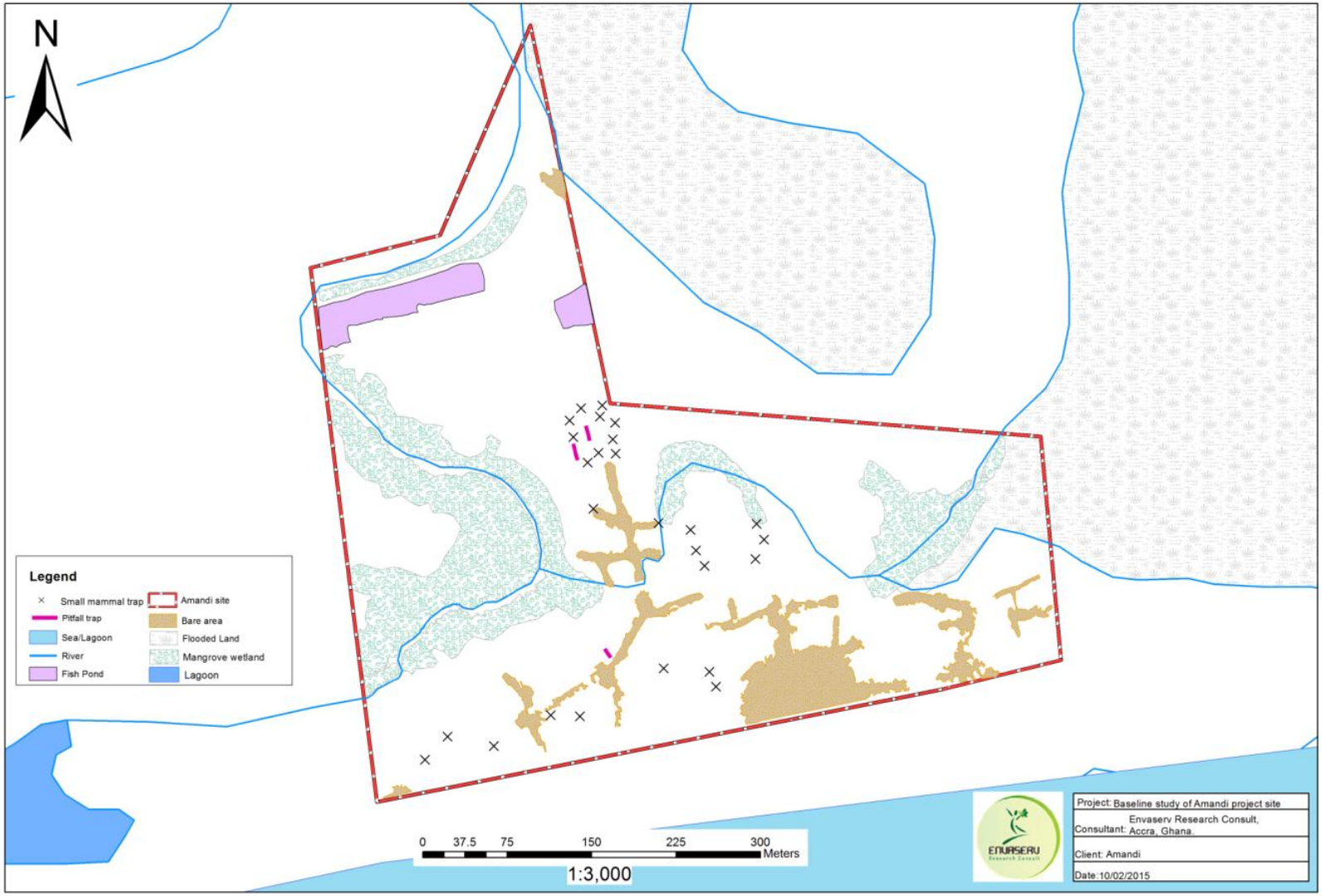
8.3.12 Mammals and herpetofauna were identified and counted in parallel with the vegetation survey. Four pitfall traps were set along a 40m drift fence along each of the three transect lines. The pitfall traps consisted of large plastic buckets spaced at 10m intervals. Each pitfall trap was buried to its rim and the space around it filled and smoothened with the dugout soil. Traps were inspected for catches in the mornings for two consecutive days.

8.3.13 Small mammals were trapped using Sherman collapsible live-traps (23cm x 9cm x 7.5cm), which were set in 10 x 10m quadrats. Three quadrats were established on each transect except for Transect 3, which had two quadrats due inaccessibility. A Sherman trap was baited with a mixture of groundnut paste and corn meal, with a trap placed in each of the corners of the quadrats. A total of 20 traps were set along the transects (see Figure 8.2). The traps were set during the day and inspected early the following morning and re- baited. This was done for two consecutive days. All the trap locations were geo-referenced.

Bird Survey

8.3.14 The bird survey was carried out using spot counts at interval of 200m along transects at the site. At each spot, birds encountered by sight or sound within 50m radius were identified and recorded. Due to the relatively small size of the site, the transects covered the entirety of the site, with observation points dotted throughout the site. Observations of birds at a distance were aided with a pair of binoculars (x10 magnification). The field survey was carried out in the morning between 6:30 am and 9:30am and also in the evening between 3:30 and 5:30pm and each species encountered was identified to the species level. Borrow and Demey, (2010), was used to confirm the identity of species encountered. Global Positioning system (GPS) reference for each observation point.

Figure 8.2 Map showing Fauna Sampling Sites



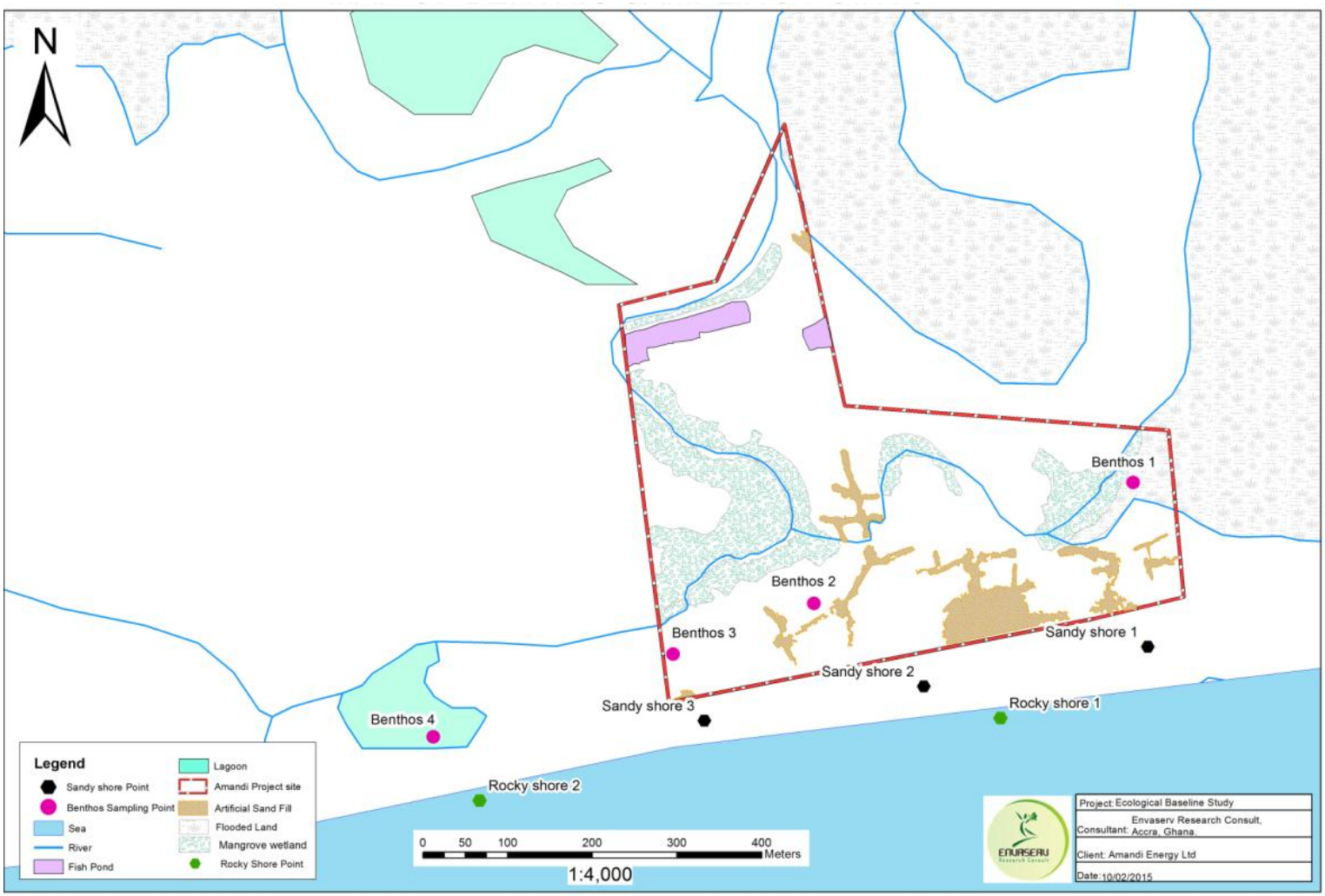
Coastal Marine Ecology

8.3.15 Three spatial locations were established for the intertidal sampling. Sandy Shore Station 1 (Eastern section shown on Figure 8.3) is characterized by artificially created groyne/headlands of rocky boulders, which was constructed to serve as breakwaters as part of the WAGP. The sheltered conditions as a result of the gryones seem to provide suitable/favourable substrate for colonization of rocky shore organisms.

8.3.16 Sandy Shore Station 2 (shown on Figure 8.3) is the mid-section and lies within AEL's Project site. The site is characterized by a small extent of exposed rocky seabed/outcrops which are covered during high tides. The site is represented by a gradient of exposure to the prevailing tidal currents and wave. Along the beach slope beyond the 30m sandy beach present a uniformly distinct green algal belt of Chaetomorpha linum with patches of Ulva flexuosa.

8.3.17 Sandy Shore Station 3 (shown on Figure 8.3) is located at western section beyond the Anankwari lagoon and it's composed of high rising rocky outcrops which provides sheltered condition and microhabitat for some organism notably sea urchins, Echinometra lacunter.

Figure 8.3 Map showing Benthic Sampling Points.



Rocky Shore

8.3.18 Sampling on the rocky shore (Rocky Shore 1 and 2 as shown on Figure 8.3) was designed to accommodate small scale heterogeneity along the shore slope. As a result, single belt transects of three were laid at each site from the back shore to the low water mark. Each transect extends to the sublittoral within safety limits imposed by the natural features, channels and conditions present at the seaward end. A continuous $1m^2$ quadrat was placed along each transect to identify and estimate species percentage cover (macroalgae) and count epibenthic animals. In cases of high numerical abundance of encrusting organisms (e.g., barnacles), actual 5% of the coverage in the quadrats was counted and the total percentage cover of the species extrapolated with the 5% count.

Sandy Shore

8.3.19 The sandy shore survey comprised of macro invertebrates and crab ecology as detailed below.

Macro-invertebrate

8.3.20 In all, three Sandy Shore Stations were located on east to west transect (as shown on Figure 8.3). An open ended box corer of surface area $0.1m^2$ (0.3 x 0.3m) was placed randomly at each location within the sub-tidal area. Sediment samples were collected from the upper 30cm into a 0.5mm mesh size sieve. The sediment samples were carefully washed in the sieve with seawater to get rid-off fine grain materials. The retained sediments were transferred into labelled plastic containers and fixed with 10% pre-buffered formaldehyde/Rose bengal solution for later taxonomic identification in the laboratory. In the laboratory, all the samples were washed to remove the formaldehyde solution and further get rid-off fine sediments. The washed sampled were sorted, identified and counted under a stereoscopic microscope.

Crab Ecology

8.3.21 Semi–terrestrial crabs especially of the genus *Ocypode* are characteristic members of the tropical sandy shore population. These crabs are ecologically and economically important as they provide practical estimates for assessing the level of anthropogenic impact on beaches due to their occurrence and abundance. Two horizontal line transects measuring about 20m each were laid on an east to west axis to cover the mid-section of the sandy shore. A $1m^2$ quadrat was laid randomly along each transect. The number of crab burrows per quadrat were counted and recorded as well as crab the hole density. Further, the diameters of the holes were measured to serve as a surrogate of the age structure of the *Ocypode* population. Crabs were also trapped and identified.

Aquatic Ecology

Mangrove and Lagoon Macro-invertebrates

8.3.22 Four sampling stations were located in an east to west transect within the mangrove wetland and the Anankwari lagoon. At each station, three PVC corer samples (with area equivalent to 0.063 m_2) constituting one replicate was collected from the 0.20m surface layer where the macro-invertebrates predominantly dwell. Two replicate samples were collected at each location. The sediment samples were washed through a sieved of a mesh size of 0.5 mm to remove fine-grained sediment. The retained sediment material in the sieve was put into HDPE containers and treated

(fixed) with 10% formaldehyde. Rose Bengal solution was added to the samples to facilitate sorting (picking of organism) in the laboratory. The formaldehyde will fix the internal organs and prevent deterioration of the organisms.

Aquatic Flora

8.3.23 Aquatic flora assessment and sampling was carried out at representative sections of the sites. The assessment method adopted was mainly opportunistic qualitative counts to document the species richness (i.e., number of species). Local inhabitants also provided information on the composition of the dominant species to supplement primary data collected.

Identification of Receptors

8.3.24 The value of sites, populations of species, species assemblages and habitats was evaluated with reference to: their importance in terms of 'biodiversity conservation' value (which relates to the need to conserve representative areas of different habitats); and their legal status.

8.3.25 Conservation Value:

Designated Sites

8.3.26 The conservation value of the site gives an indication of the necessity to conserve areas based on factors such as the importance of the site on a national and/or regional scale and on the ecological state of the area (degraded or pristine). This is determined by the presence of a high diversity, rare or endemic species and areas that are protected by legislation. The criteria used are defined as follows:

- High – Ecosystems with high species diversity and usually provide suitable habitat for a number of threatened species. These areas should be protected.
- Medium – Ecosystems with intermediate levels of species diversity without any threatened species.
- Low – Areas with little or no conservation potential and usually species poor (most species are usually exotic).

8.3.27 Areas of high sensitivity: Remnant forest patches, riparian areas as well as buffers around these areas are classified as highly sensitive and no development should occur within these areas.

8.3.28 Areas of medium sensitivity: Degraded woodland and corridors linking areas of high sensitivity.

8.3.29 Areas of medium to low sensitivity: Degraded area and historically cultivated areas. These areas are of low ecological sensitivity and can be used for agricultural activities.

Habitats

8.3.30 Guidelines on ecological impact assessment note the difficulty of devising valuation criteria that can be consistently applied to designated sites, habitats and species. The importance of habitats is evaluated on the basis of their size, recognised status (e.g. IUCN Red List of Threatened species (IUCN, 2014) and legal protection status

(e.g. the Ghana Wildlife Conservation Regulation 1971 (LI 685)). Their ecosystem service value has also been taken into consideration.

Species populations

8.3.31 The importance of populations is evaluated on the basis of their size, recognised status (e.g. ICUN Red List) and legal protection status. Assessment of the conservation status focused on the various IUCN threat categories whereas protection status focused on Schedule I of the Wildlife Conservation Regulation. All animal species listed under Schedule I of the Wildlife Conservation Regulation 1971, LI 685, are Wholly Protected in Ghana from any form of hunting and capture. Bird populations, for example, exceeding 1% of published bio geographic populations are considered to be of international importance; those exceeding 1% of published national populations are considered to be of national importance, and so forth. In some instances it is the species assemblage that is of importance.

8.4 Identification and Characterisation of Potential Impacts

8.4.1 The likely impacts of the Project during construction, operation and decommissioning, and the potential ecological effects arising from them are identified and characterised as discussed below.

8.4.2 Any activity or development in a natural area will impact on the surrounding environment in either a positive or negative way. The purpose of this study was to determine and assess the major impacts associated with proposed power plant facility development on the ecological environment.

8.4.3 The environmental impacts are assessed with mitigation measures and without mitigation measures and the results presented in impact tables (Table 8.5 and 8.6) which summaries the assessment.

8.4.4 The criteria against which these activities were assessed are discussed below.

Nature of the Impact

8.4.5 This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Magnitude of potential impacts

8.4.6 This indicates the degree to which the impact would change the conditions or quality of the ecological environment. This was qualified as low, medium or high.

8.4.7 Ecological receptors are usually nature conservation sites, habitats, species assemblages or communities, or populations or groups of a species. Impacts can be permanent or temporary, direct or indirect, and can be cumulative. These factors are brought together to assess the magnitude of the impact on particular receptors and, wherever possible, the magnitude of the impact is quantified. Professional judgment is then used to assign the impacts on the receptors to one of four classes of magnitude, defined in Table 8.1.

Table8.1: Definition of Magnitude

Magnitude	Definition
High	A permanent or long-term effect on the extent or size or integrity of a site, habitat, species assemblage or community, population or group. If adverse, this is likely to threaten its sustainability; if beneficial, this is likely to enhance its conservation status.
Medium	A permanent or long-term effect on the extent or size or integrity of a site, habitat, species assemblage or community, population or group. A short-term effect which will adversely affect the integrity of a receptor in a permanent manner. If adverse, this is unlikely to threaten its sustainability; if beneficial this is likely to be sustainable but is unlikely to enhance its conservation status.
Low	A permanent, long-term reversible or short-term effect on a site, habitat, species assemblage or community, population or group whose magnitude is detectable but will not threaten / change its conservation status.
Negligible	A short-term reversible effect on the extent, size or integrity of a site, habitat, species assemblage or community, population or group that is within the normal range.

8.4.8 Potential impacts are characterised initially in the absence of any mitigation, except where this is integral to the design of the proposed development. Any additional mitigation or compensation proposed is identified and its likely effectiveness is assessed.

Extent of impact

8.4.9 A description of whether the impact will be local (extending only as far as the servitude), limited to the study area and its immediate surroundings, regional, or on a national scale.

Duration of the Impact

8.4.10 This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

Probability of Occurrence

8.4.11 This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

Identification of Significant Effects

8.4.12 The significance of the predicted effects on ecological receptors arising from the identified impacts of the proposed development, including embedded and additional mitigation measures, is assessed. Significance is assessed as Negative, Positive or Not Significant.

Negative effects

8.4.13 For habitat areas and species, an effect is considered to be significant if the conservation status of a receptor is compromised by the final design of the Project, which can be defined by:

a Habitats – 'conservation status is determined by the sum of the influences acting on the habitat and its typical species that may affect its long-term distribution, structure and functions as well as the long-term survival of its typical species within a given geographical area'.

b Species – 'conservation status is determined by the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within a given geographical area'.

8.4.14 The decision as to whether the conservation status of a receptor is likely to be compromised is made using professional judgement based on an analysis of the predicted impacts of the proposed development (including consideration of the specific parameters outlined above).

8.4.15 A similar procedure is used for designated sites that are potentially affected by the Project, except that the focus is on the effects on the integrity of each site thus affection its ability to sustain the habitat, complex of habitats and / or levels of populations of species for which it is important.

Positive effects

8.4.16 A positive effect is considered to be significant if the Project activities cause:

a Restoration of favourable conservation status for a habitat / species population; and / or;

b Restoration of a site's integrity (where this has been undermined).

8.4.17 Following the assessment of how each receptor may be affected and its subsequent level of significance, relevant mitigation and / or compensation measures (in addition to the embedded mitigation) are identified. Once identified, the mitigation will be designed to reduce potential significant impacts. With respect to sites which support protected species, there may also be a legal obligation to provide such mitigation.

8.4.18 The likely effectiveness of all the mitigation is then assessed and the residual impacts described.

8.5 Existing Environment

Description of the Survey Area

8.5.2 The current baseline was determined and appraised through a combination of desk-based study and specific flora and faunal surveys for particular protected / notable habitats and species of conservation concern.

8.5.3 As discussed, the Project will be located in the Shama District of the Western Region of Ghana. The western boundary of the site is defined by the Anankwari River which flows into the Atlantic Ocean (Gulf Of Guinea). The southern boundary of the Project's site is approximately 100 m inland from the coast, located to the south of the site.

8.5.4 The natural habitats surrounding the site are varied in nature. South of the Project site there are coconut plantations; this strip of land has been acquired by agreement with the landowners and forms part of the land owned by AEL. Along the coast, through the coconut plantation, is a footpath occasionally used by the community members of Abuesi and Aboadze, to access the Anankwari lagoon, to the west of the Project. To the north and east of the site there is a combination of marshland and

relatively higher grounds. The marshland forms part of the Anankwari lagoon catchment. The vegetation types include mangroves and other shrubs as well as isolated palm and coconut trees.

Habitats within the Study Area

8.5.5 The 1995 EIA Report for T1 divided the terrestrial plant communities along the coastal zone into four major environments: marine, intertidal zone, strand zone and evergreen shrub zone, these habitats were verified by further survey in 2015. Habitats within these zones are covered in more detail below.

Coastal Environment - Lagoon

8.5.6 The Anankwari lagoon (approximately 300m west of the Project site) is a semi-closed shallow water body separated from the sea by a sand barrier, and connected at least intermittently to the sea by restricted inlets. It is usually oriented shore-parallel. Due to its interface location, between land and sea, and low depth, the lagoon is strongly submitted to natural constraints. Direct (wind) and indirect (rain through river flows) climatic and marine (tide) influences cause large differences and quick changes in the physical and chemical characteristics.

Figure 8.4 Anankwari Lagoon, Estuary and Sand Barrier

Coastal Environment - Vegetation

8.5.7 The Anankwari lagoon also behaves as estuarine wetlands as it is linked to perennial streams and rivers as well as plains of estuaries that are seasonally inundated during the rainy seasons. The lagoon contains strands of mangroves typically *Avicennia* and *Rhizophora*.

Figure 8.5 Stands of Mangrove on the Anakwari Floodplain

Figure 8.6 Mangroves on the Shoreline of the Anakwari Stream

8.5.8 The mangrove forest is one of the biologically rich habitats in the Project area. Another obvious change is the increase in bare land or artificially sand filled areas, which may have been created by recent activities on the land (e.g., scientific study). Artificially sand filled areas and clearing of vegetation have increased particularly in the southern and central areas attributed to pre-construction activities (access to borehole drilling sites). The eastern sections have remained waterlogged with moderately dense shrubs and grasses.

Terrestrial Vegetation

8.5.9 Growth is related to windiness, saline conditions, salt spray, and looseness of the soil.

8.5.10 The intertidal zone is the present beach zone and has little plant life except for well-attached marine algae and microscopic organisms. (This zone was included in the terrestrial vegetation zoning although it is also part of the marine environment).

8.5.11 The strand zone can be divided into the pioneer zone, where plant cover is low and growing conditions difficult, and the main strand zone where there are more stable communities. The pioneer zone is characterized by *rhizomatous* or *stolonilerous* species with their underground spreading root systems stabilizing the shifting substrate.

8.5.12 The main strand zone has a higher ground cover, better soil texture, and higher organic matter. There is a greater variety of plants and not all are adapted to saline conditions. Common grasses are *Androdopon gavanus* and *Heterodopon contortus*. This zone is often the site of copra (coconut palms) plantations. Landward, the strand zone gradually merges into the evergreen shrub zone. The shrubs may be dwarfed and shaped by the prevailing winds.

8.5.13 In Ghana, immediate coastal zone vegetation is broadly mapped as strand and mangrove. On a broad scale, the regional vegetation pattern of the area inland of Sekondi-Takoradi and extending east just beyond Shama Bay (located 7km northeast of the site), encompassing the Project area, is dry semi-deciduous. Mangrove communities may develop, especially within the coastal lagoons and, locally, these are mainly found to the west of Cape Three Points (located approximately 52km southwest from the site).

8.5.14 The area surrounding the proposed AEL site is mainly comprised of three main zones of flora / vegetation in the study area: coastal stand, seasonal swamp / wetland and grassland; and isolated clumps.

8.5.15 Portions of the study area, particularly along the shoreline, have been converted into coconut (*Cocos nucifera*) plantations. The vegetation comprised of thickets, wetlands, and strand especially at the western section of the thermal plant.

8.5.16 The strand zone is stabilized by the cultivation of coconut palms, with the exception of a central area, which was subjected to previous sand extraction activities. Coconut palms, sisal, and *Sesuvium* sp. are the dominant plant species in the coastal belt. The coastal strand is characterized by flora of the *Cyperus-Ipomeoa* association.

8.5.17 The freshwater swamp within the study area occupies a depression between the strand vegetation and the scrub or thicket vegetation. It is dominated by *Cyperus articulatus*. Further inland, the wet low-land area is dominated by grasses and sedges; while native shrubs are present in limited numbers on one of the higher knolls near the north boundary of the site. Wild oil palms are scattered throughout the site at elevations above 3 to 4 m. The majority of the land above 3 m with the above noted exceptions is subject to shifting cultivation.

Figure 8.8 AEL Site vegetation – wild palms above the Anankwari floodplain

Figure 8.9 AEL Site vegetation in lower ground waterlogged after heavy rain

Figure 8.10 AEL Site – Coconut plantation and typical coastal stand vegetation

Results of Detailed Botanical survey

8.5.18 The vegetation of the study area falls within the dry semi-deciduous and includes extensive mangrove forest. In general, the vegetation of the area is made up of mixtures of herbs (41.4%), shrubs (25%), trees (18.7%), grass (9.3%), and vine (5.3%). The floristic composition indicates a moderate diverse community consisting of herbaceous species and grasses. In all, a total of 76 plant species from 37 families were recorded along the three transects. The families with the highest occurrence were *Fabaceae*, *Asteraceae, Malvaceae* and *Poaceae*, whilst *Apocynaceae, Euphoribiaceae, Rutuceae* showed the lowest occurrence. Plants species belonging to the family *Rutuceae (Zanthoxyloides zanthoxylem*), *Avicenniaceae (Avicennia germinans), Poaceae (Paspaluum vaginatum), Arecaceae (Phoenix reclinata) and Rhizophoroceae (Rhizophora racemosa)* were particularly common in the study area. The plant species with the highest occurrence (F>50%) were *Azadirachta indic*a, *Phoenix reclinata, Zanthoxyloides zanthoxylem, Paspallum vaginatum and Cocos nucifera.* The grass *Paspallum vaginatum* accounted for a greater proportion of grass species that showed increased abundance coverage northwards. Of the herbal plant species, *Passiflora foetida, Crotalaria retusa* were common. The dominant trees species were the coconut (*Cocos nucifera*), Neem tree (*Azadirachta indica*) and the wild date palm (*Phoenix reclinata*). Along east-west gradient, the *Zanthoxyloides zanthoxylem* accounted for more than 40% of the vegetation within Transect I, with coverage increasing westward of the concession.

8.5.19 During the botanical survey in 2015, three important wetland mangrove species encountered were the *Avicennia germinans, Rhizophora racemosa* and *Laguncularia racemosa*, which formed more than 60% coverage of the total land area (see Figure 8.4). It is worth noting that the study area is one of the few wetlands in Ghana where all the three mangrove species are present. Thus the study area is critical in terms of the mangrove diversity and the potential biodiversity it supports. Mangroves are salt tolerant trees and shrubs that grow within the sheltered marine intertidal zones of the tropics and subtropics (Long and Giri, 2011). Mangrove forests are known to support significant aquatic biodiversity, serving as breeding ground for some marine and estuarine species, buffer against coastal storm, purification of water pollutants, carbon

sequestration (thus important climate change mitigator) as well as numerous ecosystem good and services to coastal populations such as firewood, charcoal, medicines, thatching used for construction, making mangrove forest a highly sensitive receptor.

8.5.20 It is stated in the Biodiversity Threats Assessment for the Western Region of Ghana, 2010 that 'Mangrove forests in Ghana are sparse and are associated with coastal lagoons and estuaries (Hughes and Hughes, 1991). In 1995, the total land area covered by mangroves was estimated at 10,000 ha (Saenager and Bellan, 1995) and is expected to have been significantly reduced currently. Good mangroves stands are restricted to three main areas: the Amanzule wetlands in the Western Region, the Kakum River estuary west of Cape Coast (Central Region), and the Volta Delta. It goes on to state 'Five species of mangroves are found in Ghana- the red mangroves, Rhizophora racemosa, Rhizophora mangel and Rhizophora harrisonii and the white mangroves Avicennia germinans and Laguncularia racemosa. The red mangroves occur in open lagoon systems which have regular tidal exchange whereas the white mangroves are primary colonists of closed lagoons (Sackey et. al., 1993). The richest diversity of mangroves occurs in the flood plains of the Kakum River at Iture which contains all five species of mangroves…..the extent of mangrove depletion in the country as a whole and the Western Region in particular is unknown (Water Research Institute, 2006).'

Plant Species Conservation Status

8.5.21 Almost all the plant species recorded were either 'yet to be assessed' (i.e. not yet evaluated against IUCN Criteria) or were of 'Least Concern' per the IUCN Red List.

Plants of Economic Importance

8.5.22 Nearly all of the encountered plants were economic plants. Also, numerous plant species encountered in the area were of medicinal value. In fact, nearly all of the terrestrial plant species can be used for medicine, food, craft, dyes, oil, fuel and games. Medicinal plants play a major role in the health system of rural communities with more than 73 species used in Ghana. Important medicinal plants recorded included *Azadirachta indica, Chromolaena odorata, Secamone afzelli, Passiflora foetida, Indigofera arrecta, Eclipta alba, Jatropha gosypiifolia* and *Ocicum canum*.

*Agricultural Plant*s

8.5.23 About 6 crop plants belonging to 4 families are cultivated in a farm north of the study area. The crops include cassava *(Euphorbiaceae),* maize *(Poaceae)*, okro *(Malvaceae)*, garden eggs (eggplant), tomato and pepper *(Solanaceae)*. The crop plants density was moderately high compared to the small farm size. The farm was weedy and the crop plants appeared dry and withering.

<u>Fauna</u>

Distribution of Small Mammals and Herpetofauna

8.5.24 Approximately 230 species of mammals are found in Ghana. Further there are around 160 reptile and 80 amphibian species in Ghana. The diversity of small mammals, reptiles and amphibians in the studied habitat was generally low with a record of five species, which was made up of two species of small mammals and three species of reptiles (Table 8.2). None of these recorded species is listed by IUCN as endangered, vulnerable or threatened. The Agama lizard and orange flanked skink recorded have

not been ranked by the IUCN. A list of mammals and herpetafauna likely to be using the habitat is provided in Table 8.3.

8.5.25 Small mammals, amphibians and reptiles provide insight to environmental health and faunal diversity because they have high energy conversion efficiency and reproductive rates and therefore serve as food sources for many other organisms. As a result, their presence as well as changes in their diversity and populations is seen as ecological indicator to deduce trends in other faunal communities. A total number of twelve small mammals were captured in the area of which 92% were Multimammate mice (*Mastomys natalensis*) and 8% being Soft-furred mouse (*Praomys tulbergii*). The eleven small mammals (92%) were captured by the Sherman trap whilst I (8%) was captured by the pitfall trap. Strikingly, of the 92%, 73% were found in transect one (near the shoreline). This percentage composition of the small mammals decreased through 18% on Transect two to 9% on Transect three.

Table 8.2 Showing results of herpetafauna and mammals found in the study area

Class	Common name	Species name	Number recorded	Method of recording			IUCN ranking	National
				Sherman Trapping	Pitfall trapping	Opportunistic observation and refuge search		
Reptilia	Agama lizard	*Agama agama*	1			✔	-	Not Listed
	Orange flanked skink	*Trachylepis sp*	1			✔	-	Not Listed
	African beauty snake	*Psammophis sibilans*	2			✔	LC	Not Listed
Mammalia	Natal multimammate mouse	*Mastomys natalensis*	11	✔	✔		LC	Not Listed
	Tullberg's soft-furred mouse	*Praomys tulbergi*	1	✔			LC	Not Listed

LEGEND

IUCN: The International Union for the Conservation of Nature and Natural Resources (IUCN) periodically publishes a Red List of Threatened Species List which categorises globally-threatened animals as follows:

X Extinct: No reasonable doubt that the last individual has died

EW Extinct in the wild: Known only to survive in captivity or as naturalized populations well outside its previous range

CR Critically Endangered: The species is in imminent risk of extinction in the wild

EN Endangered: The species is facing an extremely high risk of extinction in the wild

VU Vulnerable: The species is facing a high risk of extinction in the wild.

NT Near Threatened: The species does not meet any of the criteria that would categorise it as risking extinction but it is likely to do so in the future

LC Least Concern: There are no current identifiable risks to the species

DD Data Deficient: There is inadequate information to make an assessment of the risks to this species.

Table 8.3 A list of mammals and herpetafauna likely to be regular users of the study area

Class	Species	Common Name	IUCN ranking	National
Reptilia	*Pelomedusa subrufa*	Marsh Terrapin	LC	II
	Lygodactylus conraui	Gecko	LC	Not Listed
	Varanus. niloticus	Nile Monitor	LC	I
	Bitis arietans	Puff Adder	LC	II
	Causus maculates	Night Adder	LC	Not Listed
	Python regius	Royal Python	LC	II
	Python sebae	African Python	LC	II
	Chelonia mydas	Green Turtle	EN	I
Mammalia	*Crocidura oliveri*	White-toothed Shrew	LC	Not Listed
	Mus minutoides	African pygmy mouse	DD	Not Listed
	Arvicanthis niloticus	Rufous Nile rat	LC	Not Listed
	Rattus rattus	Common Rat	LC	Not Listed
	Cricetomys gambianus	Gambian Giant Pouched Rat	LC	II
	Thryonomys swinderianus	Grasscutter	LC	Not Listed
	Lophuromys flavipunctatus	Brush-furred Mouse	LC	Not Listed
	Protoxerus aubinii	Slender-tailed squirrel	*LC*	II

Legend

Schedule I – species are completely protected under Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995 (i.e., their hunting, capture or destruction is prohibited at all times)

Schedule II – species are partially protected under Ghana's Wildlife Laws (Ghana Wildlife Conservation Regulations, 1971, and Ghana Wildlife Conservation (Amendment) Regulations, 1988; 1995 (i.e., their hunting capture or destruction is absolutely prohibited between 1st August and 1st December of any season, and the hunting, capture and destruction of any young animal, or adult accompanied by young, is absolutely prohibited at all times).

Conservation Value of Mammals and Herpetafauna

8.5.26 The assessment did not reveal any endangered, vulnerable or threatened species. Three of the vertebrates species recorded were listed by IUCN as Least Concern. Further, the species encountered occur in many other similar habitats and thus the proposed project may not present any adverse impact to the conservation of

herpetofauna and small mammals in the area. This statement is made per the available data for this short-term survey since long-term seasonal data was not available to enable sound evaluation of the ecological impacts. However, per the list of species associated with identified habitats of the area, there is inadequate information to make an assessment of the risks to African pygmy mouse (*Mus minutoides).*

8.5.27 One species of snake *Psammophis sibilans* was found in the area is diurnal and prey on lizards and rodents. *Psammophis sibilans* has very large venom glands and produce significant amounts of venom but the venom is mild and not dangerous to humans (Bates et al., 2014).

8.5.28 The total number of small mammals, and reptiles recorded were low and generally confirm that the habitat may not support high diversity of mammals and herpetofauna. The reason could be due in great part to the marshy nature (wetland) of the area. Although marshy wetlands are generally known for their high diversity and richness in amphibians, the noticeable absence of amphibians on the wetland could be due to the salty nature as a result of proximity to the shore. Amphibians generally are intolerant to salt water because they have no salt glands and get dehydrated in salt water (Pough et al., 2003). Although the small mammal diversity of the habitat is generally low, the highest abundance was noted along the edge habitat close to the shoreline (Transect one), and this decreased landwards through Transects two to three. This result is consistent with the observation that transects two and three, which were located landward had significant portions flooded with brackish water rendering those habitats possibly unstable and inhabitable to the small mammal species. The edge habitat (Transect one) presented a more stable habitat, not easily flooded and therefore supported relatively higher species.

Avifauna Species Composition

8.5.29 Ghana is home to approximately 725 bird species, of which about 300 are associated with the savanna-forest transition zone. A total of 91 species of birds from 33 avian families and 70 genera were recorded at the site. The composition of the avifauna reflected the general mosaic nature of the habitat condition at the site. Although the site can be described as a wetland, only 19 species (21%) of the species recorded are typically associated with water. This may be attributed to the absence of an open lagoon of considerable size at the site to serve as feeding grounds. The creeks and the marshes were rather much wooded and generally lacked the open and bare areas usually found in some coastal wetlands.

8.5.30 None of the 91 bird species recorded in the study is of any global conservation significance. However 17 of the species are listed on Schedule I of the Wildlife Conservation Regulation and thus are protected from hunting. These included species from the family *Ardeidae*, *Accipitridae*, *Falconidae* and *Tytonidae*. None of the 19 species of waterbirds recorded at the site was recorded in globally significant numbers. The profile of the species recorded suggests that the avifauna of the site may be remnant of a climax community that previously existed in the area. The fallow area of which the site formed part is surrounded by industrial activities and human settlement (as previously discussed), hence it is obvious that the birds recorded are remnant of the species that are able to withstand the prevailing environmental pressures, emanating from the persistent habitat degrading human activities.

8.5.31 Since the study was carried out during the over-wintering period, the low numbers of migrant water birds recorded reflected the low potential of the site as roosting grounds. It was obvious that the site may not be important as wetland due to the

relatively small number of waterbirds that were recorded at the site and therefore not designated as one of the Important Bird Areas of Ghana (Ntiamoa-Baidu et al., 2001). The site may however be ecologically important as a wetland in flood control. The site and its immediate surrounding areas appear to be the flood plain of a number of streams flowing down south but without access into the sea.

8.5.32 Each species has its own period of peak abundance that may vary somewhat from year to year. For most of the waders the period of maximum abundance occurs between August and March, with the months of November and December being the periods of highest abundance and diversity. The months of May, June and July have the lowest number.

Aquatic Ecology

Aquatic Plants Species

8.5.33 A total of eleven (11) species representing aquatic flora in the study area were found. The most conspicuous aquatic plant species were *Avicennia germinans, Laguncularia racemosa and Rhizophora racemosa* as well as the dense multiple trunk shrub *Conocarpus erectus*. These species were observed to be associated with the Anankwari lagoon and the extensive wetland within the project site. The edges of the wetland and lagoon were fringed with aquatic macrophytes such *as Paspallum vaginatum, Sporobolus pyramidalis, Philozerus vermicularis, Sesuvium portulacastrum, Canavalia rosea, Ipomoea perscape, Remeria maritima* and *Thespesia populnea*. Generally true aquatic plants were conspicuously absent from the study area which is attributable to the brackish nature of the wetland.

Macrobenthic Invertebrates

8.5.34 The macro-invertebrate constitute an important component of the natural wetland ecosystem. Ecologically, the macrobenthos population plays an important role in the transfer of food, energy and nutrient cycling of the wetland. They form an important link in the estuarine and marine food chain as fishes, birds and marine mammals depend on them directly or indirectly for their food supply (Barnes and Huges, 1988). The macro-invertebrates are also especially suitable for cost effective long-term comparative investigations since many of the constituent species are sedentary or sessile, relatively long lived and integrate effects of environmental changes over time.

8.5.35 The occurrence of the various macrobenthic fauna included a total of 62 individuals made up of seven species, which belong to four major taxonomic groups namely *Polychaeta, Crustacea, Insecta, Mollsuca* were recorded within the mangrove wetland. Of this number, polychaetes constituted 65%, crustacean (32%) whilst the remaining 3% is made up of insects and bivalves. *Capitella capitata* numerically dominated the invertebrate community accounting for more than 60% of the total abundance giving indication of habitats perturbation and ecologically stressed system possibly due to organically-rich mangrove sediment. *Capitella capitata* is an opportunistic polychaete that has been considered an important universal indicator of organic pollution in marine sediments (Mendez et al, 2000). The presence of populations of *C. capitata* in the wetland represents an index to evaluate disturbance impact. The Sesarmid crab dominated the crustacean community. Species of Mollusca and Insecta were poorly represented in the wetland with one species each recorded. The insect encountered belong to the order Diptera (Family *Chironomidae* and genus *Chironomus*) and was only recorded west of the concession. A noticeable observation is the increasing trend in species richness and abundance from east to west. Although, mudskippers (*Periophthalamus barbarus*) were not recorded as part

of the grab samples, they formed a significant number of the fauna of the wetland observed during the field study. Among the wetland fauna, only the mudskippers are ranked on the IUCN red list as "Least Concern", the conservation status of the other recorded fauna is yet to be assessed. Many of the recorded species are common in other mangrove forests along the Ghanaian coast.

Coastal Marine Ecology

Rocky Shore

8.5.36 A total of 18 species from 12 families in 4 phyla of marine invertebrates were identified. The fauna recorded comprised 10 species of gastropods, 3 species crustaceans, 3 species cnidarians, 1 taxa each of bivalve and echinoderm. The number of species for the gastropods was higher but the highest numerical abundance was noted for the crustacean (mainly Chthalamus dentata). The gastropods and the barnacle (crustacean) collectively contributed about 98% of the total abundance recorded (n=4295) along the 60m stretch transect. The gastropods were numerically dominated by the limpet *Patella safiana*, followed by *Echinolittorina punctata, Siphonaria pectinata* and *Nerita atrata*. The gastropod *Siphonaria pectinata* was widely distributed occurring between the eulittoral to sub-littoral. The most frequently occurring fauna in that order were *Siphonaria pectinata, Patella safiana, Echinolittorina punctata, Nerita atrata* and *Chthalamus dentata*.

8.5.37 Other species of interest that were not recorded in quadrats but observed along the transect included *Echinolittorina granosa*, *Ostrea sp, Grapsus grapsus,* and colonies of *Palythoa sp*. (yellowish brown) and *Zoanthus sp.* (blue-green). The dominance and high diversity of gastropods seems to be due to the existence of sheltered rocks onto which the gastropods easily attach. Comparatively the rocky outcrops westward recorded the highest abundance. The species recorded in this study were compared to marine invertebrate species previously reported from Aboadze. The results showed that nearly all species recorded in this study are known to exist on the rocky shore of the study area[12].

8.5.38 Zonation on the rocky shores for the fauna appeared weakly conspicuous, however, the littorind *Echinolittorina punctata* was patchily abundant over a very narrow vertical band of the littorinid zone that also had a high proportion of *Siphonaria pectinata*. Within the broad midlittoral zone were the barnacle *Chthalamus dentata, Patella safiana, Nerita atrata, Siphonaria pectinata, Thais haemastoma* and the littorinid *Enchinolittorina punctata. Patella safiana* had the highest vertical range of these species reaching into sub-littoral areas. The barnacles were fairly dense in the mid-littoral. Of the other species, *Nerita atrata* was patchily abundant in crevices cuddling together possibly to conserve moisture. The lower intertidal areas had dense coverage of macroalgae with the smaller key-hole limpet *Fissurella nebecula* occurring underneath the algae.

8.5.39 The flora composition comprised 24 macroalgae species belonging to 17 families. Of the total species 29% (7) were *Chlorophyte*s (green algae), 17% (4) *Phaeophytes* (brown algae) and 54% (13) *Rhodophytes* (red algae). All of the macroalgae species identified in the study area are 'not assesed' under IUCN. The green alga *Chaetomorha linum* laced with *Centroceras clavulatum* formed an extensive conspicuous green band on the rocks of the Eulittoral (upper intertidal). The encrusting *Lithothamnia sp.* was also common in small patches in the Eulittoral. The

[12] EIA for Takoradi Thermal Power Plant Expansion Project (T3), 2009

mid-littoral composed of a multi-species algal bed dominated by red algae *Centroceras clavulatum*. Generally the mid-littoral represented a transitional zone with high diversity of macroalage species. Typical algae species encountered include *Ulva Flexuosa, Ulva faciata, Centroceras clavulatum, Padina antillarum, Padina durvillaei* and *Ralfsia expansa, Gelidium corneum Hildenbranchia rubra, Hydropuntia dentata, Bryocladia thyrsigera, Chondracanthus acicularis and Polysiphonia ferulacea*. Patches of brown algae were common on the seaward sections to the sub-tidal areas. The seaward sections had some *Sargassum vulgare, Hydropuntia dentata* but the algae grew sparse with decreasing distance toward the sublittoral. The tidal/rock pools were considerably dominated by *Sargassum vulgare,Hydropuntia dentate, Hypnea cervicornis, Ulva fasciata* and *Delidiopsis variabilis*.

8.5.40 An interesting feature was the high population of sea urchins (*Echinometra lacunter*) within tidal pools of rocky outcrops beyond the Anankwari lagoon. The high population of sea urchin has had significant effect on the diversity and number of macroalgae, leading to the absence of soft algae, rather encrusting *Lithotamnia sp*. dominates. In addition, the rocky shores at Aboadze are known to be the type locality for the *Griffithsia schousboei*, however the species was not observed during this study.

8.5.41 The Biodiversity Threats Assessment for the Western Regions of Ghana (deGraft Johnson K.A.A. 2010) states 'rocky beaches occur at Takoradi, Princess town, and Axim …support a wide variety of macroalgae which serve as important microhabitats for epifauna and fish.'

8.5.42 Once again, it is worth noting that the macroalgae community of Aboadze is similar to macroalgae communities along the coastline of Ghana, as such the project is not expected to have any significant deleterious effect on the distribution, occurrence and composition of macroalgae.

Sandy Shore

Macrobenthic Invertebrates

8.5.43 The species diversity and abundance on the sandy shore was generally low compared to the rocky shore. This reflects the physically harsh and highly dynamic environment associated with exposed sandy beaches including the Aboadze beach. A total of 14 individuals were identified and recorded in the three samples. The macrofaunal community of the sandy shore comprised of 5 species belonging to two major taxa.

8.5.44 Crustacea were numerically dominant accounting for about 64% of the total macrofauna. The crustacean was represented by *Ocypode cursor, Excirolana sp.,* and *tanaids*. The species composition showed that the macrobenthic community was largely represented by a single species (*O. cursor*) which contributed to greater than 40% of the total abundance and spanned the whole area. *Polychaetes* were poorly represented at the various sampling points and were represented by *Goniada sp.* and *Nephtys sp*. The most dominant polychaete species was noted for *Goniada sp.* (3 ind/m^2) at Sandy shore Point 3. The macrobenthic fauna showed considerable variation in composition and abundance along the same stretch of beach, although they had similar characteristics. The abundance ranged from 2-8 individuals (mean=5±3.05). Sandy shore point 3 (west) recorded the highest abundance and lowest were at Sandy shore 1 (east). Overall species diversity and richness increased westward, similar to trends observed for the wetland macrobenthos and the rocky shore studies.

Crab Ecology

8.5.45 A total of 150 individuals belonging to *O. cursor* were recorded along the beach. The burrow size ranged between 0.03 -10 cm and 0.01-6 cm for Transect 1 and Transect 2 respectively. The maximum diameter recorded was 10 cm and the smallest burrow size was 0.01cm.

8.5.46 Sizeable burrows dominated the sandy beach an indication that the beach is less frequently disturbed by natural and anthropogenic factors resulting in the dominance of adult crabs. The number of burrows per quadrat ranged between 8-121 ind./m^2. The highest number of crab burrows and density were observed for transect 1 westward of the beach. The average burrow density (63 ind./m2) for this study was significantly higher than reported values (7 ind./m2, EIA Eni Offshore Cape Three Points Oil & Gas Project 2014) for disturbed shore in the Ellembelle district of the Western region where human use of the beach was considerably high resulting in adverse impact on the numbers of the ghost crab community. Barros (2001) found evidence suggesting significantly higher burrow density of ghost crabs with lower anthropogenic impact. Ghost crabs are ecologically important and are reported to play a vital role in the preservation of intertidal environments through the aeration of the bottom substrate as they sift through the sands. They offer practical advantage for estimating beach ecological status because of their occurrence and abundance on many beaches. Berry (1976) reported that because of their burrowing and scavenging habits, ghost crabs may be adversely affected by increased oil traffic and its resultant increase in the amount of oil spills on the beaches. Contact with oil is believed to reduce ghost crab breeding rate and increase mortality at molting. Nonetheless, globally there is no immediate adverse impact on the numbers and distribution of ghost crabs. In developing countries, including Ghana the biggest threat to the ghost crab is alterations to the upper intertidal zone caused by residential and commercial development of coastal areas. Consequently the crabs are either displaced to unfavourable environment or exterminated. Given the high abundance of ghost crabs at the project site, and along the coastline of Ghana the project is less likely to significantly impact on the populations of the species in the area.

Shoreline Morphology

8.5.47 The topography of a beach determines the effect of wave energy on that beach. Extensive and flatter shores tend to have irregular profiles and more gentle conditions, however with increasing steepness, water movement tends to be more violent. The profile of a beach extends from upper limit of wave action to the low water mark of spring tides including the seaward zone over which sediments may be moved by waves.

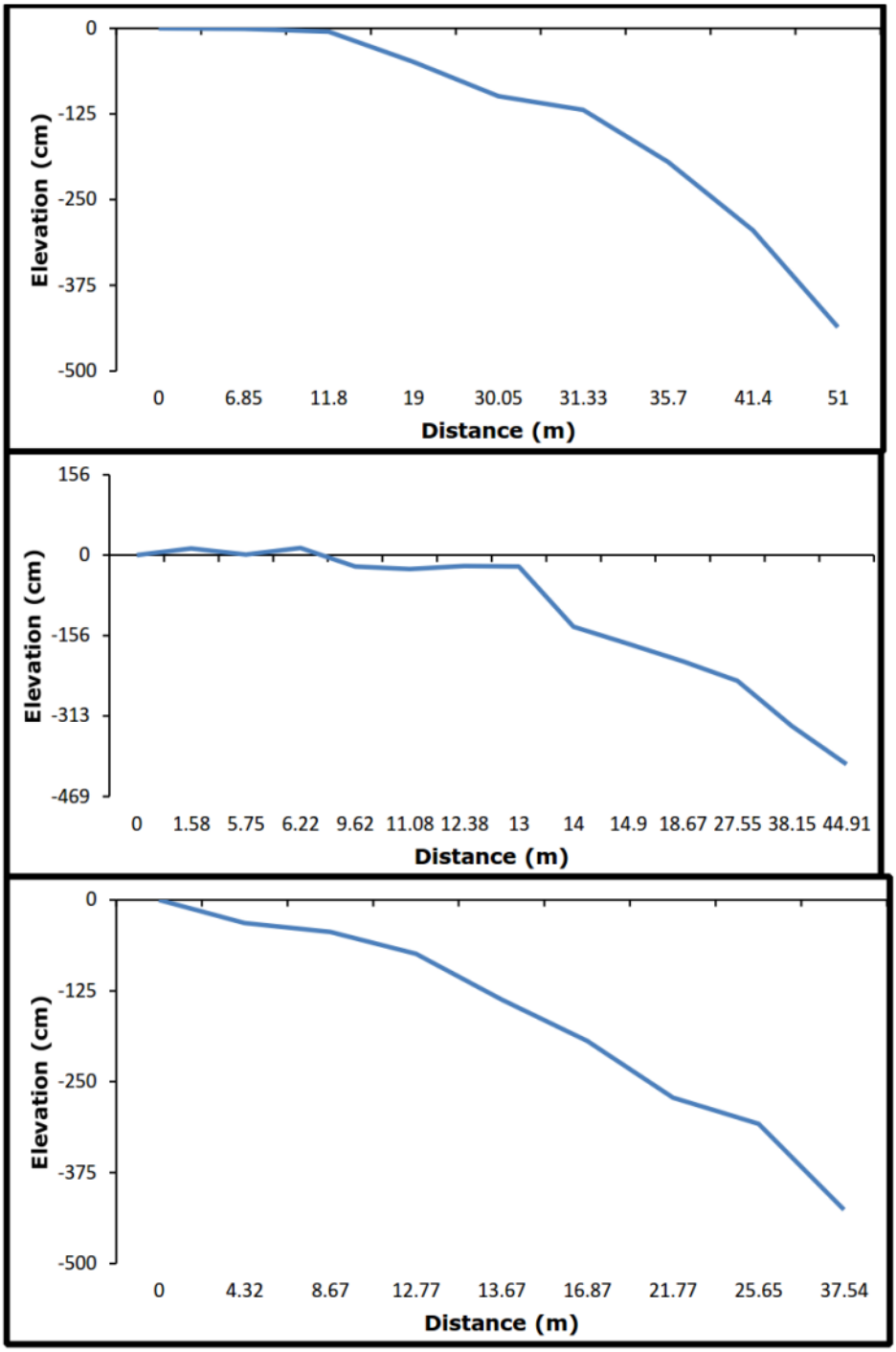
8.5.48 An important feature of beach profiles is their overall gradient, i.e. the average slope between seaward and landward limits. The gradients vary between two extremes: profiles are either steep or shallow (Pethick, 1984). The unique topography and slope of any beach area is the outcome of several interactions between abiotic and biotic factors. Textural properties of beach sediments and the size of waves have been documented to significantly influence beach slope variation (King, 1959). The shores of Ghana have been reported to exhibit variable beach morphology. Furthermore, coastal erosion, flooding, and shoreline retreat are serious problems along the coast (Boateng, 2009).

8.5.49 The profile of the beach for the east, west and midpoints of AEL's site are provided in Figures 8.11 below. The beach gradient (Height:Distance) measured for all the sites show gentle sloping beach with intermittent sharp scarps. The mean beach width

recorded was 44.48 m ranging between 37.54m and 51.0 m. The longest stretch was recorded at the east and the shortest midpoint of the concession. About 10m of the beach reaching the backshore is relatively flat with turf of *Sersuvium portulacastrum*. Although a greater part of the beach within the project area appeared firm, portions appeared eroded possibly as a result of significant wave action.

8.5.50 It is known that five species of turtle nest along the shorelines of Ghana including leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricate*), loggerhead turtle (*Caretta caretta*) and olive ridley turtle (*Lepidochelys olivacea*). Leatherback and hawksbill are classified as Critically Endangered, green turtles as endangered and olive ridley as vulnerable by the IUCN Red List of Threatened Species. There is no publicly available survey data on the use of the beach within the site by turtles. However, the study area is considered to be unsuitable for nesting turtles given the steepness of the beach and that it is well lit.

Figure 8.11 showing shoreline profile for the east, west and midpoints of AELs site



Marine Habitats

8.5.51 The Amandi CCPP Seawater Supply Intake Project[13] completed in 2014 has been used to provide baseline information on marine habitats, intertidal habitats and fish assemblages and is summarised below.

8.5.52 A total of 79 species (mean=11 species) comprising 54 polychaete, 13 crustaceans and 6 molluscs, and 6 species placed in 'Others' category were. The species designated as 'Others' comprise 5 different taxa namely *ophiuroids, oligochaetes, sipunculids, nemertina and cnidaria*. The macrobenthos were numerically dominated by the taxa *polychaeta,* accounting for more than 53% of sampled individuals. *Crustacea* contributed 24 %, while 'Others' category accounted for 18% and *Mollusca* made up 5 %.

Intertidal Ecology

8.5.53 The intertidal region within the project sphere is predominantly sandy with rocky outcrops on the eastern section of the beach which serves as substrate for colonization by rocky shore organisms. In addition, a groyne berm constructed to provide sheltered conditions is expected to enhance successful colonization by marine flora and fauna. The composition of the rocky intertidal with the project area comprises several epibenthic and macroalgal species. The epibenthic fauna consists of gastropods, crustaceans, echinoderm and cnidarians. Common fauna species found on the rocky intertidal of the project area are *Thais haemastoma*, *Siphonaria pectinata, Patella safiana, Fissurella nebecula, Nerita atrata* and *Cthalamus dentata.* Dominant flora species include *Chaetomorpha linum*, *Sargassum vulgare*, *Padina durvillaei*, *Ulva fasciata* and *Enteromorpha flexuosa*.

Fish Assemblage

Pelagic fish

8.5.54 The pelagic fish stocks are exploited commercially and comprise the small pelagics and the large pelagic resources. Major small pelagic fish resources account for approximately 80% of the total catch landed in the country and include sardinella species (*Sardinella aurita & Sardinella maderensis*), chub mackerel (*Scomber japonicas*), anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus sp*.), African moon fish (*Selene dorsalis*), West African Illisha (*Illisha African*), Atlantic bumper (*Chloroscombrus chrysurus*), barracuda (*Sphyraena sp).*

Desmersal species

8.5.55 Demersal stocks are also commercially important with widespread distribution on the continental shelf of Ghana. The species composition of the demersal assemblage include members of the *sparidae* family (e.g. blue spotted seabream *Pagrus caeruleostictus*, Angola dentex *Dentex angolensis*, Congo dentex *Dentex congoensis)*; Sciaenidae family (croakers), Mullidae (Goatfishes), Lutjanjdae (snappers), Serranidae (Groupers)). About eighteen (18) commercially fish species are described as "threatened" in Ghanaian waters due to heavy exploitation. These include the Blackchin guitarfish, dusky grouper, bottlenose skate (endangered), Thunnusobseus (vulnerable), Goliath grouper, Wide sawfish and Large tooth sawfish

[13] ESC (August 2014) draft report data/information has been incorporated into this Updated ESIA; supplementary information is presented in Appendix 7A.

(critically endangered). A World Bank report in 2011 indicated a 40% increase in the reported number of threatened fish species from an initial number of 25 to 42.

8.6 Environmental Impact

Construction

8.6.2 The principal potential impacts to ecological receptors can reasonably be expected to occur during the construction phase where habitat within the boundary of the Project site will be lost through site clearance works and the physical development of the land and marine environment.

8.6.3 Similarly, such activities may lead to direct species mortality as the various plant and equipment are moved around the site and supporting habitats are lost causing displacement (potentially to areas unsuitable to support such species).

8.6.4 The potential impacts without mitigation arising during construction of the Connections include:

a Permanent and temporary habitat loss;

b Habitat fragmentation;

c Habitat degradation;

d Direct mortality during site clearance and construction;

e Direct and indirect disturbance from construction activities including visual, noise, vibration and lighting; and

f Pollution caused by increased levels of dust, use of hazardous materials and incidental release of chemicals, fuels or waste materials.

8.6.5 The characteristics and magnitude of these impacts are presented in Table 8.5.

Operation

8.6.6 The potential impacts without mitigation arising during operation include direct disturbance (visual, noise and lighting) from operational use, air quality and water quality changes from operational use which may degrade surrounding habitats, and there may be risk to habitats and species of pollution incidents.

8.6.7 The characteristics and magnitude of these impacts are presented in Table 8.6.

Decommissioning

8.6.8 The potential impacts without mitigation arising during decommissioning are considered to include:

a Direct and indirect disturbance from construction activities including visual, noise, vibration and lighting; and

b Pollution caused by increased levels of dust, use of hazardous materials and incidental release of chemicals, fuels or waste materials.

8.6.9 The habitat and species composition is likely to have changed by the decommissioning of the plant therefore a reassessment of the baseline and ecological impact is recommended at this stage.

8.7 Mitigation

8.7.1 Within the context of an ecological impact assessment, mitigation is one of a hierarchy of measures that are undertaken to prevent or reduce adverse impacts:

a Avoidance / prevention: measures taken to avoid or prevent adverse impacts, for example, scheme layout and the timing of site works;

b Reduction / mitigation: measures taken to reduce adverse impacts, for example, retaining walls and pollution interceptors; and

c Compensation / offsetting: measures taken to offset significant residual adverse impacts, i.e. those that cannot be entirely avoided or mitigated to the point that they become insignificant: for example, habitat creation or enhancement.

8.7.2 In this section, specific mitigation measures are proposed for all significant ecological impacts on the habitats and species identified in the preceding sections. Generic mitigation measures are also proposed that include best practice methods and general principles that can be applied to the Project, and are relevant to all habitats and species.

8.7.3 Prevention or avoidance of these adverse impacts is the primary aim of ecological mitigation. Where this is not possible measures are proposed to reduce the impact and if these are also not possible then measures to offset the impact would be included in the mitigation strategy.

Construction

8.7.4 A construction level ESMP (CESMP) will be implemented by the appointed contractor, and (a) Works Method Statement(s) will be developed to illustrate how impacts on ecology will be managed throughout the construction process. Good construction site management will be implemented to avoid / minimise generation of excessive litter, dust, noise, lighting and vibration. This will be controlled and monitored through the CESMP.

8.7.5 Measures will be implemented to avoid / minimise the potential for fuel and chemical spills. There will be no storage of potentially contaminating materials in areas of hydrological sensitivity. The CESMP will cover provisions for pollution incident response to ensure that impacts from any potential accidental spills can be reduced to a minimum. In addition, the following measures will be included in the ESMP:

a Work compounds and access tracks etc. will not be located in, or adjacent to, areas that maintain habitat value or are within areas supporting protected species;

b Site fencing will be established to prevent access to areas outside working areas, particularly in areas adjacent to features of interest / value;

c Procedures will be implemented to address site safety issues, including storage of potentially dangerous materials;

d Briefings and instruction will be given to contractors regarding the biodiversity issues associated with the site;

e Confirmation will be provided that best practice construction methodologies will be followed throughout;

f Protocols and contingency plans will be established to deal with incidents should they arise;

g Design measures will be incorporated to ensure dust deposition is removed altogether or significantly minimised; and

h Relevant national or international guidance will be followed, as appropriate, to prevent pollution of water courses by silt or chemicals.

8.7.6 Appropriate habitat and species-specific mitigation strategies should also be prepared and incorporated into the ESMP to provide all the necessary details of the mitigation procedures that are identified in the following sections.

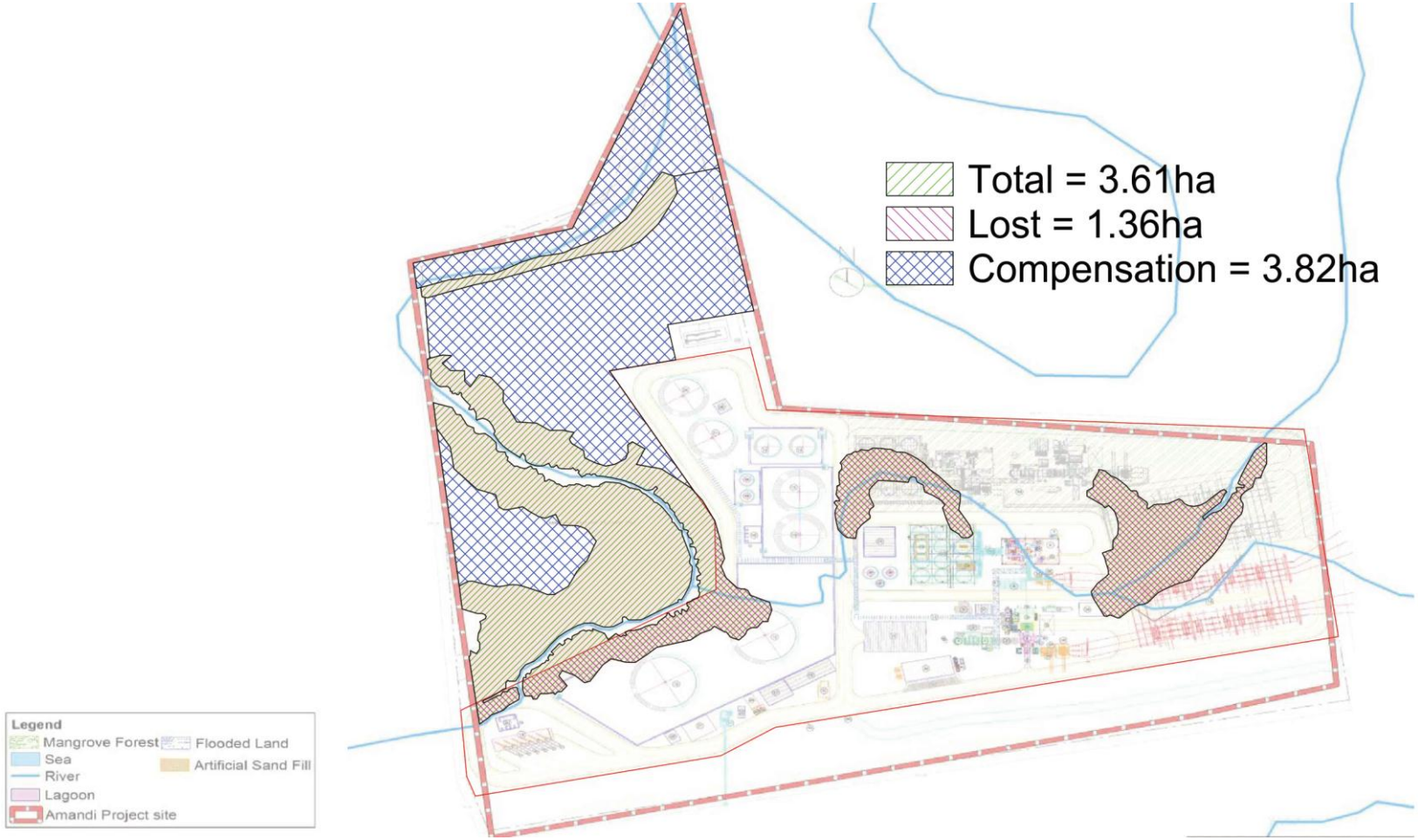
8.7.7 It is considered that the establishment of the ESMP, with the incorporation of the above key principles will directly offset many of the potential construction impacts of the Project in terms of disturbance.

8.7.8 The aims of the Critical Natural Habitat Mitigation Area (s) are to:

- be in proximity to the river, but that is not mangrove or other critical habitat, preferably land of low ecological value;
- link to existing mangrove, providing a continuity of habitat and facilitating the colonisation and dispersion of flora and fauna;
- meet target condition of a fully functioning mangrove ecosystem providing a nursery for fisheries (helping to sustain fish stocks for biodiversity whilst providing socio-economic benefits to communities), breeding ground for some marine and estuarine species; and
- compensate ecosystem services such as a buffer against coastal storms, purification of water pollutants, carbon sequestration (thus important climate change mitigation) as well services for the population such as firewood, charcoal, medicines, thatching used for construction.

8.7.9 It is best practice to implement the Critical Natural Habitat Mitigation Area (s) in advance of site clearance for construction , this enables a lead in time for the habitats to establish and can act as a refuge for displaced or translocated species during site clearance. It also would also allow for a continuation of ecosystem services. Generally if the biodiversity gains are delayed in delivery it is considered the risk of losing biodiversity components is increased due to the temporary loss of habitats, as such a higher multiple of compensation can be attributed. The area of Critical Natural Habitat Mitigation will be set using the *Business and Biodiversity Offset Programme (2012) Resource Paper: No net loss and Loss- Gain Calculations in Biodiversity Offsets* to ensure that any lag in habitat establishment is taken into consideration.

Figure 8.11


Total = 3.61ha
Lost = 1.36ha
Compensation = 3.82ha
Legend
Mangrove Forest
Flooded Land
Sea
Artificial Sand Fill
River
Lagoon
Amandi Project site

Operation

8.7.10 Mitigation proposals for operation of the Project will likely focus on the potential for contamination or degradation of habitats / species in the vicinity of the Project site. As such, it is considered that, subject to the relevant on-going works, the mitigation proposals from the other specialist impact sections (e.g. air quality, noise, water quality) within this document are appropriate for the protection of ecology during operation of the Project (or will be if requiring further development).

Decommissioning

8.7.11 During decommissioning, similar mitigation measures to those presented for the construction phase will be implemented. Updated ecological surveys and assessments will be undertaken to confirm the baseline conditions at that time. The results of these assessments will be used to inform any changes or additions to the avoidance and mitigation measures.

8.7.12 In addition, a Site Closure Plan will be prepared prior to decommissioning that will detail the manner in which the Project will be decommissioned. This will ensure that the site is left in an appropriate state to allow for any intended future use.

8.8 Residual Impact

Construction

8.8.2 The residual impact will be short term moderate to low adverse impacts on the ecological entities with the project site and immediate sphere of influence with a high probability of occurrence. Overall ecological impact significance is expected to be low with the implementation of best practice guidelines for noise, vibration, air and water quality and once net gain is achieved through the Critical Natural Habitat Mitigation Area (s) for the mangrove forest, which should be established within 5 years, by which point the residual impact will be low adverse and not significant.

Operation

8.8.3 Given the implementation of mitigation and monitoring measures, it is considered that the main potential residual impacts from operation of the Project will be long term low level impacts on the ecological entities with the Project site and immediate sphere of influence with a high probability of occurrence. The only area of uncertainty is the effects of nitrogen and sulphur deposition on habitats and in particular the mangrove; therefore a worst case scenario is predicted, with a moderate residual impact in the short to medium term with a potential significant impact on mangrove at the local level. Given in the long term the fuel will change from oil to gas and this is likely to reduce emissions, the residual impact in the long term is anticipated to be low adverse and not significant.

Decommissioning

8.8.4 The residual impact will be determined once the assessments of the unmitigated impacts and the definition of relevant mitigation measures are completed.

Monitoring

8.8.5 There is the need to carry out ecological monitoring during various phases of the Project to obtain adequate data that would assist in sound impact evaluation.

8.8.6 Proposed indicators for monitoring the ecosystem health of the critical habitats include:

- Mangroves;
- Terrestrial Fauna;
- Macrobenthos;
- Terrestrial vegetation; and
- Avifauna.

Full details of monitoring parameters are provided Appendices 8A.

8.9 Cumulative Impact

8.9.1 There are four additional power plants proposed for the area.

8.9.2 At this stage detailed Ecological Impact Assessments are not available for the proposed power plants (other than One Energy's, which has been reviewed). Therefore, the prediction of cumulative ecological effects will be based upon several assumptions. It is assumed that all power plants will be sited within similar broad habitat types and will support similar species as the AEL plant due to their close proximity and lack of fragmentation allowing the colonisation and dispersion of species between areas. As such during construction, it is considered there will be a loss of a further 75ha of wetland habitats (including either lagoons, streams, mangrove and swamps) with potential losses and disturbances of flora and fauna which may result in a change in habitat and species composition. Also many of the construction programmes are scheduled between 2015 and 2016 which will increase the workforce to a further potential 2,000 people in the area (based upon each power station requiring up to 500 people as stated for the AEL Project). Although this may benefit the local population through employment it will increase pressures on flora and fauna in the area through an influx of people with increased food (potentially increasing bush meat hunting pressure), fuel (wood /charcoal) requirements and additional living and sanitary arrangements. The cumulative effect on all flora and fauna and ecosystem services has the potential to be short – medium term major negative.

8.9.3 Following the implementation of best practice guidelines, whereby the most sensitive habitats are avoided where possible and biodiversity offsetting including off site habitat creation and best practice guidelines for noise/dust/water are implemented. It is also assumed there is Ecological Supervision including allotting the best seasons for construction (e.g. to avoid sensitive periods for avifauna such as the overwintering period) and assisting with species displacement. With provision of sufficient infrastructure for sanitation and assurance of availability of domestic food supplies it is anticipated the residual cumulative effect will be reduced to short – medium term moderate negative.

8.9.4 During the operational phase in the absence of mitigation the potential for degradation of water and air quality will be increased. As some of the plants are upstream from the Project any pollution incident associated with these plant may contaminate the site. Cumulatively this could have a short – medium term major negative effect.

8.9.5 It is assumed each power plant will implement good practice guidelines for water, air and noise and will have pollution incident response plans minimising transfer of pollution between sites and plants downstream reducing residual cumulative effects to

long term low negative. There will be an increase in recurrent disturbance to fauna particularly avifauna and best practice guidelines will be required to locate turbines away from sensitive areas and to minimise noise and vibration, with a residual cumulative effect of long term low negative.

Table 9.5. Potential Ecology impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Mangrove, freshwater swamp, indigenous flora Anankwari lagoon – disturbance only as 300m west of site.	Clearance works for construction causing loss/ disturbance Potential disturbance during construction from noise, dust vehicle movements and from an increased population (500 people).	Medium negative	Moderate negative	Standard best practice guidelines to reduce dust movements. Working hours restrictions to minimise disturbance. Provision of domestic food supplies (e.g. chickens, goats) to minimise hunting/pressure from local communities to hunt. Provision of sanitation and welfare facilities for workforce to minimise localised pollution	Short term Low negative (high probability of occurrence)
Mangrove	Potential loss of mangrove forest (critical natural habitat) on site resulting in fragmentation. Associated loss of ecosystem services (carbon sink/ flood control/ fish nursery/ fuel supply/ building materials).	Medium negative Medium negative	Major negative Moderate negative	Establish Critical Natural Habitat Mitigation Area (s) to produce net gain in habitats but there will be a lag of ~ 5years to establishment resulting in a temporary loss of mangrove and ecosystem services. International Biodiversity Offsetting principals will be applied to take account and offset the time lag.	Short term Low negative (high probability of occurrence) Short term Low negative (high probability of occurrence)
Anankwari River	Potential diversion of stream	Medium negative	Major negative	Avoid culverting which would minimise biodiversity of the stream, increase fragmentation and create maintenance issues. Create an open channel and involve geomorphologists in design to minimise maintenance requirements and increase biodiversity and ecosystem service value.	Short term Low negative (high probability of occurrence)
Marine habitats	Clearance works for pipelines will cause loss of habitats and	Low negative	Low negative	Minimise working area and avoid/ create buffer around sensitive	Short term Low negative

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
	potentially fragmentation.			areas.	(high probability of occurrence)
Other indigenous vegetation	Vegetation clearance for civils works Loss of vegetation as food source (crops)	Low negative Low negative	Moderate negative Moderate negative	The extent will be limited to the construction footprint with other areas fenced off for protection.	Short term Low negative (high probability of occurrence) Short term Moderate negative (high probability of occurrence)
Small mammals and herpetafauna	Potential killing or injury and displacement from working area due to noise/vibration/dust during construction	Low negative	Moderate negative	Vegetation will be cleared in a phased manner towards retained vegetation. Establish Critical Natural Habitat Mitigation Area (s) area as soon as possible. Form buffers around key sensitive areas such as the Anankwari River. Ecological supervision will ensure species are not killed or injured during construction and species where necessary will be moved to safety. All staff will be given a Tool Box Talk on the importance of biodiversity and given advice on finding species. Through best practice minimise light spill/ noise and vibrations off site.	Short term Low negative (high probability of occurrence)
Avifauna	Temporary loss of natural habitat and food sources due to vegetation clearance. Reoccurring disturbance due	Low negative	Moderate negative	Construction should avoid overwintering periods and be carried out in the off migration	Short term Low negative (high probability of occurrence)

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
	to noise/vehicle movements and dust			periods. Restoration of habitats will ensure habitat on the long term for birds.	
Marine flora and fauna	Loss of flora and fauna with killing and injury	Low negative	Low negative	Minimise footprint of pipelines.	Short term Low negative (high probability of occurrence)

Table 9.6. Potential Ecology impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
ECOLOGY IMPACTS					
Flora and fauna	Potential degradation of habitats and reduction in species biodiversity due to poor air and water quality from the power station.	Medium negative	Moderate negative	Implement best practice guidelines maintaining good water quality standards and minimising air pollution (refer to Air quality and Water quality chapters).	Short to medium term Low - Moderate negative (probable)
Fauna	Reoccurring disturbance of species using the wider area from operational noise and vibration from turbines and maintenance activities.	Low negative	Low negative	Turbines will be located away from natural habitats. Noise/vibration supressing devices will be implemented in accordance with best practice guidelines.	Long term Low negative (high probability of occurrence)
Flora and fauna	Potential for pollution incident	Medium negative	Moderate negative	All hazardous chemicals will be stored in accordance with best practice guidelines. Undertake regular monitoring of the oil pipeline condition to ensure no leaks or vandalism. An incident response plan will be set out in the eventuality of a spill to	Long term Low negative (high probability of occurrence – i.e. pollution event unlikely)

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
				contain it.	
Marine fauna and fish species	Potential for marine species/ fish kills by operation of sea water pump inlet	Medium negative	Moderate negative	Fit pumps with filters and ensure flow is no more than $2ms^{-1}$ to minimise drawing into the pumps. Undertake regular maintenance of the pump inlets (bi -annually) to ensure filters are not damaged.	Long term Low negative (high probability of occurrence)
Marine flora and fauna	Discharges out to sea from plant	Low negative	Low negative	Monitor the effluents to ensure that the discharges are within safe parameters.	Long term Low negative (high probability of occurrence)

SECTION 9

SOCIO-ECONOMIC

9 SOCIO-ECONOMIC

9.1 Introduction

9.1.1 This Section provides a summary of the existing socio-economic conditions in the vicinity of the site before the start of the Project; this is based on a desk study and stakeholder engagement with the local communities in the area, governmental institutions and private sector bodies. It includes a summary of methods employed to undertake the study, an overview of the area and a description of communities found in proximity to the Project site and the potential impacts.

9.2 Methodology

9.2.1 The ESC team reviewed existing information and available socio-economic studies of the region where the Project is being developed. This included looking at background Ghanaian information on a national level and at the Shama District level, where the Project will be built.

9.2.2 The aim of the baseline study was to understand the general socio-economic environment and potential wider impacts that could be felt by the local communities surrounding the site.

9.2.3 Using a participatory approach, the local team of ESC used its existing knowledge of the region and knowledge of the social dynamics within the area to approach and engage government institutions, the academic sector, the private sector bodies and the communities surrounding the Project site. The Ghanaian institutions consulted and the topics discussed included:

a Ministry of Energy – Project concept, approval and implementation.

b Ministry of Finance – Project financing and tax exemption.

c Energy Commission – Project approval and energy licensing issues.

d EPA - Environmental permitting procedures.

e Public Procurement Board – Procurement of project machinery, contract and consultancy service providers, amongst others.

f Ghana Water Company – Provision of water at Project site for construction, plant operation, fire fighting, drinking, within others.

g Aboadze Traditional Authorities – Project land/site acquisition.

h Shama District Assembly – Site clearance permit, building permit, provision of waste management services, and relevant district information on tourism, health, population, amongst others.

i ECG – Power purchase issues and temporary power for construction.

j GRIDCo – Interconnection to national grid system for IPP owners.

k VRA – Possible arrangement for provision of shared facilities for alternative fuel supply, waste oil disposal, fire management, oil spill management and worker health/hospital services.

l Ghana Police – Security issues.

m Regional Hydrological Department (Western Region) – Baseline study for plant water requirements.

n RIMOG and Sub-Consultants - Underground water supply consultations.

o Ghana Maritime Authority – Discharge/intake pipeline permit.

p Land Valuation Division of the Ghana Lands Commission (Sekondi Office) – Registration of land lease agreement and deed, valuation for compensation payments; provision of advice and working with AEL with respect to grievance management for the Project.

9.2.4 Since identifying the site's suitability for the AEL power plant development, AEL carried out informed consultations and participation with landowners, chiefs, elders and the general population in the riparian communities of the area including Aboadze, Abuesi, Dwomoh and Shama. Assemblymen and other opinion leaders attended these meetings to ensure discussions between the Project and the local people were carried out in an appropriate and transparent manner.

9.2.5 As part of this engagement, consultations carried out with local communities and businesses/private sector bodies have included and will include as part of the on-going stakeholder engagement process throughout all project stages:

a Chief and Elders of the local areas (including Nana Kobina Atom III – Chief of Aboadze where the Project is located, as well as Chiefs of Abuesi, Dwomoh, Chief Fisherman etc)

b Aboadze Community

c Aboadze Royal Family – Compensation beneficiaries (owners/farmers of crops and unused infrastructure within the Project's site)

d Nyametease village

e Malam village

f Local Cuisine Catering Services Limited

g Kwaku Anlo village

h Cluster of five town houses beyond the Anankwari River (west of the site)

i Single house and beach house beyond the Anankwari River

j Two bedroom house being built beyond the Anankwari River

k Biki Orphanage

l Landowners of neighbouring three parcels of land, adjacent to the eastern boundary of the site

m VRA

n Abuesi town

9.2.6 The local communities have leaders appointed by themselves. A typical approach for consultation would be to firstly, set out the purpose of the of the visit to communities and consequently, the community(ies) would determine who should represent them /lead the consultation process.

9.2.7 In most cases, the head of the community or his / her appointed representative leads the community during the consultation/meeting. This is done with other recognized members of high social standing in the communities. In the case of the relatively larger communities like Aboadze, Abuesi etc, Community Leaders /Chiefs represent the people. In addition, the Unit Committee Members and the Assemblyman

(Government Representatives in the Communities elected through the District Assembly System) form part of these stakeholders' consultations / meetings.

9.2.8 As discussed, there are a number of other facilities that are proposed to be built nearby the Project site and consultations have taken place with operators associated with these plants including:

a VRA T4 project - an LCO-fired CCGT power plant (to be located 400 m east of the site)

b Globeleq IPP - a 400 MW power plant (to be located 200 north of the site)

c One Energy Project – a 750 - 1,000 MW CCGT power plant (to be located 450 m north of the site)

d Jacobsen IPP - a 360 MW power plant (to be located 1 km north northeast of the site).

Early stage discussions have also been held with ASG IPP, JACHFAM and Abengoa Water.

9.2.9 Consultation with these developers is on-going as it is recognised that there are opportunities for collaboration and coordination. However, it should also be noted that different programmes for development can also limit some opportunities.

9.2.10 The various consultation methodologies for the baseline study in the field included:

a Open forum discussions

b Field observations

c Key Informant Interviews

d Transect walks

e Informative Power Point presentation

9.2.11 The information obtained was then analysed and summarised to identify the baseline socio-economic conditions, to determine the potential Project impacts, to develop the mitigation measures and to enable monitoring and evaluation of the Project. Through this process AEL obtained an understanding of the social spectrum of the local area, the dynamics, hierarchies and wants of the local community. This involvement also gave AEL an opportunity to introduce themselves and present the Project to the local area.

9.2.12 The impact predictions described are based on an assessment of the primary and secondary data collected during the socio-economic baseline assessment. Based on an analysis of collected stakeholder views, the socio-economic assessment considers the likely nature of these impacts with the Project.

9.2.13 Proposed management measures have been designed to promote positive impacts and avoid, minimize, manage, mitigate, or compensate for negative impacts. An assessment of the residual impact after the application of the proposed mitigation or management measures is provided.

9.2.14 A SEP has also been developed alongside this updated ESIA to ensure effective stakeholder engagement and consultation through all Project lifecycle stages. It includes:

a An overview of the stakeholder engagement activities and consultations that have already taken place

b Identification of key stakeholders

c The principles of consultation and disclosure that will be adopted

d A future stakeholder engagement programme

e Roles and responsibilities to effectively manage stakeholder engagement

f A grievance mechanism

g A register of comments and concerns with AEL's feedback

9.2.15 The SEP will be periodically reviewed and updated during project implementation.

9.3 General Description of the Site and Environment

9.3.1 The Project site is located in the Shama District of the Western Region of Ghana, in an area designated for industrial development. When AEL first leased the Project site e the land was uninhabited marshland and largely untouched, with minimal crop patches in the southern and central sections of the site, a disused salt pan and an unfinished / disused foundation structure within the site boundary.

9.3.2 VRA currently operate the existing VRA Takoradi Power Plants to the east of the Project site, and there are currently plans to develop an additional 190 MW (T4). The area between the VRA Takoradi Power Plants and the Project site is privately owned and composed of uninhabited marshland (with an abandoned structure). The land north of the proposed site is mostly undeveloped swampy grassland, with patches of subsistence agricultural land used by a local village also north of the site. The western boundary of the site is defined by the Anankwari River which meets the sea south-west of the site. Descriptions of the proposed development for the area around the Project are provided in Section 4.8.

9.3.3 The closest receptors to the Project site are:

a Landowners of neighbouring three parcels of land, two of which contain structures (southeast of the site)

b Owner of abandoned buildings on beach to the west of the Project site

c New buildings, including five town houses (330 m west of the site, west of River Anankwari)

d VRA Takoradi Power Plants (500 m east of site)

e A single residence and beach house (500 m southwest of the site, west of River Anankwari)

f A two bedroom house being built (600 southwest of the site)

g Kwaku Anlo village (910 m north of the site)

h Biki Orphanage (1.3 km northeast of the site)

i Nyametease village (1.5 km north east of the site)

j Malam village (1.4 km north east of the site)

k Local Cuisine Catering Services Limited (1.4 km north northeast of the site)

l VRA Hospital (1.6 km northeast of the site)

m Esipon town (1.8 km northwest of the site)

n VRA Club House, High School and township (1.7 km north east of the site)

o Esipon Sports Stadium (1.8 km north west of the site)

p Inchaban town (2 km northeast of the site)

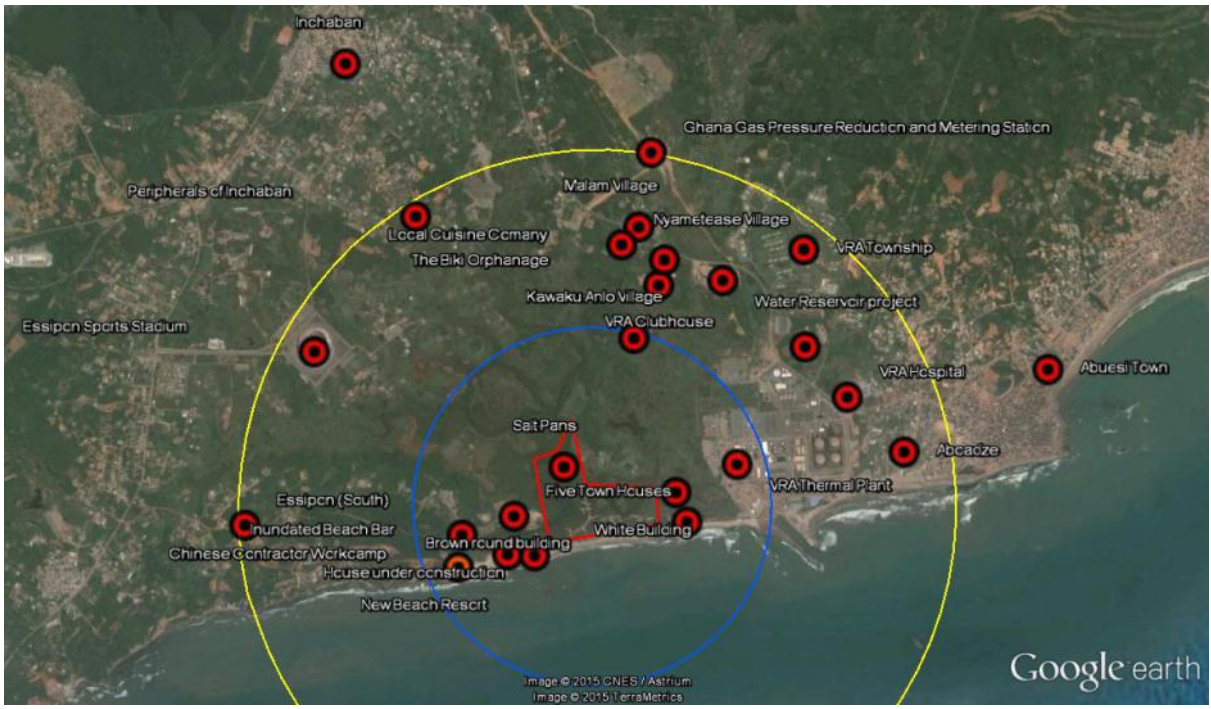
q Aboadze town (2 km east of the site)

r Abuesi town (3.5km east of the site)

s Water reservoir project for Aboadze (currently under construction 1.4 km northeast of the site)

9.3.4 The locations of the receptors to the Project's site are shown in Figure 9.1 (the blue circle represents a distance of approximately 1 km from the Project whilst the yellow circle represents a distance of 2 km). These areas define the potential zone of influence for impacts from the Project.

Figure 9.1: Potential Socio-Economic Receptors



9.4 Local receptors

Crops and Infrastructure within the Project Site

9.4.2 The site has been leased, by AEL, from the Royal Family of Aboadze. The lease agreement was reached following AEL presentations to landowners and all other relevant stakeholders. The Project Affected People (PAPs) include owners/farmers of the crops within the proposed site boundary, together with owners of unused infrastructure found within the site.

9.4.3 The crops grown are primarily coconut with some oil palm and mango. The coconut is confined to the immediate coast of the subject parcel of land. They are all matured and fruiting at the time of referencing. Other crops on the land at the time of

referencing are a few oil palms and mango trees which have grown in-the-wild scattered on the subject property (see Figures 9.2 and 9.3 below).

Figure 9.2 - Coastal Coconut Plantation

Figure 9.3 - Uninhabited/unused marshy terrain

9.4.4 There are also abandoned salt pans and a building foundation on the land. AEL understands that the building foundations have been abandoned for more than five years (Figure 9.4).

Figure 9.4 - Building foundation

9.4.5 The on site disused salt pans consist of five dug manhole-like structures used for storing brine water when the sea flows into the Anankwari River at high tide. The brine water would have been stored for a number of days and heated by the sun to form a high concentrated solution that consequently crystalizes into salt crystals for collection and bagging.

9.4.6 The locations of the assets within the Project site boundary are shown below in Figure 9.5. The crops and disused structures have been valued by a registered valuer, reviewed by ESC and Parsons Brinkerhoff, and the PAPs have been compensated accordingly. The Compensation Report is appended to this document (see Appendix 9A).

Figure 9.5 - Location of assets belonging to compensation beneficiaries within the site boundary

Landowners of neighbouring three parcels of land (eastern boundary)

9.4.7 There are three parcels of privately owned land to the eastern boundary of the Project site. There are two structures on these pieces of land. One is an uncompleted building (100m from the site's eastern boundary) owned by the respective land owner, see Figure 9.6. To date it has been used as temporary accommodation for contractors in the area (who have been dismantling a wrecked ship offshore), and AEL understands that it may be demolished to pave the way for the JACHFAM gas tank storage site to the east of the Project site.

Figure 9.6: Structure to South-East of Project Site

9.4.8 Another building near the site's eastern boundary (45 m) is a four room structure, privately owned by the respectively landowner, see Figure 9.7. It is currently used by a caretaker for a neighbouring project, and has in the past been used as a site camp by AEL's security personnel. AEL understands that it may also be demolished to pave the way for the JACHFAM gas tank storage site.

Figure 9.7: Structure to East of Project Site

Abandoned Buildings West of Project Site

9.4.9 These disused structures are outside the Project site perimeter and within the Anankwari River exclusion zone (on the east side of the river). It was originally intended to be a beach resort but the structures regularly flood when the river is unable to flow to the sea due to sandbar blockage, see Figures 9.8 and 9.9.

Figures 9.8 & 9.9: Abandoned buildings to the west boundary of Project site

New Buildings West of Anankwari River

9.4.10 There are a cluster of five town houses on one compound, located 330 m from the western boundary and beyond the Anankwari River (see Figure 9.10). Consultation with the owner of this facility revealed that, apart from one unit, the remaining four are still under construction (fitting and fixtures) and remain unoccupied.

9.4.11 AEL is consulting with the other developers of the identified industrial projects proposed for the area around the Project site regarding the possibility of a joint lease of this facility. The facility is being developed as a commercial residential facility that intends to benefit from the rise in top level managers to be located in the area for the various proposed power projects. The owner has indicated the works will not be completed until tenants are found.

Figure 9.10: New Buildings West of Anankwari River – Five town houses

There is currently another house under construction near the five town houses. This two bedroom single unit (see Figure 9.11) lies to the immediate south west of the five town houses, approximately 600 m west of the Project site. Details of this facility are currently limited. The caretaker at the site however indicated that they are aware of the AEL Project across the Anankwari River.

Figure 9.11: New Buildings West of Anankwari River – Single unit under construction

9.4.12 There is also a single building near the beach (see Figure 9.12), southwest across the Anankwari Estuary, 500 m from Project site. As above, the owner has indicated that this property could be leased for management staff of any of the identified proposed industrial projects.

Figure 9.12: New Buildings West of Anankwari River – New beach house under construction (AEL's Project site on the far side)

Kwaku Anlo Village

9.4.13 Kwaku Anlo village is made up of 4 thatched mud houses (as shown in Figure 9.13), located approximately 910 m north of the Project site and falls within the proposed site boundary of the One Energy project.

9.4.14 The villagers are subsistence farmers. There is a planned relocation of the villagers by VRA, who has allocated the land to One Energy. During AEL's consultation with the residents, they indicated that they have been informed by the One Energy project (through VRA) and that they will be relocated in early 2015.

9.4.15 There were three formal consultations with the residents of Kwaku Anlo village. The initial consultation was undertaken in September 2013 with the Founder – Kwaku Galo (Anlo) representing the households. AEL presented details of the Project in order to solicit their views and concerns about the Project. The Kwaku Anlo residents expressed their support for the Project and looked forward to its commencement in order to present an opportunity for employment of their children.

9.4.16 In October 2013, further consultation was sought, by AEL, to ensure that additional residents of the village were provided with information about the Project.

9.4.17 The most recent consultations took place in December 2014 to determine the status of the relocation of the village. It was indicated that the villagers have been informed about the imminent relocation as part of the development of the One Energy project.

Figure 9.13 - Kwaku Anlo village

Biki Orphanage

9.4.18 An orphanage lies approximately 1.3 km north east of the Project site. During initial consultation, it was determined that this receptor is being relocated to a larger facility (doubling capacity to 10 bedrooms), to be built by the developers of the Jacobsen IPP.

Nyametease Village

9.4.19 The village lies 1.5 km north-north east of the Project site, close to the Inchaban – VRA Power Plant road and the site for the proposed Jacobsen IPP. The village consists of six households, with a total population of 41. There are eight landcrete buildings and one incomplete sandcrete building at foundation stage, see Figure 9.14. Potable water is available in the village through a standpipe. The village is also connected to the national grid.

9.4.20 AEL held formal discussions with the Nyametease community on two occasions. During the first meeting (September 2013), AEL presented the details and location of the Project and explained the potential impacts. During the consultation, it was understood that the people of Nyametease would be relocated by the developers of the Jacobsen IPP.

9.4.21 Further consultation took place in December 2014. During this meeting, AEL presented the latest progress update to the villagers and explained the anticipated construction timetable.

Figure 9.14 - Nyametease Village

Local Cuisine Catering Services Limited

9.4.22 Local Cuisine Catering Services Limited, located 1.4 km north of the Project site, is a privately owned business. It consists of an office made from a metallic container, sandcrete block constructions and a wooden shed.

Malam Village

9.4.23 Malam village is located next to the Local Cuisine Catering Services company and in proximity to the Nyametease village (1.4 km from the Project site). The village comprises a sole block building with three bedrooms. The family that lives there comprises a security officer, his wife and three children.

Aboadze Town

9.4.24 The Aboadze township lies approximately 2 km east of the AEL site. Aboadze is a relatively undeveloped, rural fishing community. The shoreline in the village and the near-shore area is almost completely taken up by canoes (see Figure 9.15).

Figure 9.15: Aboadze Town

9.4.25 It is a very lively, close-knit community, with a large number of children. The town has seen a trend in increasing population density.

9.4.26 Most of the population in the Aboadze area is either engaged in fishing (men), trading (women) or in schooling (children). There is a strong expectation of people being employed on skilled jobs as part of the new projects in the area.

VRA Township

9.4.27 This township has been developed by VRA to house its staff and their families. This is located 1.7 km from the Project site, and is made up self-contained residential units; it is purpose built for the VRA Takoradi Power Plants. It also has a fully complimented hospital serving both VRA and the people of Aboadze and the surrounding communities.

9.4.28 The VRA Township has an international school which enrols children up to the level of a high school. Other amenities within the VRA Township include a club house for recreation. The VRA Township occupies 72 ha of land.

Esipon Town & Sports Stadium

9.4.29 The Esipon Sports Stadium is one of Ghana's newly built sport stadia. It is located on the Esipon – Sekondi road, 1.8 km northwest of the Project site. This facility was built to host the events of the Africa Cup of Nations football competition (CAN 2008) and is being used for sport events in the region.

9.4.30 The study area (including sencetive receptors within 3.5 km of the project site) also includes the southeastern part of the Esipon town. It is largely made up of greenfield and some housing development.

Inchaban Town

9.4.31 The periphery of Inchaban town lies 2 km from the site. Inchaban is one of the major towns of the Shama District. It is a buoyant commercial town located on the main Accra – Takoradi Highway. Inchaban serves as a nodal town, linking other towns in the District and the Western Region.

Abuesi Town

9.4.32 Abuesi lies approximately 3.5 km east of the Project. Abuesi is a subsistent and commercial fishing town with significant fishing activity along its coast. According to the Fisheries Department record in 1990, it was estimated that the village contained 825 fishermen. Officials of the Fisheries Department estimated that approximately 1,000 fishermen live in Shama, an adjoining town.

9.4.33 Aboadze and Abuesi are twin towns and share common amenities and infrastructural facilities including schools and library.

9.5 Population and Demographics

9.5.1 The population of Ghana is divided into around 75 ethnic groups. In the recent census of 2010, the estimated population of Ghana was 25,000,000 made up of 51 per cent females and 49 per cent males. Ghana has an overall population density of approximately 78 persons/km^2. These statistics can be seen in Table 9.1.

Table 9.1: Ghana National Population Statistics

Region	Area (km^2)	Total	Male	Female
Western	23,921	2,376,021	1,187,774	1,188,247
Central	9,826	2,201,863	1,050,112	1,151,751
Greater Accra	3,245	4,010,054	1,938,225	2,071,829
Volta	20,570	2,118,252	1,019,398	1,098,854
Eastern	19,323	2,633,154	1,290,539	1,342,615
Ashanti	24,389	4,780,380	2,316,052	2,464,328
Brong Ahafo	39,557	2,310,983	1,145,271	1,165,712
Northern	70,384	2,479,461	1,229,887	1,249,574
Upper East	8,842	1,046,545	506,405	540,140
Upper West	18,476	702,110	341,182	360,928
All Regions	**238,533**	**24,658,823**	**12,024,845**	**12,633,978**

Source: Ghana Statistical Service (GSS) 2010 Population Census Results

9.5.2 The most densely populated parts of the country are the coastal areas, the Ashanti region, and the two principal cities, Accra and Kumasi. About 70 per cent of the total population lives in the southern half of the country.

9.5.3 The most numerous peoples are the coastal Fanti, and the Ashanti, who live in central Ghana, both of whom belong to the Akan family. The Accra plains are inhabited by the Ga-Adangbe. Most of the inhabitants in the northern region belong to the Moshi-Dagomba or to the Gonja group.

9.5.4 The proposed Project is located in the newly created Shama District, in the Western Region of Ghana. This District covers a land area of about 215 km^2 and comprises 48 settlements. The region recorded a population density increase of 48, 80 and 99 persons per square kilometre for the census years of 1984, 2000, and 2010, respectively.

9.5.5 The population of the Shama district, according to the 2010 Population and Housing Census was 81,966 with 38,704 males and 43,262 females. Compared to the 2000 census figures, this represents a 23.5 per cent increase over the last 10 years. The estimated population growth rate of the district stands at 2.0 per cent (GSS, 2010), lower than the regional and national growth rates of 3.2 per cent and 2.7 per cent, respectively.

9.5.6 The population density of the Shama District is one of the highest in the region and has resulted in an increasing pressure on land and the district economy in general. Urban centres include densely populated areas such as Shama, Abuesi, Aboadze, Inchaban, and Supomu Dunkwa. Most of the local population lives in village communities such as Beposo, Komfoeku, and Shama junction; although there are smaller, scattered single family units throughout the area.

9.5.7 To address the issue of high population growth rate and population in the district, the new Assembly, in collaboration with the District Directorate of Ghana Health Service, is in the process of developing measures to control the population growth and to avoid an increasing strain on the district economy.

9.5.8 Most of the population in the Aboadze area is either engaged in fishing (men), trading (women) or in schooling (children). Most of the youth are currently employed in commercial driving or buying and selling goods. There is an expectation that they will be employed in skilled jobs for the proposed power projects (including the AEL Project) in the area.

9.5.9 Tables 9.2 to 9.4 present population statistics for the Shama District according to age group, gender, as well as those older than 12 years and the marital status.

Table 9.2: National, Regional and Shama District Population by Sex and Type of Locality (GSS, 2010)

	Per Cent	Population			Population in households	No of households	Household size	Locality		Population 18 years and over		
		Both sexes	Male	Female				Urban	Rural	Both sexes	Male	Female
Country	100	24,658,823	12,024,845	12,633,978	24,076,327	5,467,136	4.4	12,545,229	12,113,594	13,632,299	6,431,820	7,200,479
Western Region	9.6	2,376,021	1,187,774	1,188,247	2,307,395	553,635	4.2	1,007,969	1,368,052	1,298,515	640,773	657,742
Shama District	3.4	81,966	38,704	43,262	80,632	19,291	4.2	46,070	35,896	42,441	18,761	23,680

Table 9.3: Population of the Shama District by Age Groups and Sex, (GSS 2010)

All ages			0-14 years			15-64 years			65+ years		
Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
81,966	38,704	43,262	33,769	17,112	16,657	44,323	20,158	24,165	3,874	1,434	2,440

Table 9.4: Population of Shama District 12 years and Older by Marital Status

All marital status	Never married	Total ever married	Ever Married				
			Informal/Consensual union/Living together	Married	Separated	Divorced	Widowed
54,557	22,462	32,095	1,315	24,204	693	2,875	3,008

9.6 Ethnic Groups

9.6.1 The ethnic groups in the region include Fantes, Elmina, Ekumfi, Komenda and Sekondi. The population of Aboadze is predominantly Fantes who have migrated from the surrounding areas. They account for 86.49% of the population while settlers' accounts for about 13.51% of the population. The official language of the people of this district is English, but the common local dialects are Ahanta and Fante.

9.6.2 No "indigenous" or vulnerable ethnic groups or individuals have been identified in the Project vicinity or broader area, hence IFC PS7 is deemed not applicable to the Project.

9.7 Religious and Cultural Groups

9.7.1 In terms of religion, the district has different groups, with Christianity accounting for the majority of the population (78.6 per cent). There is tolerance between the diverse religious groups and people live in a peaceful manner with each other. It is believed that the first Methodist Church in the Aboadze was established by Albert Nkrumah, a Fante from Ekumfi, who settled in the 18th Century (as a fisherman).

9.7.2 The churches include among others Presbyterian, Baptist, Holy Fire Chapel, The Truth Tabernacle, Catholic, and Jehovah Witness Kingdom Hall. There are also two mosques.

9.7.3 Fetishes were the only known forms of worship before the establishment of the first churches. Currently, the elders of the area recognize two main fetish shrines in the community – Burburase Shrine, and Kwekudonsuro Shrine - and libations are poured at these spots in August during the annual Apaatwa festival of the people of Dwomo. An old catholic cemetery, which is no longer in use, can also be located in Aboadze whilst other cemeteries belonging to the Methodist and other churches are located about 3 km away from town.

9.7.4 The Shama Traditional Council, which comprises three divisions, coordinates all activities of the traditional authorities in the district. The Council meets regularly to discuss issues affecting the development of the various communities. Council meetings are also used to settle disputes among various families and individuals. The Council thus serve as alternative dispute resolution forum for settling disputes and a focal point for initiation and implementation of development projects. The principal Chief of the Shama traditional area is Nana Kweku Binah II.

9.7.5 The colourful "Nye-yi Pra" festival is one festival which attracts many people in the district. It is celebrated from September to November annually. The festival is a major source of tourism and can serve as a source of revenue generation for the district.

9.8 Historical & Cultural Heritage

9.8.1 The area around the Project was initially settled by the Akan-speaking people with the study area falling under the jurisdiction of the Ahanta tribe. Sekondi-Takoradi, also known as Shama Ahanta East Metropolitan Assembly, like most coastal towns of Ghana, has had a long association with the Europeans. From the 15th century onwards, the Ahanta area, which covers the metropolis and the entire southeastern part of the Western region, was a scene of intense trade with Europeans. The main trade commodity was gold. At the beginning of the 20th century, a wharf was built at Sekondi to mark a significant industrial and commercial leap in the area. The area

became known as European Town. A new and modern harbour was built at Takoradi in 1928 and it became the most important port in the country until the development of Tema.

9.8.2 To protect their interests, the Europeans constructed 76 forts along the Ghanaian coast under the ownership of the British, Dutch, Danes and Portuguese. The nearest fort to the proposed site (Fort San Sebastian) is at Shama on the Pra Estuary approximately 10 km north of Aboadze. The landowners of Aboadze are said to have migrated southward on hunting expeditions and settled at the village of Dwomo, 2.5 km off the main Accra-Takoradi road in Inchaban. Aboadze started as a hamlet with the name Akuraban (meaning hamlet) and those who settled were predominantly migrant fishermen.

9.8.3 Discussions with the chief of Aboadze (Nana Atom III) indicated that there were no sites of cultural / archaeological/historical significance in the area of the Project site and the surrounding area. However, the Anankwari River is regarded by many as sacred.

9.8.4 It is also understood that no material of cultural, archaeological or historical interest was encountered during the construction of VRA Takoradi Power Plants since there are no records of such sightings in any VRA reports.

9.9 Aesthetics and Tourism

9.9.1 The coastal area of Ghana offers varied opportunities for tourism and holds significant potential for growth in this sector. The major assets are the broad beaches and cliffs, the coastal lagoons and estuaries offering a leisure resource, rich birdlife, historical monuments (forts, castles, lighthouses, etc.) and cultural activities.

9.9.2 Aboadze is a relatively undeveloped, rural fishing community. The shoreline in the village and the near-shore area is almost completely occupied by canoes. It is a very lively, close-knit community.

9.9.3 A significant feature of the Ghanaian coast is the presence of historical monuments with three of them, at Cape Coast (approximately 46km east of Aboadze) and Elmina (approximately 36km east of Aboadze), designated as World Heritage sites by UNESCO. Overall, there are about 40 forts and castles dotted along the entire coast, with 24 of them designated as structures of historical importance. These forts and castles contribute financially both to national and local economies because of the attraction they present to both local and foreign tourists. The castle at Shama (approximately 6 km east of Aboadze) is considered to be a very important tourist point, while the fishing villages themselves may draw a limited number of tourists. Two of the Forts can be seen in Figures 9.16 and 9.17 below.

Figures 9.16 and 9.17: Fort Orange (Sekondi) and Shama Fort (Shama)

9.9.4 There is a growing number of beach resorts and increased patronage in Ghana, particularly on public holidays, special occasions and weekends. The majority of these resorts can be found in the Greater Accra, Central and Western Regions.

9.9.5 The Shama District possesses some unique tourist features which require further development. This includes Fort Sebastian with the tomb of the ancient first black philosopher Amo, the estuary of River Pra at Shama and the "Nye-yi Pra" festival which is celebrated annually.

9.10 Infrastructure

9.10.1 Within the district there is a diverse range of infrastructure providing different services such as a hospital (VRA hospital), schools (nursery, primary, junior high school and senior high school), health centre, pharmacy, chemical shops, places of convenience, electricity, telephonic, rural bank, a police station, market and small industries. The Aboadze township has a number of schools, churches and other amenities.

9.10.2 There are both private and government schools at the primary and junior high level. These include Roman Catholic Primary and Junior High School, Islamic Primary and Junior High Schools, amongst others.

9.10.3 As previously discussed, the VRA Township is located at about 1.7 km north east of the Project site. It houses the senior staff members and has a club house and football field. The VRA International School is also within the confines of the township. The township is well structured with sealed road networks and maintained lawns. There is also a community library, a newly built market, a community cold storage facility built by VRA and a Rural Bank. A VRA hospital serves the needs of the workers on the VRA power plant as well as that of the community. VRA also has an air quality monitoring facility within the Aboadze township.

9.10.4 The Ghana Water Company water treatment plant at Inchaban provides potable water to 65 per cent of Aboadze and Abuesi.

9.10.5 Cellular phone network service covers the entire district. These services are provided by four cellular network firms currently operating in the district. The major networks with coverage in the district include Expresso, Vodafone, Tigo, Airtel and MTN.

9.10.6 Figure 9.18 gives an overview of the main infrastructures around the VRA Takoradi Power Plants (located east of the Project site).

Figure 9.18 - Aerial Map of the VRA Power Project Area

9.11 Education

9.11.1 The Shama District has three educational circuits managing 54 pre-schools, 57 primary schools, 39 junior high schools and 2 senior high schools. Class enrolment sizes range from 46 to 50. Higher education, facilities are located In Sekondi-Takoradi. The closest university is located at Cape Coast, approximately 46 km east. The Aboadze Islamic Primary School's location is shown in Figure 9.18.

9.11.2 As part of the continuing effort by the VRA Takoradi Power Plants management to support the local community, AEL has indicated that it will engage the community on what additional educational assistance can be offered to the Aboadze area to improve upon the current situation.

9.12 Fisheries

9.12.1 Subsistence and commercial fishing is a significant activity along the coast of the district. Aboadze, Shama and Abuesi are all very active fishing villages. Agyepong et al, (1990) estimated that the village of Abuesi contained 825 fishermen. Fisheries Department officials however, estimated that there are approximately 1000 fishermen in Shama. There are no direct estimates available for number of fishermen in Abuesi, however, it was estimated that there are approximately one third as many boats as in Aboadze. Fishing communities have been consulted as part of consultations with the wider settlements described above in Section 9.2.

9.12.2 The common most dominant fish species in the area are the round sardinella (Sardinella aurita) with a range of 14-57 per cent, Long-fin herrings (Illisha Africana)

ranging from 6-13 per cent, Bumper (Chloroscombus chrysurus) range of 6-12 per cent and the Skipjack tuna (Katsuwonus pelamis). The tuna species was the only dominant offshore species.

9.12.3 Cassava fish, long-finned herring, ribbonfish, shrimp, tuna, lobster and cuttlefish are the species that are generally taken in shore of the 10 m contour, and are the species of importance in Shama Bay and in the vicinity of the Pra River estuary.

9.12.4 Crab and shrimp are also caught in the coastal lagoons and river mouths, and shrimp are exploited offshore. Shrimp is also a major resource in the area and are an important component of the beach fishery in Shama Bay. Shrimp breeding grounds are said to occur along the Shama Bay shoreline and the estuary is utilized during early life stages. The tuna fishery is operated by both artisanal and tuna fleets, utilizing their own unique techniques. The canoe fishery is limited to the in- shore coastal zone while the tuna fleet operates from the coast to the equator.

9.12.5 Lobsters are present along all of this shoreline, among the rock, and are said to be locally most abundant between Shama and Abuesi. No lobsters are reported to be fished across the front of the proposed site or near the Anankwari estuary. Lobsters are marketed in Sekondi-Takoradi and are also purchased locally (Shama) for export.

9.12.6 Cassava fish are locally the most important species in Shama Bay, being present in abundance in the Pra River mouth, and to a lesser extent further west along the shoreline to Aboadze Point. Catches are smoked and sold in the villages, as well as being shipped into Sekondi-Takoradi, although primarily still utilized for local consumption. Anchovy are also fished locally in Shama Bay, directly off the Pra River mouth during the upwelling.

9.13 Health in Ghana

9.13.1 The WHO's health statistics for Ghana in 2010 confirm that the three main health challenges of the country are:

a Malaria;

b Human immunodeficiency virus (HIV) / acquired immune deficiency syndrome (AIDS); and

c Diarrhoea.

Malaria

9.13.2 Malaria is endemic in Ghana with seasonal and geographical variations. Every year 3.5 million people contract malaria in Ghana and approximately 20,000 children die from the disease (accounting for 25 per cent of the deaths of children under the age of five). Even if a child survives after contraction, the consequences of severe malaria such as convulsions or brain dysfunction can hamper long-term development and schooling. The annual economic burden of malaria is estimated to be 1-2 per cent of the Gross Domestic Product of Ghana.

HIV/AIDS

9.13.3 As of 2014, an estimated 150,000 people are infected with the virus in Ghana. HIV prevalence is at 0.8 per cent in 2014 and is highest in the Eastern Region of Ghana and lowest in the northern regions of the country. In response to the epidemic, the government has established the Ghana AIDS Commission which coordinates efforts

amongst non-governmental organisations (NGOs), international organisations and other parties to support education and treatment of AIDS throughout Ghana and alleviating HIV/AIDS issues in Ghana.

Diarrhoea

9.13.4 The WHO estimated in 2011 that diarrhoeal diseases deaths in Ghana reached 23,516 or 12.53 per cent of total deaths. The age adjusted death rate is 175.69 per 100,000 of the population, ranking Ghana as second in the world for this kind of death.

9.13.5 Diarrhoea kills 9 per cent of children in Ghana. In 2012, Ghana was the first African country to introduce pneumococcal and rotavirus vaccines at the same time in order to help tackle pneumonia and diarrhoea. This was carried out by UNICEF and the Ghana Health Service.

9.14 Predicted Impacts

9.14.1 The potential social, economic and health related impacts likely to be associated with the Project from site preparation to its operational phase comprise:

a Economic displacement due to loss of land and/or cultivated areas occupied by the Project;

b Effects on fishing communities with regards to the offshore pipeline;

c Issues arising from access to land and the sea;

d Effects from noise and air quality (refer to these chapters);

e Indirect effects on tourism from landscape or visual perspective;

f Effects on cultural heritage including festival or historical sites;

g Increase in traffic;

h Employment opportunities;

i Increase in residential land values due to demand for worker housing;

j Influx of migrant workers and effects on local population, including competition for housing and services;

k Competition for food supplies leading to an increase in prices;

l Growth of local economy;

m Disruption of local communities with an increase in crime and anti-social behaviour; and

n Increase in prostitution leading to higher risk of STIs.

9.14.2 The impacts for the construction, operation and decommissioning phases are described below. They are assessed in accordance with the methodology in Chapter 4 and summarised in tables at the end of this chapter.

9.15 Social Impacts

Construction

9.15.2 Potential impacts arsing during the construction phase have been described below and summarized in Table 9.5; proposed mitigation is described in section 9.17.

Employment Opportunities and Local Economic Benefits

9.15.3 As discussed in Section 4, the Project is anticipated to create an average of approximately 300 - 350 jobs during construction, most of which will come from nearby villages and towns. There could be up to 700 workers at the peak of the construction phase (for all components of the Project i.e. plant and ancillary development). Construction will require a high number of specialised workers. Due to this need for skilled labour, a large proportion of the employee work force is likely to be hired from outside of the local villages. It is anticipated that approximately 10 per cent (50-60) will be expatriate workers.

9.15.4 AEL envisage that as many people as possible will be employed from the surrounding local villages and towns. An estimate of how many has not been stipulated. Workers will be hired for periods of time lasting from a few days (for specific construction tasks) to the full extent of the construction period. Peak employment is estimated to be 6 months. Construction of the project will lead to a positive impact on the employment of the area and region.

9.15.5 Initial consultation with the residents of the Nyametease village revealed that they are aware of the imminent commencement of the Jacobsen IPP project which is very close to their location. The residents expressed positive feedback about the commencement of this development and the Project as being beneficial for their local economy. When asked about how they believe these developments will benefit them economically, they indicated that the commencement of the construction of such projects will bring opportunities for employment which could continue during their operation.

9.15.6 Some of the women expressed their positive attitude towards the developments as they see them as opportunities for them to engage in petty trading and food vending with the construction workers on site. This, they hope, will improve their livelihoods financially and enable them to pay for their children's education.

9.15.7 The residents indicated that they had been informed by the land owners (Chief of Inchaban) that the Jacobsen IPP would be developed near their village soon, and therefore they should not carry out anymore constructions of any permanent structures. They are aware that sometime in the future, they may be relocated from their village as a result of the Jacobsen IPP. However, they are not sure about the exact time frame and hope the relocation will be carried out.

9.15.8 The residents of the nearby Malam village (single residence), like those of the Nyametease village, are aware of the Jacobsen IPP which will be located north of the AEL Project, and hence closer to them. They have also expressed positive feedback about the Project as they consider it will bring employment opportunities. They also consider that with the influx of workers for all identified developments they anticipate an increase in commercial activities.

Growth of Local Economy & Price Increase of Goods

9.15.9 Some local businesses' will benefit from the influx of migrant workers due to an increase in trade of a variety of products, including agricultural, fishing, services, recreational activities, amongst others.

9.15.10 For example Local Cuisine Catering Services Limited is expected to be one of the main businesses to sell food to the migrant workforce during the construction phase.

The owner has welcomed the AEL Project and is looking forward to the economic advantage it would bring to her business.

9.15.11 Nonetheless, the price of food and other goods sold in the surroundings of the site may increase due to this influx of workers. It is expected that this impact will however be limited to the construction phase.

Influx of Migrant Workers

9.15.12 Migration will occur to the surrounding areas as there is an opportunity for employment. This in-migration can lead to negative impacts on the surrounding villages/communities, including:

a Increased pressure on land availability, existing facilities (housing amongst others) and services (hospitals, amongst others);

b Disruption of local communities with an increase in crime and anti-social behaviour; and

c Increase in prostitution leading to higher risk of sexually transmitted diseases such as HIV/AIDS.

Accommodation for Workers

9.15.13 It is expected that many of the workers will either originate from the neighbouring area or be staying in houses and apartments in Takoradi; temporary camps will not be required to house the workforce. AEL is in discussions with the owner of the townhouses (currently under construction) found west of the site in order to determine if the facilities will be suitable for senior level workers.

Health, Safety and Security

9.15.14 The risks of accidents and injury will mainly concern the construction workers. Health and safety measures related to the working conditions will be developed by the Contractor, as part of their CESMP, in a Health and Safety Plan prior to the commencement of construction works. Nonetheless, this plan should include recommendations and measures to protect the surrounding villages / communities during this phase of the Project. Barricading the working area and the development of an emergency plan including the local villages / communities are the main points to cover with this impact.

Traffic

9.15.15 During the construction phase, even though some construction materials and equipment will be brought to the site potentially by sea, traffic density through the highway north of the site will increase as equipment and labour will be transported by road. Given the concentration of population in the area, especially that of Aboadze to the east, this is likely to generate increased traffic risks.

9.15.16 Approximately 50 heavy good vehicles per day will be expected to transit the area during the construction phase throughout the day. Approximately 100 cars transporting construction staff to and from site during the morning and in the evenings are expected. During construction, traffic movements will be actively managed by AEL's Contractor such that significant numbers of vehicles will not use local roads during peak times.

Effects on Fishing / Fishing Communities

9.15.17 Fishing is not carried out in proximity of the AEL site as the offshore area is restricted due the WAGP.

9.15.18 In the case of the VRA Takoradi Power Plant development, construction materials are landed at the Takoradi Port and brought by road to the construction site and it is anticipated to be the same for AEL. This will limit any indirect impact on fishing from construction vessel movements.

Economic Displacement due to Loss of Land and / or Cultivated Areas

9.15.19 There is no physical displacement of PAPs on site or as a result of the ancillary developments. As discussed previously there is limited displacement of onsite crops and structures. The "Valuation of Crops & Others for Compensation Payment" Report (Appendix 9B), the 'Compensation Report', identifies eight PAPs.

9.15.20 The AEL site is leased from members of the Aboadze Royal Family. During the stakeholder engagement process, the affected members of the Royal Family had the opportunity to ask questions and also clarify what the implications of the land lease would be.

9.15.21 As part of the lease, AEL engaged the Land Valuation Division of the Ghana Lands Commission (Sekondi Office) in order to determine the compensation to be paid for the crops and the identified infrastructure within the site, including a salt pan and an abandoned building foundation. A "Valuation of Crops & Others for Compensation Payment" report (Appendix 9A) has been prepared by the same Land Valuation Division and AEL, to ensure that the PAPs were compensated properly.

9.15.22 The PAPs, as stated in the Compensation Report are members of the Royal Family and are legally entitled to benefit from the lease of the land for the Project.

9.15.23 Cognisance has been taken of IFC PS5 and consultations held with these PAPs determined that they did not rely on these crops as their main source of livelihood, but were used as additional sources of income. The valuations determined that the crop areas were past their optimal conditions and had been extended to beyond their optimum productive lifetime. Further to this, the crop areas were not being tended to or managed on a regular basis, and much of the production of the crops occurred in wild conditions.

9.15.24 The compensation was negotiated and agreed with the PAPs on a voluntary basis. Values were calculated at market value, with the view of ensuring that the PAPs could replace lost assets with assets of similar value and be better off overall. An explanation of how the compensation values were calculated is discussed in the "Valuation of Crops & Others for Compensation Payment" report.

9.15.25 It should be noted that the trees did not constitute the main source of livelihood for any of the landowners as the landowners all have other businesses. Any harvesting of coconuts has been undertaken by landowners and their families there is no indirect economic impact on casual labourers.

9.15.26 It should also be noted that medicinal plants identified during ecological surveys (see Section 8) are not harvested at the site.

9.15.27 Construction of the proposed LCO line and the Project access road will also pass through these three land parcels. As mentioned in the above, consultations are on-going in order to obtain permission and/or lease the lands to carry out the necessary works in these areas. Potential impacts in regards to restricted land access are at this stage unknown.

9.15.28 Construction of the overhead transmission lines will be carried out in the south eastern section of the AEL site and will have two connection points. One set of transmission lines will run north east towards the 330kV substation located in the T1 and T2 Power Plant compound. The second connection of the overhead transmission line connects to the southern section of the T1 and T2 compound. The transmission lines are planned to pass through three adjacent parcels of land found in the south eastern site boundary of the AEL site. The transmission lines are being developed by a third party (GRIDCo).

Effects on Access

9.15.29 In regards to access of the local population to the sea, AEL will not bear any impacts. The Ghana Maritime Regulations stipulates that a buffer zone should be observed between any coastal developments and the sea (water line). This maritime regime is being observed by the Project. A similar buffer zone is being observed between the Anankwari River and the Project.

9.15.30 It is concluded that the local populace has full and unobstructed access to the sea, Anankwari River and land. Nonetheless, consideration should be given to the fact that the beach front stretch is designated as a restricted area by the Ghanaian Navy as a security measure to protect the WAGP and the VRA Power Plant. As such there is currently very limited movements and activity from the public in this stretch of beach, even though occasionally, some members of the public have been spotted in the beach.

Effects on Tourism

9.15.31 As discussed, in general, the beach front stretch has been observed as a restricted area by the Ghana Navy. Therefore, there is very limited movement and activity by the public in the area. The beach to the south of the Project site is consequently not a populated place or a usual place of public leisure or tourism activity. However some visitors have been noted in the vicinity of the proposed Project site.

9.15.32 There are no tourist locations in the immediate vicinity of the construction site or anticipated for the wider construction areas associated with the overhead transmission lines, LCO pipeline, the water intake or discharge pipelines and access roads.

Effects on Cultural Heritage

9.15.33 There are no known historical or heritage sites that would be affected by the proposed development. Historical sites are of some distance (10 km) from the Project so there would be no indirect visual impact. Sites of religious significance are associated with the main settlements in the area (e.g. Aboadze) and would not be affected. However, the Anankwari River is regarded by many as sacred. This is understood to not to be overly problematic, so long as the appropriate religious rituals are under taken prior to the works, which AEL will fully support.

Operation

9.15.34 Potential impacts during the operation phase have been described below and summarized in Table 9.6 below.

Employment Opportunities and Local Economic Benefits

9.15.35 During operation, an estimated 30 – 40 staff will be required to run the plant, with a peak of approximately 40 – 60. It is anticipated that the majority of the workforce is likely to be hired from the local areas and that employees will be trained as appropriate. The Project operation will lead to a positive impact on employment of the area and region from workers being employed at the AEL plant and also from an increase in commercial activities in the surrounding areas.

Growth of Local Economy & Price Increase of Goods

9.15.36 Workers will be predominantly employed from the local areas. As such there is not expected to be significant price rises of food and other goods sold in the surrounding area. In the long term, the presence of the AEL plant will potentially provide opportunities for other businesses to be developed in the area of plant.

Influx of Migrant Workers

9.15.37 A large migrant workforce will not be used as permanent workers will be hired from the local areas.

Accommodation for Workers

9.15.38 It is currently anticipated that there will be no provision for worker accommodation when it is operational.

Health, Safety and Security

9.15.39 There will be Emergency Preparedness Plan as part of an overall Health and Safety Plan (a component of the Project's Operational ESMP) to protect the workers and community in the event of an emergency such as a fire, with plant shut down as required. Local emergency services will be informed and there will be communications with the surrounding communities as appropriate. A security fence will be constructed around the site and the site will be fitted with closed circuit television. Workers will be trained to minimise health and safety risks associated with the tasks they perform.

Traffic

9.15.40 When the plant is operational it is expected that there will be 40 - 50 vehicles per day to and from the site. This will be significantly less than during the construction phase.

Effects on Fishing / Fishing Communities

9.15.41 During operation there are anticipated to be no direct impacts on fishing or the fishing community. Access to land and the sea by people from the highest population centre of Aboadze town will not be affected. The town's fish landing beach is approximately 2 km from the site.

9.15.42 There are potential indirect effects on fishing from the offshore intake and discharge pipelines for the Plant. The effluent from the offshore discharge is not expected to cause any significant impacts to potential fishing activities in the area. The proposed Project discharge flow rate will be approximately 25 t/h, as such it is expected that the mixing zone, given the high dilution capacity of the receiving seawater, will be barely noticeable except in the immediate vicinity of the proposed discharge location. The water intake will be fitted with mesh screens to prevent fish mortality. The mesh size will seek to limit the intake velocity of the water to less than 0.2 m / s to prevent fish entrainment on the screens.

Economic Displacement due to Loss of Land and / or Cultivated Areas

9.15.43 As set out under construction impacts, landowners will be compensated for loss of trees (principally coconut) and as their main business interests are elsewhere, no operational impact has been predicted.

Effects on Access

9.15.44 Following construction of the transmission lines, LCO line, intake and discharge pipelines and access road, it is expected that there will be continued unobstructed access to the sea, although as discussed there is already very limited movements and activity from the public on this stretch of beach. There are not anticipated to be any additional land restriction access issues.

Effects on Tourism

9.15.45 As detailed previously, the beach front stretch is a restricted area by the Ghana Navy and it is not a usual place of public leisure or tourism activity. The plant is to be located in an area designated for industrial development.

9.15.46 There are no tourist locations in the immediate vicinity of the site or anticipated for the routes of the overhead transmission lines, LCO pipeline, intake and discharge pipelines and access roads.

Effects on Cultural Heritage

9.15.47 As discussed, there are no known historical or heritage sites that would be affected by the proposed development. Historical sites are 10 km from the Project so there would be no indirect visual impact. Sites of religious significance are associated with the main settlements in the area and would not be affected. However, the Anankwari River is regarded as sacred.

Decommissioning

9.15.48 The potential impacts arising during decommissioning phase are considered similar to the construction phase, albeit to a lesser extent. These include:

a Health and safety risk to employees and the community associated with decommissioning;

b Pollution caused by decommissioning associated with hazardous materials, chemicals, fuels, wastes; and

c Reduction in employment in area following decommissioning and site closure with impact on local economy.

9.16 Mitigation

9.16.1 The section sets out measures to mitigate negative impacts and enhance positive impacts. The Project has a detailed ESMP (Appendix X) which sets out measures to manage impacts and provides further detail on some of the measures set out below.

Labour Management Plan

9.16.2 A Labour Management Plan will be prepared by the Contractor as part of their CESMP for the construction phase. It will cover maximising employment opportunities for the Project within the local communities, managing expectations, and reducing the potential for influx into the area during the construction. The Plan will also aim to take into account vulnerable groups such as women.

9.16.3 The Plan will include for job training and capacity building during the construction activities.

9.16.4 This influx of workers will be limited for the Project, with clear recruitment and employment policies put into place. The Project will aim to reduce the influx of workers by:

a Making clear that there will be no recruitment of workforce “at the gate”, clearly advertising the formal recruitment process, hence discouraging an influx of opportunistic in-migrants; and

b Work in conjunction with local authorities, municipalities, village Chiefs and their staff to discourage settlement of opportunistic in-migrants.

9.16.5 The Labour Management Plan will be updated (as required) for the operations phase, as part of the Operations ESMP, prior to the end of construction.

9.16.6 A Retrenchment Plan will be developed prior to site decommissioning and closure for employees that will lose their jobs.

Provision of Accommodation

9.16.7 It is understood that no temporary accommodation will be provided or constructed for the workforce. If however camps are developed, they will need to be designed and operated by the contractor in accordance with the requirements set by IFC PS2 and the relevant guidelines within the guidance document Workers’ Accommodation: *Processes and Standards: A Guidance Note by IFC and the European Bank for Reconstruction and Development (EBRD)*.

9.16.8 The key principles regarding the provision of worker’s construction compounds are:

a Fundamental human rights of the workers and freedom of association in particular the need for respect. Accommodation for the workers should not restrict their rights and freedoms.

b Minimum space per worker with need to be considered, to ensure appropriate space is provided for each. A safe water supply for the workers dwellings, along with sewage facilities and garbage disposal systems will be needed. Appropriate protection from the elements, against heat, cold, dampness, noise, fire, diseases, animals and in particular, insects.

c Adequate ventilation will be required given the high temperatures in the area, such as air conditioning. Both natural and artificial lighting must be provided and maintained in living facilities.

d Separate beds should be made available for all workers, with the minimum space between them being of at least 1 m. Double deck bunks are not advisable for fire safety.

e Canteen facilities, cooking and laundry facilities should be made available and kept clean. These facilities should be made separate from the sleeping quarters.

f Management plans, such as health and safety, security plans should be put into place for the accommodation facilities.

g A security plan should be implemented to avoid any thefts, attacks, etc. Security staff must be checked to ensure that they have not been implicated in previous crimes and/or abuses.

h Process and grievance mechanisms for workers' to articulate their grievances mush be in accordance with PS2.

i Community representatives must be provided with an easy means to express their opinions and to lodge complaints to the management. There must be a transparent and efficient process for dealing with community grievances in accordance with PS1.

Health, Safety and Security Plan

9.16.9 As previously discussed, to address both occupational and community health and safety risks, a Health, Safety and Security Plan will be prepared as part of the construction CESMP, operations ESMP and decommissioning plan. It will include the company policy, and measures to comply with national laws and the international guidelines including recommendations and measures to protect the surrounding villages / communities during the applicable phase of the Project. Aspects to be covered in this Plan include:

a Barricading the working areas;

b Health and safety training for all employees;

c Health and safety training on the use of chemical and hazardous materials (including oil);

d Provision of the appropriate Personal Protective Equipment (PPE);

e Traffic management plan and driver training;

f Accident prevention monitoring;

g Training in the use of all equipment;

h Safeguards of environmental pollution of water resources;

i Safeguards in hazardous materials handling and transportation;

j First Aid access and communications; and

k Emergency Preparedness Plan and Emergency Response Procedures.

The decommissioning plan that will cover safe shut down procedures, pollution prevention measures, safe equipment dismantling and transportation, waste management, site clean-up and remediation if required.

9.16.10 In addition, health education with regard to communicable diseases will be undertaken as part of the induction training for workforce members. This will include health education on STIs as well as diseases such as malaria.

9.16.11 There will be an influx of people during construction, although this will be minimised via the Labour Management Plan. However an increase in the wealth in the area may also lead to an increase in STIs through prostitution. As such, provision will be made for education awareness of communicable diseases within the wider community.

9.16.12 Induction training will be undertaken for construction and operation personnel covering aspects such as health, safety and environmental and cultural awareness.

9.16.13 Worker grievance mechanism will be put in place for both construction and operation so that workers can raise reasonable workplace concerns and for the monitoring and resolving of such concerns. Personnel will be informed of this mechanism at the time of being hired.

Traffic Management

9.16.14 In order to reduce/avoid any potential impacts in relation to traffic, AEL will ensure that:

a That local authorities are involved in defining optimum Project traffic routes and times for transit;

b Defensive driving training will be provided to drivers;

c Speed limits will be enforced for heavy good vehicles and workforce transportation vehicles;

d The provision of site vehicle maintenance in order to ensure technical failures do not occur;

e Through planning and channelling of traffic, the densest areas of traffic if possible will be avoided. A dedicated access road will be built to access the site

immediately south of the VRA Takoradi Power Plants in order to avoid these areas of dense traffic; and

f AEL will engage communities on road risk and educate them through constant communications, road signals as well as with communications with the local authorities and community leaders.

Effects on Fishing / Fishing Communities

9.16.15 No obstructions to fishing boat movements are anticipated so mitigation has been identified.

Economic Displacement due to Loss of Land and / or Cultivated Areas

9.16.16 Appendix 9A (Compensation report) provides a report that has been conducted to ensure that compensation will be provided to the affected peoples where the site will located. If there is economic displacement associated with land for overhead transmission lines, the LCO line, intake/discharge pipeline and access roads, AEL will meet the requirements of IFC PS5 including provision of compensation in line with the guidance and if necessary develop an Livelihood Restoration Plan.

Oil Spill Response and Management Plan (OSRMP)

9.16.17 A construction OSRMP will be developed by the Contractor and then updated (as necessary) for operations in accordance with the EPA NOSCP guidance documents and published information. The NOSCP mandates all institutions having the possibility of an oil spill to report to the National Reporting Centre for coordination of oil spill clean-up efforts, and thereby to take advantage of equipment which might be available at other institutions for a holistic clean up.

9.16.18 The OSRMP will take into consideration the oil spill response plans of the adjacent VRA Takoradi Power Plants in order to account for any additional volumes of oil that will be stored and transported through the pipeline and identify any new/increased risks associated with the changes.

9.16.19 Training for the response and management of oil spills will be delivered to relevant staff members at the site. Suitable equipment will be provided to effectively respond and manage oil spills of varying scales.

9.16.20 The OSRMP will include:

a The names and responsibilities of the spill response coordinator and team members;

b The procedures for notifying the oil spill coordinator and relevant team members;

c The procedures for notifying off-site agencies and organisation of spills and coordinating the response of these groups with onsite personnel;

d An inventory and site map of all spill response equipment and materials;

e The general procedures to be followed for responding to oil spills of various sizes in different locations under different scenarios;

f Record keeping and reporting requirements;

g Decontamination procedures of personnel and equipment;

h Method to identify the quantity, area coverage, direction of travel and state of the oil spill, with reference to potential for combustion;

i Reporting procedure to National Reporting Centre (where the national oil spill reporting centre is situated); and

j Depending on the nature and scale of the oil spill, the National Oil Spill Reporting centre may then allocate further resources to assist in the further containment/management/clean-up of the oil spill.

9.17 Residual Impact

Construction / Decommissioning / Operation

9.17.2 The potential residual impacts can be considered to be insignificant following implementation of the mitigation measures discussed above.

9.18 Cumulative Impact

9.18.1 The cumulative impacts on social and / or economic receptors will be as a result of the existing plants and the new plants that are proposed to be built.

9.18.2 Key points include:

a There will be greater long-term employment opportunities and economic benefits for the region, although there could be short term pressures on local services including housing, food prices, possible increases in crime, antisocial behaviour, health risks if there is a significant influx of migrant workers, particularly during the construction phase and more so if this occurs concurrently for the different sites. Mitigation in the form of Labour Management Plan and provision of suitable worker accommodation (if required) should be implemented by all the operators

b Health safety and security risk could be increased, especially the community risk in the event of major accident scenario at the industrial complex. Mitigation in the form of Health and Safety Plans incorporating Emergency Preparedness Plans and co-ordination with the enclave (as applicable)

c There could be significant increased traffic particularly during the construction phases and more so if this occurs concurrently for the different sites. A Traffic Management Plan should be developed for all sites being developed.

Table 9.5 Potential social impacts during the Project's Construction / Decommissioning Phases

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
ECONOMIC IMPACTS					
Local communities (High)	Increase in employment during the construction period	Medium	Major positive	Local Recruitment Plan favouring local communities.	Major positive
Local communities (High)	Decrease in employment following decommissioning and site closure	Low	Moderate	Retrenchment Plan for employee job loses	Minor
Local communities (High)	Economic displacement due to loss of land where site will be located and where ancillary infrastructure will be built during the construction period	Low	Moderate	Adequate compensation provided to affected peoples and if necessary develop a Livelihood Restoration Plan	Minor
Local communities (High)	Effects on fishing communities from construction materials transported by sea	No change	None	None required	None
Local communities (High)	Growth of local economy due to influx of migrant workers during the construction period	Medium	Major positive	Economic growth for region	Major positive
SOCIAL IMPACTS					
Local communities (High)	Access to land and sea during the construction period	Very Low	Minor	Not applicable	Minor
Beach front (Low)	Effects on tourism during the construction period	Very Low	Minor	Not applicable	Minor
Aboadze sites of religious significance, Anankwari River (Medium)	Effects on cultural heritage during the construction period	Low	Minor	Construction programme to be designed to allow appropriate religious rituals to be undertaken	Insignificant
Local communities (High)	Influx of migrant workers and effects on local population, including competition for housing and services during	Medium	Major	Provision of worker accommodation (if required) Use of a grievance mechanism	Minor

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
	the construction period				
Local communities (High)	Competition for food supplies leading to an increase in prices during the construction period	Low	Moderate	-	Minor
Local communities (High)	Disruption of local communities with an increase in crime and anti-social behaviour during the construction period	Low	Moderate	Induction training including cultural awareness	Minor
Local communities (High)	Increase in prostitution leading to higher risk of sexually transmitted diseases during the construction period	Low	Moderate	Health education and awareness programmes	Minor
HEALTH IMPACTS					
Local communities (High)	Increase in traffic during the construction period	Low	Moderate	Traffic management plans	Minor
Local communities (High)	Construction worker and community safety and security during the construction period and site decommissioning and closure	Medium	Major	Health and safety plan Oil Spill Response and Management Plan Grievance mechanisms for workers and external stakeholders	Minor

Table9.6. Potential social impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
ECONOMIC IMPACTS					
Local communities (High)	Increase in employment during the operational period	Low	Moderate positive	Local Recruitment Plan favouring local communities.	Moderate positive
Local communities (High)	Growth of local economy due to employment during the operational period	Low	Moderate positive	Economic growth for region	Moderate positive
SOCIAL IMPACTS					
N/A					
HEALTH IMPACTS					
Local communities (High)	Increase in traffic during the operational period	Very Low	Minor	Traffic management plans	Minor
Local communities (High)	Employee and community safety and security during the operational period	Low	Moderate	Health and safety plan Oil Spill Response and Management Plan Grievance mechanisms for workers and external stakeholders	Minor

SECTION 10

SOILS AND GEOLOGY

10 SOILS AND GEOLOGY

10.1 Introduction

10.1.1 This section summarises the soils and geology at the Project site and outlines the potential environmental impacts of its construction, operation and decommissioning. It describes the status of the site in terms of existing contamination and the potential risks posed to human health (particularly future site users). Where potentially significant impacts have been identified, mitigation measures have been proposed to reduce the severity of such impacts to an acceptable level.

10.1.2 The construction and demolition activities of the Project have the potential to impact on ground conditions at the site and the surrounding area. Any contamination of the Project area also has the potential to impact on human health, controlled waters, and ecology.

10.1.3 The operation of the site is not expected to have any impacts on the surrounding soils and geology

10.2 Methodology

10.2.1 For the purposes of assessing impacts on local soils and geology, the assessment takes into consideration the construction of the main project elements and any associated infrastructure required onsite, namely the oil pipeline connection, raw water intake and discharge piping, and access road. As stated in chapter 5, the overhead electricity line is not part of this Project and is not assessed in this ESIA.

10.2.2 The assessment includes the following:

- Establishment of baseline conditions for the site with respect to geology, hydrogeology and presence of any potential contamination;
- Identification of sensitive receptors;
- Identification of risks to identified receptors in both construction, operational and decommissioning phases of the Project;
- Assessment of the magnitude of impacts likely to result from the Project;
- Potential measures for mitigating any impacts resulting from the Projects; and
- Identification of residual and cumulative impacts.

10.2.3 The potential impacts during the construction phase include:

a Disturbance of existing contamination and the creation of pathways to receptors;

b Creation of pollution incidents through (e.g. improperly maintained equipment); and

c Disturbance to or loss of important deposits of geology and soils.

10.2.4 As mentioned, following construction of the plant, there are not anticipated to be any operational impacts upon soil or geology.

10.2.5 Tables 10.1 to 10.3 have been used in assessing the attribute importance of receptors and the significance criteria against which the magnitude of potential impacts from the Project may have on soils, geology, hydrogeology and human health.

10.2.6 The baseline geological, hydrological and hydrogeological conditions of the proposed site have been described with reference to the information provided by AEL, including numerous map resources and intrusive ground investigation and soil sampling undertaken at the Project site in December 2014.

Soil Sampling Methodology

Takoradi T3

10.2.7 As part of the Takoradi T3 project, a series of soil analysis were undertaken to address potential contamination of the site. Located approximately 300m east of the AEL site, these analyses have been considered in the baseline for the AEL Project to to give high level indication of the potential ground conditions.

10.2.8 The soil assessment was based on a 60 m transects of which three sampling points were located at 10 m intervals. Within each habitat type, soil samples were taken from the depth of 0-15 cm and 15-50 cm at each of the sampling points. These were pulled together as composite samples.

10.2.9 Results of this analysis are presented in the baseline section below.

AEL Project

10.2.10 In addition to the soil analysis at the Takoradi T3 site, a limited intrusive investigation was also carried out across the AEL Project site. This investigation, undertaken in December 2014, included the excavation of 2 trial pits and 5 sampling boreholes to a depth of 2.5m.

10.2.11 Between 2 and 4 soils samples were taken from each of the sample sites, and were presented to the Centre for Scientific and Industrial Research, Water Research Institute, Environmental Chemistry Laboratory for analysis using internationally recognised standards.

10.2.12 In addition to the above soil samples, a single ground water sample was also taken for analysis.

10.2.13 Results of this analysis are presented in the baseline section below.

Significance Criteria

10.2.14 Tables 10.1 to 10.2 define the criteria against which the magnitude and significance of impacts has been defined on a variety of receptors of varying sensitivity. The significance criteria are defined by Table 4.4.

Table 10.1: Defining Attribute Importance for Receptors

	Attribute Type						
Attribute Sensitivity	**Geology/Soils**	**End users**	**Construction Workers**	**Surrounding Land Uses**	**Controlled Waters**	**Ecological Systems**	**Built Environment**
High	Protected ecological sites for geology/soils Good quality Agricultural land Land supporting nationally rare plant species	Residential, growing areas, amenity areas	Extensive earthworks and demolition of buildings	Residential area	Major aquifer or surface water in close proximity to site	Nationally or internationally designated sites	Buildings of high historic value or other sensitivity
Medium	Poorer agricultural land Currently used for important crops Land supports regionally/locally rare plant species	Public open space	Limited earthworks	Open space, commercial area	Minor aquifer	Locally designated ecological sites	Buildings, including services and foundations
Low/ Negligible	Brownfield / industrial site. Site of little or no agricultural value.	'Hard' end use (e.g. industrial, car parking)	Minimal ground disturbance	Industrial area	No surface water bodies or aquifers close to the site	No sites of ecological importance close by.	N / A

Table 10.2: Criteria for Assessing the Magnitude of Impacts

Magnitude	Impact	Description
Major Impact	Adverse	A permanent or long term adverse impact on the integrity and value of an environmental attribute or receptor, or exposure to acutely toxic contaminants. For example, harm to human health, designated habitats or pollution to controlled waters.
	Beneficial	Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Moderate Impact	Adverse	An adverse impact on the integrity and/or value of an environmental attribute or receptor, but recovery is possible in the medium term and no permanent impacts are predicted.
	Beneficial	Benefit to, or addition of, key characteristics, features, or elements or improvement of attribute quality.
Minor Impact	Adverse	An adverse impact on the value of an environmental attribute or receptor, but recovery is expected in the short-term and there would be no impact on its integrity. For example, temporary effects on receptors not designated under environmental legislation.
	Beneficial	Minor benefit to, or addition of key characteristics, features or elements; some beneficial impact on attribute or a reduction in the risk of a negative impact occurring.
Negligible impact	-	No impact would be detectable, either positive or negative.

10.3 Existing Environment

Study Area and Receptors

10.3.2 The "study area" for the ground conditions and contamination assessment covers land within the site boundary of the Project and land within 500m buffer from the site boundary.

10.3.3 This study area incorporates the following receptors:

a All geology and soils within the Project site and construction activities outside of the site (e.g. excavation of oil pipeline)

b Site staff and construction workers; and

c Controlled waters (ground and surface waters) within the 500m buffer described above.

10.4 Baseline Conditions

Regional Topography

10.4.2 The topography of the region is characterised by low level sandy beach coastline with coastal plains and associated aquatic features onshore. Further inland, low level plains irregularly interspersed with low level forested hills (0-100 m above sea level), stretch northwards north-eastwards to the Kwahu Plateau (100-500 m above sea level) which forms the watershed for the Volta River and the rivers in western Ghana which flow into the gulf of Guinea.

Site Topography

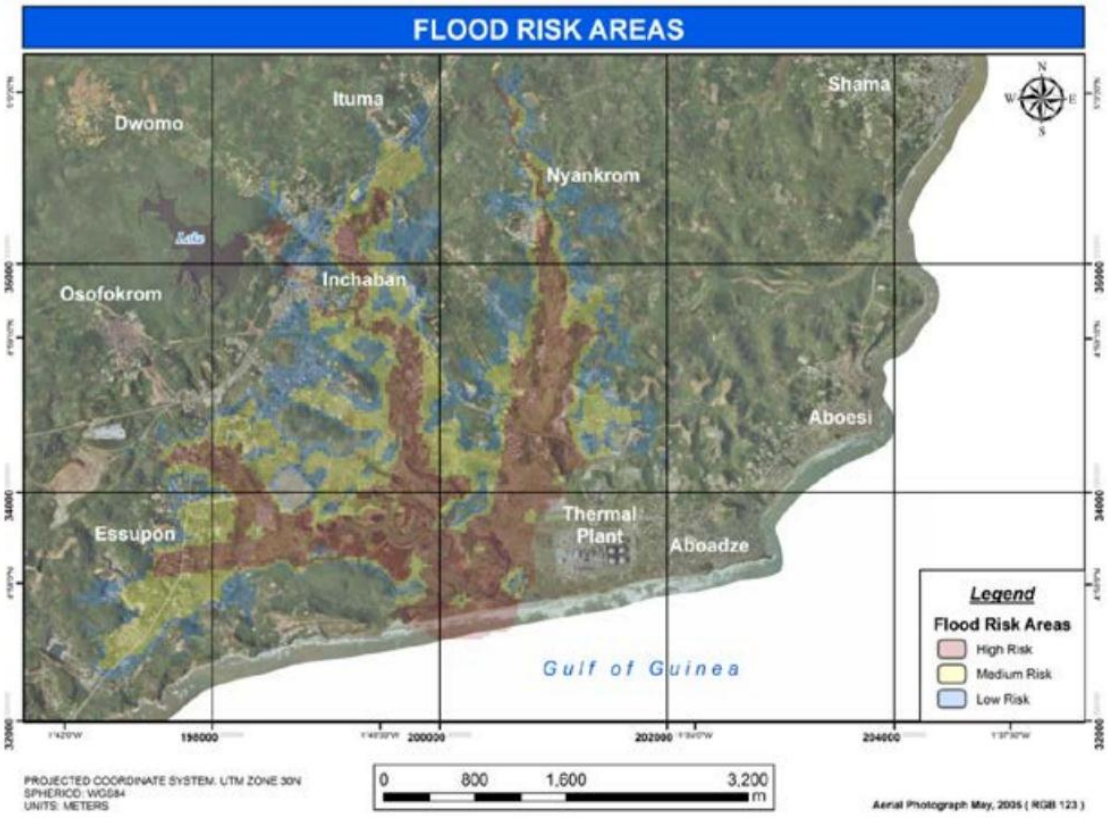
10.4.3 The Project site topography is comprised of the coastal plain found inland immediately adjacent to the beach area. It is vegetated by patchy low level thick scrub interspersed by small ponds, lagoons and streams. The elevation at the Project site ranges between 1 and 10 m above sea level, with the higher land forming a broken elevated ridge to the north of the site.

Hydrology

10.4.4 Immediately to the west of the Project site is the Anankwari River which meanders greatly and exhibits a number of ox bow lakes, suggesting high flow rates.

10.4.5 As stated in Chapter 8, studies by the University of Ghana have found that the river is prone to seasonal flooding in the rainy season. Figure 10.1 below shows an extract of the flood risk map for the River. The area in which the AEL plant (i.e. east of the VRA "thermal plant" in Figure below) is to be constructed is currently located in or adjacent to an area of High Risk (without mitigation).

Figure 10.1 Flood Risk area of the Anankwari River



10.4.6 The Anankwari River is isolated from the ocean by a sand bar that builds up across its mouth into the gulf of Guinea during the dry season.

10.4.7 Flows in the river are controlled by a dam located at Inchaban, approximately 3.6 km upstream the rivers confluence with the Atlantic Ocean. The volume of water released by the dam is dependent on the quantity of rainfall experienced in the area throughout the season. Downstream of the dam, smaller tributary streams also flow into the Anankwari, and discharge into the Atlantic. One of these tributaries currently crosses the Project site. This will be diverted to the north as part of the Project.

10.4.8 The majority of the coastline south of the Project site is covered with coconut trees which stabilise the sandy soils along the beach areas. At present, the coastline is experiencing erosion and this has affected the soils amongst the coconut plantation, resulting in the occasional uprooting of coconut trees (Figure 10.2). A regional topographic map, local topographic map and local land cover map are shown in Figures 10.3 to 10.5.

Figure 10.2 – Coastal Erosion at Aboadze

Figure 10.3 – Regional Topography Map

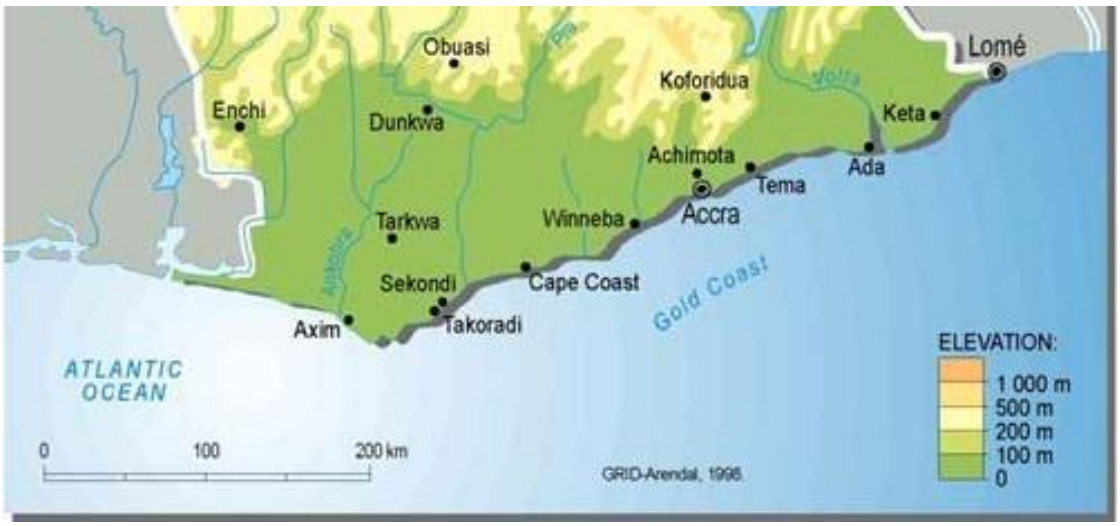


Figure 10.4 – Local Topography Map

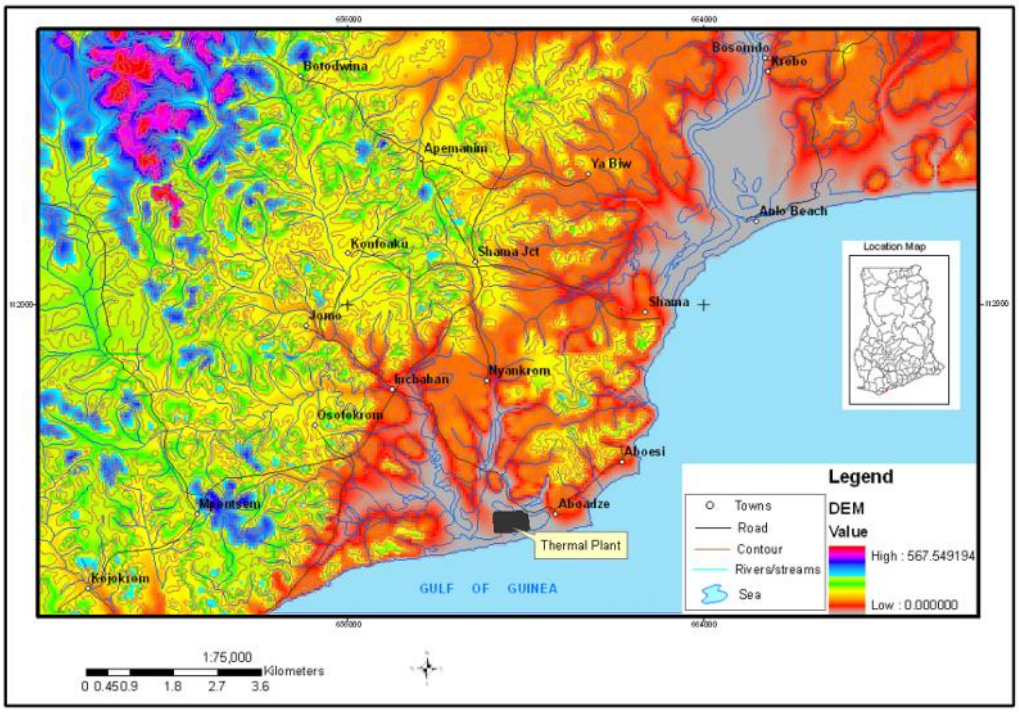
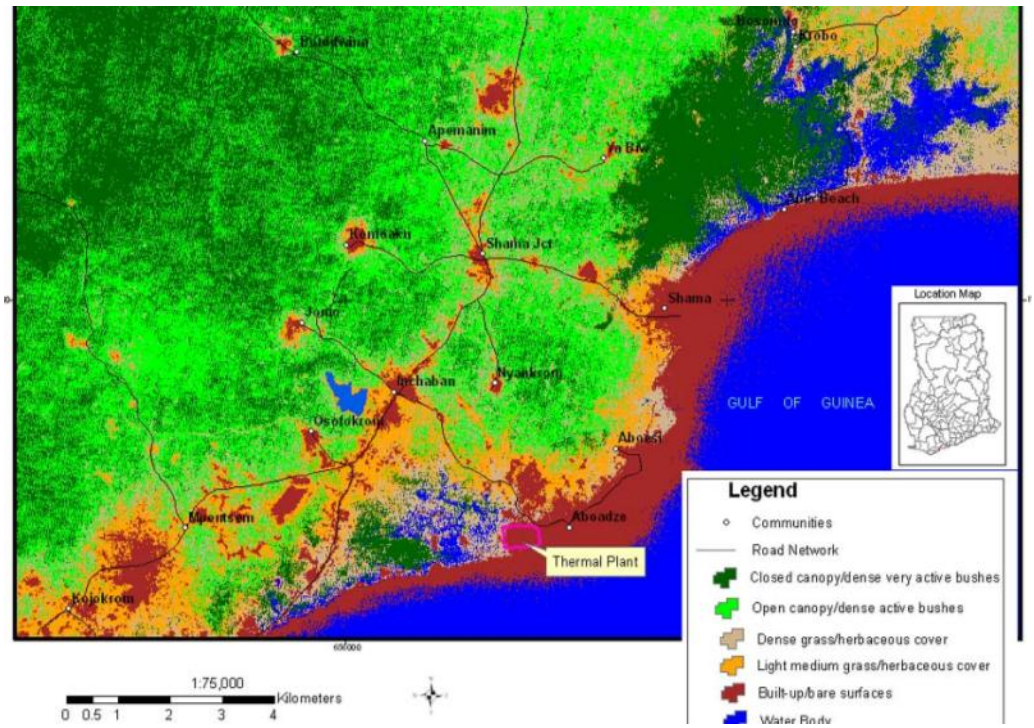


Figure 10.5 – Local Land Cover Map



Geology and Seismology

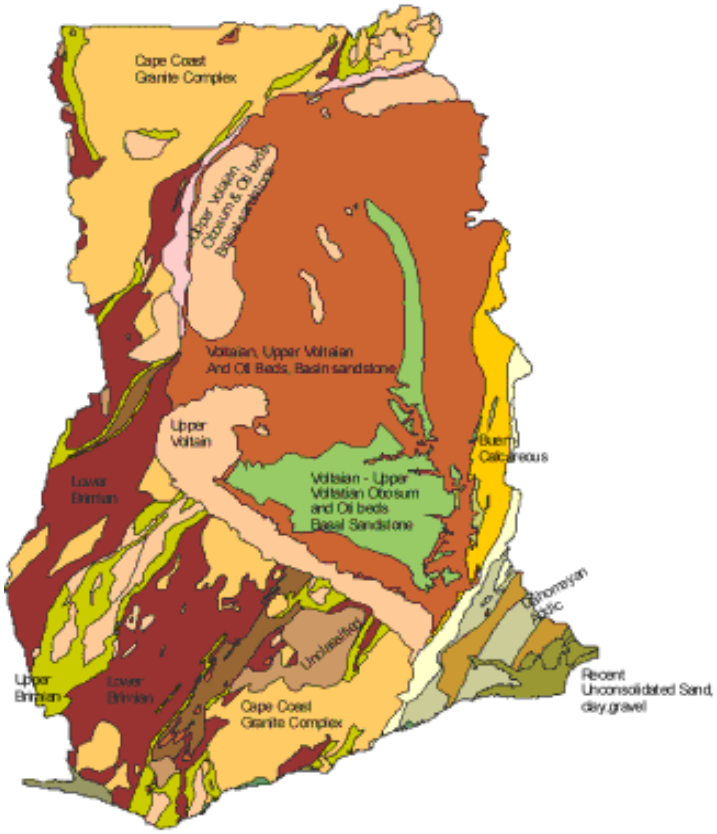
Regional Geology

10.4.9 The geological structure of the Ghanaian coastal line were likely formed by continental drift during the Cretaceous period (about 135 million years ago), when Africa broke away from South America. The geological composition consists of hard granites, granodiorites, metamorphosed lava, and pyroclastic rock. Some coastal areas are covered by Ordovician, Silurian, and Devonian sandstone and shale.

10.4.10 Seismic studies have indicated that Ghana's seismicity is associated with active faulting, particularly near the intersection of the east-west trending Coastal Boundary Fault and the northeast to southeast Akwapim Fault Zone. It has been reported that the first major seismic activity in Ghana occurred in Elmina (Central Region) in 1615. Thereafter, subsequent events took place in 1636, 1862, 1906, 1939, and 1997. In 1997 alone, three events were recorded in January, February, and March with magnitudes of 3.8, 4.1, and 4.8, on the Richter scale respectively.

10.4.11 Figure 10.6 below provides an over view of the wider geology of Ghana

Figure 10.6 – Ghana Geology Map



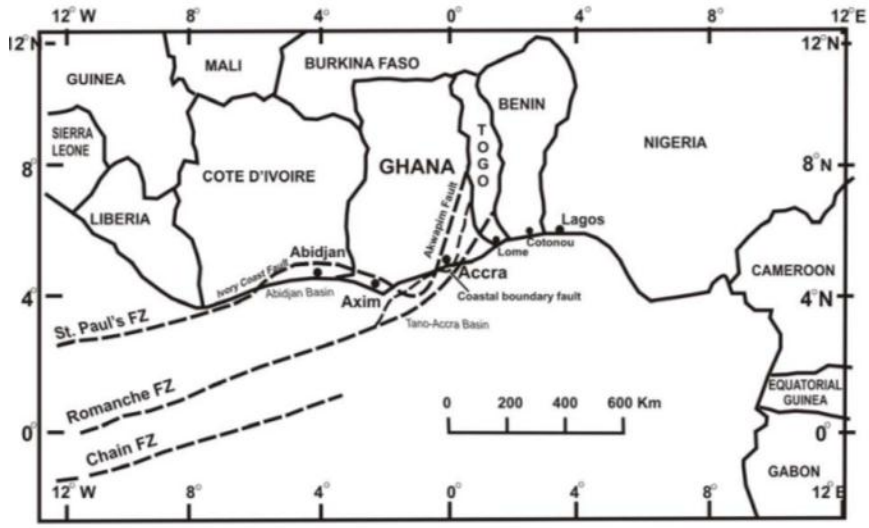
Local Geology

10.4.12 The underlying bedrock in the study area is of Precambrian to Carboniferous age, the basement rocks consist primarily of gneiss, granites and schist. Throughout most of the region, these rock types are overlain by sediments of the Sekondi Series which

are believed to be of Devonian or Carboniferous age. They consist mainly of sandstones and shale; with occasional conglomerate strata.

10.4.13 Overburden in the region consists of weathered bedrock that can reach thicknesses of 20 m. In contrast to the north of Ghana, Southern Ghana is not a highly active seismic area; although it is capable of producing significant earthquakes. Specifically, the area 100 - 200 km east and southeast of the site exhibits periodic seismic active, and there are a series of fault lines that have been mapped through the general region.

Figure 10.7 – Geological Faults in South Ghana[14]



10.4.14 Sedimentary rock of the Ajua Shale and Elmina Sandstone units of the Sekondi Series underlie the Project site. The Ajua Shale's are present in an east-west depression across the north end or the site, but there are no surface outcrops. Outcrops of Elmina sandstone occur east of the site in Aboadze along the shoreline on the outer edge of the site, and along the basal ridge near the northern contact with the Ajua Shale.

10.4.15 Surface outcrops along the tidal zone of the shoreline consist of fresh to slightly weathered sound rock; whereas, outcrops exposed further inland usually have a completely weathered mantle of 0.5 to 1 m overlying sound bedrock. The rock weathers to a brown, hard sand, and clay to clayey, sand.

Soils

10.4.16 The major of soils within the area are forest and coastal savannah ochrosols. Forest ochrosols are developed in forest and savannah environment under rainfall between 900 mm and 1650 mm. The organic matter content of such soils is low, with pH generally less than 5.5.

10.4.17 Coastal savannah ochrosols are mainly red and brown, moderately well drained medium to light-texture soils developed over Voltaian sandstone, granite, phyllites

[14] Kutu (2013) Seismic and Tectonic Correspondence of Major Earthquake Regions in Southern Ghana with Mid-Atlantic Transform-Fracture Zones. International Journal of Geosciences, 2013, 4, 1326-1332

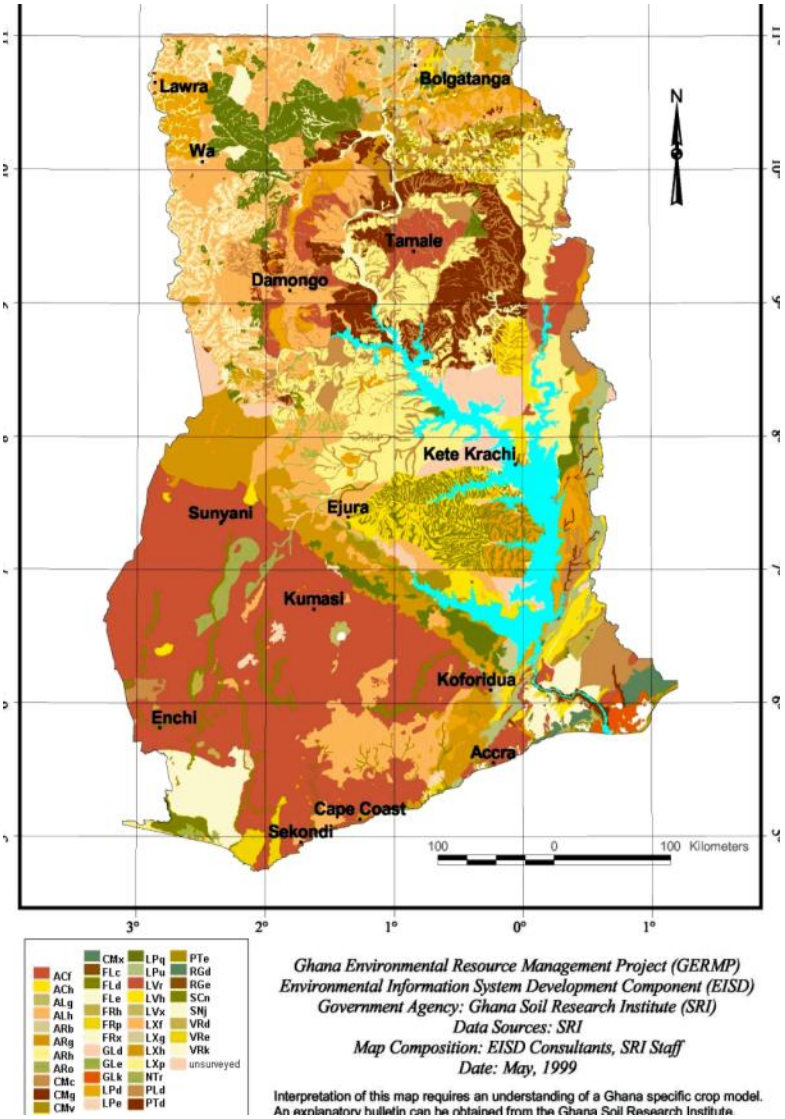
and schists. They are also generally low in organic matter due to insufficient accumulation of biomass (less than 2% in the topsoil).

10.4.18 Soil reaction ranges from near neutral pH (6.0 - 7.0) near the surface, becoming slightly basic to moderately acid with depth. The soils within the wetland indicated total organic carbon (TOC) levels range of 0.3-1.1 and 0.059-0.769 % for the dry and wet periods respectively. Total organic matter (TOM) levels ranged from 1.0 to 1.8 per cent. The wetland areas recorded total hydrocarbon (THC) values ranging from 0.6 µg/g to 1.1 µg/g.

10.4.19 Iron in the soil ranged from 1299 µg/g to 2081µg/g. Other metal such as mercury ranged from 1.04 µg/g to 1.55 µg/g, while cadmium and lead concentration ranged from 0.4 µg/g to 3.04 µg/g. The concentrations of the remaining elements (e.g., zinc, copper, etc.) were within the range of about 2 µg/g to 20 µg/g.

10.4.20 Figure 10.8 below presents a map of the general soil types found across Ghana.

Figure 10.8 – Ghana Soil Map



Soil Analysis at Takoradi T3

10.4.21 During the planning of the Takoradi T3 project, a series of soils quality test were carried out which have been used to provide wider detail for the soil assessment of the AEL Project. Tests for Polyneclear Aromatic Hydrocarbons (PAHs) in the soil showed that phenanthrene levels ranged from 0.045 µg/g to 0.262 µg/g. There were differences in PAH content of topsoil layers compared to deeper soils (lower at deeper soils).

10.4.22 Microbes isolated and identified in the soil samples included levels of total coliform bacteria, thermotolerant coliform bacteria, Pseudomonas spp., Clostridium spp., Sulphate-reducing Desulphovibrio spp., hydrocarbon oxidizing bacteria, hydrocarbon degrading bacteria, and total heterotrophic bacteria, as well as fungi moulds and yeasts. The levels of microbes isolated in the soil samples are presented in Table 10.3.

Table 10.3: Microbial Soil Composition

Microbial Parameter	Unit of measurement	A – composite (0-15cm)	A – composite (15 -50 cm)	B – composite (0 – 15 cm)	B – Composite (15 – 50cm)
Total Coliform	(g^{-2})	14620	154000	154000	150000
Fecal Coliform	(g^{-2})	<1	110	<1	<1
Total Heterotrophic Bacteria	(g^{-1})	680	560	720	800
Pseudomonas spp.	(g^{-1})	9	24	18	154
Clostridium spp.	(g^{-1})	960	520	800	400
Desulphovibrio spp	(g^{-1})	<1	<1	<1	<1
Hydrocarbon Oxidizers	(g^{-1})	126	27	18	115
Hydrocarbon degraders	(g^{-1})	80	44	90	110
Moulds	(g^{-1})	640	440	480	70
Yeast	(g^{-1})	50	14	8	4

Source: EIA for T3 Project

10.4.23 The results showed high counts of total coliform bacteria in the different samples. High levels of coliform bacteria were recorded ranging from 14 x 103 to 15 x 105 cfu/100 g. Total coliform bacteria are normal flora of soil and their presence may not necessary indicate contamination.

10.4.24 Faecal coliform bacteria count which is an indication of possible contamination of the soil with faecal matter ranged from < 1 to 110 cfu/100g, with the composite sample (15-50 cm) recording the highest count.

10.4.25 The total heterotrophic bacteria count was high in the samples, which ranged from 560 to 800 cfu/100g. These included the various coliform bacteria, the Clostridia, the Pseudomonas, and the hydrocarbon bacteria. The levels of sulphate-reducing bacteria in the different soil samples from the sampling areas were very low. This is because the activity of sulphate-reducing bacteria is particularly apparent in mud at the bottom of ponds and streams and along seashores.

Hydrocarbon Bacteria

10.4.26 Hydrocarbon oxidizing bacteria and hydrocarbon degrading bacteria together with the total coliform bacteria formed the largest group of bacteria present. Values for hydrocarbon oxidizers in the various samples ranged from 18 to126 cfu/g. The hydrocarbon decomposers isolated ranged from 44 to110 cfu/g.

10.4.27 The presence of hydrocarbon decomposing bacteria in a sample is an indication of presence of high oil content possibly from the thermal plant. The levels of hydrocarbon oxidizing bacteria ranged from 18 to126 cfu/g. Concentrations of Clostridium spp. recorded were very high for all the soil samples, reported values ranging from 400 to 960 cfu/g. Naturally soil samples harbour higher levels of clostridia.

10.4.28 There were high levels of mould but very low levels of yeasts in the soil samples. Values of mould ranged from 70 to 640 cfu/g. Moulds in soil assist with decomposition of organic compounds with some acting as pathogens.

Ground Contamination within the AEL Site

10.4.29 Further to the analysis carried out for the T3 project, an intrusive investigation of soils was also carried out at the Amandi Site in December 2014. Four soil samples were analysed from across the site for a number of commonly suspected contaminants, including: Volatile Organic Compounds; Total Petroleum Hydrocarbons (TPH); Benzene, Toluene, Ethyl benzene and Zylene (BTEX); Heavy Metals; Phenols; PAHs; Polycholrinated biphenyls (PCBs); and Organic Pesticides.

10.4.30 The laboratory limits of detection for the potential contaminants were sufficiently below the adopted Generic Assessment Criteria (GAC) Intervention Values for soil and groundwater. The GACs were based on Netherlands guidance values published in the Soil Remediation Circular of 2009. The laboratory detection limit for TPH however exceeded the adopted GAC Intervention Values for ground water. Table 10.4 below identifies the laboratory detected limits exceeding the 'Intervention Values'.

Table 10.4 Detected limits exceeding Intervention Values

Laboratory Analyte	LOD	Intervention Values		Intervention Value Exceeded
		Soil	Ground Water	
TPH	50mg/l	5000mg/l	600ug/l	YES
Arsenic, Cadmium, Chlorium, Copper, Lead, Mercury, Nickel, Zinc, Cyanide-total, PAH, PCBs, Phenol-total, Organochlorine pesticides.	NO EXCEEDANCE The laboratory limits of detection for the potential contaminants were sufficiently below the adopted GAC Intervention Values for soil and groundwater			

10.4.31 The results of chemical analysis on 4 soil samples showed that the concentrations of the potential contaminants, TPH, PAHs, PCBs, OCPs, BTEX, Phenol, Cyanide and

Heavy metals: Zinc, Lead, Copper, Tin, Chromium, Cadmium, Vanadium and Mercury were below the threshold of the adopted assessment criteria which implies the soil is uncontaminated by these potential pollutants. However, all the soil samples analysed showed elevated concentration of arsenic.

10.4.32 The concentration of arsenic in the soil samples exceeded the 'Intervention Value' of the adopted substance contamination criteria which implies the soil is polluted by arsenic.

10.4.33 The results of chemical analysis of one groundwater sample showed that the concentrations of the potential contaminants, PAHs, PCBs, OCPs, BTEX, Cyanide and Heavy metals: Arsenic, Zinc, Lead, Copper, Tin, Chromium, Cadmium, Vanadium and Mercury were below the threshold of the adopted assessment criteria which implies the shallow groundwater is uncontaminated by these potential pollutants. The concentration of phenols detected in the groundwater sample at Bore Hole No.7 at 0.5m exceeded the groundwater 'Target Value' of the adopted criteria.

10.4.34 Based on the results of this limited sampling and testing, Arsenic is considered the contaminant of concern in soil and Phenol in shallow groundwater at the reference site. The laboratory detection limit for TPH of 50mg/l exceeded the groundwater 'Intervention Value' of 0.6mg/l and the contamination of the groundwater by TPH could not be ascertained.

Summary of Soils and Geology Baseline

10.4.35 The topography of the site is generally low lying with a range in elevation across the site of 9 m. The site is covered in patchy low level scrub.

10.4.36 The site is within the flood risk zone of the Anankwari River which is known to flood seasonally. The site exhibits a number of pools, lagoons and streams. There is evidence of coastal erosion in areas along the coastline.

10.4.37 The soils at the site are coastal savannah ochrosols, of neutral to acid pH with low organic content, they overly bedrock of sandstone and shale. There are no surface outcrops of rock at the site. The region has previously experienced earthquakes of moderate strength.

10.4.38 The soil in close proximity to the site contains bacteria related to high levels of hydrocarbon presence in the soil. There are also faecal bacteria in the soil sampling results.

10.4.39 Soil and ground water samples taken from the site show higher levels of Arsenic and Phenol respectively, which could indicate contamination of the soil and groundwater, although it has not been possible to establish if these values a representative of naturally occurring contaminants or those that have been introduced from external factors. Further details are provided in Appendix 10A (Phase 2 Contamination Investigation Report).

10.5 Environmental Impact

Construction

10.5.2 During all construction works across the Project site, the main impact on sensitive receptors will be due to:

a Disturbance of any existing contamination and the creation of pathways to receptors, through ground breaking activities and excavation (e.g. foundation construction, pipeline excavation) or de-watering;

b Creation of pollution incidents through (e.g. improperly maintained, handled, or stored equipment); and

c Disturbance to or loss of deposits of geology and soils, also through ground breaking activities / excavation.

10.5.3 In the process of identifying the environmental impact during construction, it has been assumed that several measures will be applied throughout to minimise the impact of construction activities. These include:

a Working in accordance with best practices; and

b Maintaining safe working practices and, the use of correct and appropriate PPE.

10.5.4 The mitigation measures are assumed to be implemented at all times throughout the construction phase.

Human Health (Construction Workers)

10.5.5 During construction, the existing soil conditions are anticipated to negatively impact upon construction workers, due to the hydrocarbon bacteria and found in the soil, which indicate high levels of hydrocarbons in the soil.

10.5.6 Potential impacts to health (arising from oral, inhalation or dermal contact with potential pollutants within the ground) are negated by the implementation of the confirmed mitigation measures (as set out above) at all times. The most relevant of these confirmed measures is the appropriate use of PPE at all times. For this site, appropriate PPE will be determined in accordance with protocols contained in the ESMP.

10.5.7 The ESMP which accompanies this ESIA (Appendix X) includes a suggested protocol to follow in the event of construction workers discovering pollutant or contaminant substance/material.

10.5.8 In line with Tables 10.1 to 10.3, the construction workers are considered as highly sensitive receptors as there could be extensive earthworks across the site. A minor adverse impact is expected from the potential effects on the construction workers from the possible pollutants likely to be encountered in the soil at the site.

10.5.9 Assuming that the correct PPE and mitigation was implemented this minor adverse impact would be reclassified to a negligible impact.

Geology and Soils

10.5.10 The sensitivity of the underlying geology and soils at the site is considered to be medium / low, due to the existence of porous sandstone bedrock and small patches of land across the site which is cultivated by local villagers.

10.5.11 The disturbance of underlying deposits will be limited mainly to topsoil and underwater seabed sediments. Therefore, the construction of the Project is not considered to result in the loss of large amounts of geology / soils when considered against the extent of similar underlying deposits in the wider area.

10.5.12 As such, overall the construction of the Project will have a minor adverse impact on the underlying geology and soils (low negligible sensitivity) and therefore the overall significance of effect will be not significant.

Hydrogeology

10.5.13 The construction of the foundations (e.g. piled foundations on to bedrock) could create a preferential pathway for contaminants / pollutants to impact upon any groundwater aquifers underlying the site or any overlying soil substrates.

10.5.14 Drainage and de-watering activities could also mobilise existing pollutants in the groundwater and adversely pollute or contaminate other receptors.

10.5.15 During investigations at the site, ground water was identified just below the surface (0.8m below ground level) and was found to coincide with levels of surface water on the site and water levels in the Anankwari River. Observations over a period of twelve (12) months show that groundwater level on the site coincides with the water level in the nearby river and ponded water level on parts of the site area. Monitoring data suggests a moderate connection between seawater and site aquifer on the fact that the Elmina Sandstone outcrops on the sea bed directly south of the site. This indicates high hydraulic conductivity in the surficial deposit and unrestricted hydraulic connection with the Elmina Formation.

10.5.16 If piling is required for the construction of foundations, appropriate construction techniques will be implemented including negating risk for downward/upward migration of potential contaminants.

10.5.17 A range of measures could be put in place such as the use of bentonite / grout seals when boring or through the removal of any overlying contamination.

10.5.18 This groundwater resource has been assessed as a receptor which is of medium sensitivity and importance with the potential for a moderate / minor adverse impact. With the implementation of correct construction methods and environmental protection measures the impact could be classified as minor / negligible adverse impact on hydrogeology.

Stockpiles

10.5.19 If stockpiles are sited close to water bodies and the runoff is allowed to enter them, this could cause siltation or increased contamination of water bodies and groundwater, leading to impacts on ecology and human health.

10.5.20 If allowed to occur and completely unmitigated, this would lead to a major adverse impact on the Anankwari River and associated tributaries.

10.5.21 However, no stockpiles will be sited adjacent to the water bodies, and all runoff will be managed by siting stockpiles on impermeable liners and flat surfaces, and if necessary by covering stockpiles in dry, windy or particularly wet conditions, or using a fixing agent. The mitigation measures are outlined in the ESMP and a full methodology will be developed following the detailed design of the project.

Compaction of Soil / Removal of Vegetation

10.5.22 The site is currently covered in patches of scrub, thicket and mangrove as well as one small coconut plantation. In preparation for the construction of the Project, the

majority of vegetation on the site would need to be removed permanently, creating a minor adverse impact. The soil / vegetation on the site is a resource has been assessed as a receptor which is of medium sensitivity and importance. Note as discussed in Chapter 8, 3.82 ha of the site will be used to promote new growth of mangrove.

10.5.23 The construction activities will lead to soil compaction which could create localised flooding and or run off into water bodies of potentially contaminated water and suspended solids, leading to environmental degradation in the short term. This would create minor adverse impact.

Mobilisation of Existing Contamination

10.5.24 The excavation of foundations, drainage and de-watering, all have the potential to mobilise existing contamination at the site. Soil laboratory assessment has shown that there are hydrocarbon degrading bacteria present in the soil at the Project site, a strong indicator that there are high levels of oil in the soil, possibly from the neighbouring VRA Takoradi Power Plants.

10.5.25 Mitigation measures will be put in place to avoid the mobilisation of contamination to watercourses. These measures are outlined in the mitigation section and include careful stockpiling of any arising which will be tested to determine whether they are suitable to be re-used on site, all water from drainage and de-watering activities to be disposed of off-site and the on-site treatment of spoil where necessary.

10.5.26 Additionally, the ESMP will specify procedures to follow in the event of discovering hotspots of contamination, such as stopping work and carefully remediation if necessary.

Operation

10.5.27 The majority of the site will be covered in hardstanding, and therefore, any pollutant linkages with the soil will be broken. Any areas landscaped or not covered in hardstanding will be covered in 600 mm of clean cover to break any potential pollutant linkages.

10.5.28 Some excavation works may be required during the operation in the event that the oil pipeline / sea water intake pipeline become damaged or cease to function normally and require excavation to be repaired. The impact of this is likely to be in line with those during construction, but to a far lesser extent and likely to be minor or negligible.

10.5.29 The potential impacts and mitigation measures on watercourses during operation are addressed in Chapter 7 of this ESIA (Water Resources and Quality).

Decommissioning

10.5.30 The impacts during decommissioning will be temporary and moderate in nature, and would be similar to those described above for construction.

10.5.31 The concrete foundations will likely be left in the ground after decommissioning of the Project; it is common for concrete foundations to remain in-situ for many years following decommissioning of sites. The environmental impact of this is predicted to be negligible as the foundations will be constructed of an appropriate grade of concrete to resist degradation from the soils and groundwater. The remaining ground

will be reinstated back to its original condition (before the Project was commissioned) with suitably clean topsoil and vegetation cover, where appropriate and no significant residual impacts are anticipated.

10.6 Mitigation

Construction

10.6.2 During construction the majority of the assumed mitigation measures that would be taken (highlighted in Paragraph 10.5.3) would be described in the CESMP. As per the ESMP, the CESMP will incorporate the appropriate mitigation measures (such as covering stockpiles or siting stockpiles away from water courses), such that it would be unlikely that the minimum number of adverse impacts would arise during construction.

10.6.3 The construction of the Project has the potential to create impacts relating to human health and surface water/groundwater quality through mobilisation of contamination. Prior to any construction, a works method statement will be produced by the contractor to minimise the risk of mobilising contaminants in the soil at the site.

10.6.4 Prior to any construction works a method statement will be produced by the construction contractor which will outline a safe method of working in order to limit impacts on the potential sandstone aquifer beneath the site and any surface water bodies.

Human Health (Construction Workers)

10.6.5 The construction site will be cordoned off and access will be limited to construction workers and official vehicles. On-site security staff will be present at all times during construction to ensure controlled access to the construction site such that no unauthorised persons will come into contact with potentially harmful materials.

10.6.6 All construction workers will be required to wear appropriate PPE at all times and adhere to the CESMP. Toolbox talks will be given on construction safety and e.g. the process to follow in the event of a discovery of contamination or accidental spillages.

Geology and Soils

10.6.7 In order to limit disturbance, the site roads will be constructed first to allow movement of vehicles around the Project site on areas of hard-standing.

10.6.8 Any vegetation, topsoil and subsoil will be removed to expose a suitable sub-grade. Any soils, sub-soils or aggregate suitable for reuse will be stockpiled on impermeable liners. Soils which are to be reused on-site will be tested both geo-technically and chemically for contamination. This will form part of a general approach that will focus on the re-use, recycling and reduction of waste spoil.

10.6.9 Following initial testing, it is anticipated that some of the soils on the site are contaminated, although the degree and source of contamination (naturally occurring or imported) is not clear. Following further testing during construction, if spoil excavated from the site is found to be contaminated it will treated on site so that it is available for re-use, or transported off site to a controlled disposal facility.

10.6.10 Any additional soil materials that are to be imported to the construction site will be certified for their chemical concentrations to ensure that contaminated materials are not being introduced to the area.

10.6.11 Speed restrictions will be imposed on-site to minimise any disturbance of bare surfaces and the amount of disturbed surfaces left exposed for significant time periods will be minimised. Stockpiles of loose, fine materials will be damped down or covered over if necessary, again to reduce erosion and the production of dust.

Hydrology/Hydrogeology (Water Use and Disposal)

10.6.12 The access roads will be constructed to manage drainage of surface water and a temporary wheel washing facility will be installed to prevent transfer of soil onto nearby public roads. All drainage will be managed with the rest of the surface water drainage from the construction site and will be passed through oil interceptors and silt traps as appropriate.

10.6.13 Surface water, perched waters or groundwater from dewatering operations will not be discharged to drains (surface water, foul or surface water drains) without the appropriate permits/consents.

10.6.14 The disposal of any surface water, perched waters or groundwater will be the responsibility of the construction contractor. If necessary, the surface water, perched waters or groundwater will be tanked off-site for disposal at a suitable facility, or could be treated on-site.

10.6.15 Temporary drainage routes and silt fences, made from geo-textile, will be constructed if deemed necessary. Any pumping will be undertaken using appropriately sized pumps and at such a rate as to avoid disturbance or erosion of the stream banks. The location of dewatering pipe work will be carefully positioned. The construction contractor will regularly inspect and maintain all dewatering pumps, pipe work and connections.

10.6.16 In locations where there are no access tracks and where heavy machinery is required to operate, geo-grid surfacing/ matting will be utilised to minimise the likelihood of soil compaction.

<u>Operation</u>

10.6.17 There are no impacts anticipated with the operational phase of the Project in relation to contamination or ground conditions. Nevertheless all hazardous, chemicals and materials stored on site will be done so in accordance with best practice guidelines. The operational ESMP will contain an emergency spill response and management plan in case a spill occurs during operation.

10.6.18 The site will be mainly capped with a layer of impermeable hardstanding, which will break any pollutant linkages to future site users. Additionally, any landscaped areas of soft standing will be capped with a 600 mm layer of clean cover, thus again breaking any pollutant linkages.

<u>Decommissioning</u>

10.6.19 A decommissioning plan will be prepared in compliance with best practice, as per the ESMP. At this stage it is anticipated that the decommissioning area will be delineated and measures taken to avoid the use of vehicle outside the working boundary.

Geology and Soils

10.6.20 Any soils, sub-soils or aggregate suitable for reuse will be stockpiled on impermeable liners.

10.6.21 Any additional soil materials that are to be exported from the site will be required to have certification of their chemical concentrations to ensure that contaminative materials are not being introduced to the area.

10.6.22 The site will be re-instated (as far as is reasonably possible) to its former use before development. Clean topsoil and turf will be imported where necessary and the site will be re-graded.

10.6.23 Speed restrictions will be imposed on site to minimise disturbance of bare surfaces and the amount of disturbed surfaces left exposed for significant time periods will be minimised. In order to further limit disturbance, the site roads will be removed last.

10.7 Cumulative Impact

10.7.1 The VRA Takoradi Power Plants are understood to have been constructed to the same high standards as the proposed AEL Project. Furthermore, the baseline study data collected during the planning of the T3 plant was used to compliment the site works for the AEL plant. As such, there will be no cumulative construction impacts with the AEL Project. The only operational impact which could be envisaged would be associated with possible chemical spillage / leakage. However, as for the AEL Project, the VRA Takoradi Power Plants also adopt strict spillage protocols which ensure that they do not result in the pollution of soils or ground water.

10.7.2 As such, the risk of cumulative operational impacts is considered to be negligible. Furthermore, as the VRA Takoradi Power Plants have been operational for some time, it is likely that they will be decommissioned before the AEL Project. Consequently, the potential for cumulative decommissioning impacts is also considered to be negligible.

10.7.3 As described above for the existing VRA Takoradi Power Plants, the operational cumulative impacts for the five prospective power projects on soil and geology are expected to be negligible. As such, the only potential for cumulative impacts with the AEL Project would occur if they were to be constructed or decommissioned at the same time.

10.7.4 At this stage details of the construction programme of these plants is somewhat limited. It is understood that the Takoradi T4 site aims to commence construction in June 2015, the Globeleq plant aims to commence construction in September 2016, and the One Energy project is due to start being constructed in Spring /Summer 2016. The Jacobsen project construction date is not known.

10.7.5 Given that it is anticipated that the AEL plant will commence construction in the fourth quarter of 2015 it is expected that there will be some degree of overlap with the Takoradi T4, Globeleq and One Energy plants.

10.7.6 Given the unknown programme for the Jacobsen project, a worst case approach has been taken and assumed that it is also aligned with the AEL Project.

10.7.7 Such an overlap of the construction programme would see a cumulative increase in the construction impacts on soil and geology. Assuming that the ground conditions

are similar to those at the AEL site, it is likely that there will be an increased risk of leaching of contaminated materials into adjacent watercourses through the disturbance of soils and runoff from stockpiles if not appropriately managed.

10.7.8 However, it is anticipated that the adjacent projects will be constructed following the same strict best practice methods as will be employed during the construction of the AEL Project, including the production of their own ESMP and appropriate PPE.

10.7.9 As such, it is anticipated that all cumulative effects will be appropriately mitigated and the cumulative impacts will be negligible.

Table 10.5. Potential Soil and Geology impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Construction Workers (High)	Impacts to health arising from oral, inhalation or dermal contact with potential pollutants within the ground	Minor	Adverse	PPE / Best practice construction methods	Negligible (not significant)
Geology and Soils (Medium / Low)	Loss of geology /soils	Minor	Adverse	N/A	Minor Adverse (not significant)
Ground water / Hydrogeology (Medium)	Pollution of groundwater	Moderate / minor	Adverse	Best practice construction methods	Minor Adverse / Negligible (not significant)
Soil / Vegetation (Medium)	Soil compaction / surface flooding / run off of contaminated water	Minor	Adverse	Best practice construction methods	Minor Adverse (not significant)

Table 10.6. Potential Soil and Geology impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Maintenance Workers (High)	Impacts to health arising from oral, inhalation or dermal contact with potential pollutants within the ground	Minor	Adverse	PPE / Best practice construction methods	Negligible (not significant)

SECTION 11

WASTE

11 WASTE

11.1 Introduction

11.1.1 This Section provides a discussion of the approach to waste storage, handling, management and disposal that AEL will adopt, during construction, operation and decommissioning of the Project.

11.1.2 The IFC General EHS Guidelines provide guidance on the approach to waste management that is expected for new projects. The Guidelines apply to any facility that generates, stores or handles any quantity of waste. The correct / preferred methods for dealing with wastes is dependent upon the nature of the waste, particularly whether the waste can be classified as hazardous or non-hazardous.

11.1.3 The assessment of waste follows the approach set out in the methodology (Tables 4.1 – 4.4). The approach to waste management is discussed briefly followed by identification of waste streams during construction, operation and approach to decommissioning.

11.2 Waste Hierarchy

11.2.1 AEL, during all phases of the Project, will seek to apply the waste hierarchy as part of their waste prevention and management policy.

11.2.2 The waste hierarchy consists, in order of preference, of:

a Prevention;

b Re-use;

c Recycling;

d Other recovery (e.g. energy recovery); and

e Disposal.

11.2.3 The use of this hierarchy will be incorporated in the ESMP for the Project; all contractors / suppliers will be required to prepare their specific CESMP with due regard to this guiding principle.

11.2.4 This approach will allow AEL and its contractors to establish waste management priorities at the outset of activities based on an understanding of the potential risks and impacts and considering waste generation and its consequences.

11.3 Construction

11.3.1 The ESMP will provide for the submission of construction method statements and a Waste Management Plan (as part of the CESMP) for approval by AEL and relevant stakeholders (that may include the Shama District Authority and the EPA, as appropriate), prior to commencement of construction.

11.3.2 Specific measures could include, amongst others, the stockpiling of excavated sediment and testing for waste acceptance criteria, to determine whether it can be re-used on- or off-site, and the testing and removal, as appropriate, of any water encountered on-site where contamination is suspected which will be handled by a suitably licensed waste contractor.

11.3.3 The ESMP will ensure that all construction waste will be dealt with in a manner that complies with the regulations and (upon leaving the site) waste will be treated and disposed of by suitably licensed contractors. Where hazardous waste is transported from the Project, it will be handled in accordance with the relevant regulations, and, where necessary, be transported in sealed tankers. Application of waste classification will also apply as set out below.

11.4 Operation

Classification of Wastes

11.4.2 The IFC General EHS Guidelines 1.6 (Waste Management) state:

"*Wastes may* […] *be defined as "hazardous" by local regulations or international conventions, based on the origin of the waste and its inclusion on hazardous waste lists, or based on its characteristics*."

11.4.3 The revised Waste Framework Directive (rWFD) (2008/98/EC) provides, for Europe, a definition of hazardous waste as, "a waste possessing one or more of the 15 hazardous properties set out in Annex III of the rWFD," and requires the correct management and regulation of such waste. Waste classification is based on the European List of Waste (Commission Decision 2000/532/EC) (formerly the European Waste Catalogue) and the 'hazardous properties' provided in Annex III of the rWFD.

11.4.4 There are three categories of entries in the List of Waste (LoW):

a **Absolute** entries are automatically considered hazardous;

b **Mirror** entries are linked entries that are considered hazardous (or non-hazardous) if they contain "dangerous substances" and the waste possesses properties specified in Regulation (EC) 1272/2008 on the classification, labelling and packaging of substances and mixtures; and

c **Non-Hazardous** entries are neither absolute or mirror entries.

11.4.5 For the purposes of this Section, as relevant, consideration is given to the LoW for the determination of the nature of identified wastes (given that specific compositions are not currently known).

Project Wastes

11.4.6 A feature of the gas turbine technology, on which the proposed Project is based, is that the discharges to the land are minimal and would be restricted to the following:

a used gas turbine air intake filters (typically replaced annually);

b used ion exchange resins (typically replaced at 5 year intervals);

c Used Reverse Osmosis membranes;

d separated oil / sludge from oil / water separators;

e sludge from the LCO pre-treatment equipment;

f used oil or chemical containers; and

g general office waste.

11.4.7 For the wastes identified above, the relevant entries of the LoW are presented in Table 11.1.

11.4.8 These wastes would be returned to the original supplier where possible or removed by an appropriate licensed contractor for disposal in an appropriate manner.

11.4.9 Disposal of all such solid wastes will be carried out under a service agreement between the Project, the VRA Takoradi Power Plants and the Shama District Assembly Waste Management Department.

11.4.10 A hazardous waste disposal agreement will be signed with the Shama District Assembly and all such disposals will be monitored by AEL.

Table 11.1: European List of Wastes Entries *

Project Waste	LoW Waste Code	Waste Descriptor	Type of Entry
General Office Waste	20 03 01	Mixed municipal waste	Non-Hazardous
Demineralisation Media	19 08 06*	Saturated or spent ion exchange resins	Absolute Hazardous
	19 08 08*	Membrane system waste containing heavy metals	Mirror Hazardous
Oily Water	13 05 02*	Sludges from oil/water separators	Absolute Hazardous
	13 05 03*	Interceptor sludges	Absolute Hazardous
	13 05 04*	Oil from oil/water separators	Absolute Hazardous
	13 05 05*	Oily water from oil/water separators	Absolute Hazardous
Waste Mineral Oil	12 01 06*	Mineral-based machining oils containing halogens (except emulsions and solutions)	Absolute Hazardous
	12 01 07*	Mineral-based machining oils free of halogens (except emulsions and solutions)	Absolute Hazardous
Compressor Wash Fluid	20 01 29*	Detergents containing dangerous substances	Mirror Hazardous
	20 01 30	Detergents other than those mentioned in 20 01 29	Mirror Non-Hazardous

Table 11.1: European List of Wastes Entries *

Project Waste	LoW Waste Code	Waste Descriptor	Type of Entry
Used Antifreeze	16 01 14*	Antifreeze fluids containing dangerous substances	Mirror Hazardous
	16 01 15	Antifreeze fluids other than those mentioned in 16 01 14	Mirror Non-Hazardous
Laboratory Waste	16 05 06*	Laboratory chemicals, consisting of or containing dangerous substances, including mixtures of laboratory chemicals	Mirror Hazardous
Discarded Chemicals	16 05 07*	Discarded inorganic chemicals consisting of or containing dangerous substances	Mirror Hazardous
	16 05 08*	Discarded organic chemicals consisting of or containing dangerous substances	Mirror Hazardous
	16 05 09	Discarded chemicals other than those mentioned in 16 05 06, 16 05 07 or 16 05 08	Mirror Non-Hazardous
Scrap Metal	02 01 10	Waste metal	Non-Hazardous

** Note: Air filters are predominantly made of steel (frames) and plastic / fabric filter materials that are considered non-hazardous. However, these may be treated as 'special wastes' (i.e. not 'hazardous') that are removed from site by suitably licensed contractors that have the capacity to process such items.*

Storage

11.4.11 Using the above LoW (or any updates to the list, based on the continuous monitoring and review cycle that will form part of the implementation of the ESMP), all wastes will be assessed and classified such that hazardous and non-hazardous wastes are segregated and appropriate storage / containment facilities are provided to minimise the environmental, health and safety risks associated with the storage of such substances.

11.4.12 Secondary containment will be considered for the pre-disposal storage of all potential wastes for the Project. The implementation of such measures will be as appropriate to the potential magnitude of impact associated with loss to the environment.

11.4.13 For hazardous substances (e.g. sludge from the LCO pre-treatment), specific management measures will be prepared and relevant and suitable training will be provided to employees that will include:

a Appropriate sharing of information regarding compatibility of substances;

b All storage will be clearly labelled to allow for the easy and rapid identification of the substances contained therein and the associated environmental risks;

c Control of access to areas where hazardous substances will be stored;

d Where necessary, emergency procedures in the event of a release will be prominently displayed in the relevant areas of the site;

e All hazardous substances will be stored above ground; and

f Frequent inspections of all storage facilities.

Monitoring

11.4.14 In order to verify adherence to the documented procedures regarding storage and handling of waste and that these procedures are fit for purpose, AEL will frequently monitor, review and update (as necessary) all policies and training.

11.4.15 AEL/ its contactor will:

a Undertake regular visual inspections of the integrity of all waste storage facilities;

b Require regular audits of waste segregation and collection / removal practices;

c Prepare periodic reports (to be made available to relevant stakeholders, on request) regarding the generated amounts of each waste and measures taken to reduce waste;

d Maintain records of all waste removed from site and details of the ultimate disposal methods; and

e Undertake periodic monitoring off all waste removal contractors used by the Project.

Disposal

11.4.16 Disposal of all solid wastes will be carried out under a service agreement between the Project, the VRA Takoradi Power Plants and the Shama District Assembly Waste Management Department.

11.4.17 A hazardous waste disposal agreement will be signed with the Shama District Assembly and all such disposals will be monitored by AEL.

11.5 Decommissioning

11.5.1 During decommissioning, the waste hierarchy as set out in Section 11.2 will be applied to ensure that opportunities to re-use and recycle materials are maximised. There will be a number of structures that will need to be dismantled and removed from this site. There will be potential for re-use of components, particularly metals and concrete. There is also potential for contamination.

11.5.2 A full Environmental Departure Audit will be carried out prior to decommissioning. This will examine, in detail, all potential environmental risks existing at the Project site and make comprehensive recommendations for any remedial action required to remove such risks.

11.5.3 The decommissioning process will be in full accordance with the prevailing legislation and guidance will be followed and the departure audit will be complied with.

11.5.4 Following completion of the demolition, a Final Environmental Departure Audit will be carried out to ensure that all remedial work has been completed successfully; the audit reports will be made available to any future users of the Project site.

11.6 Cumulative Effects

11.6.1 The addition of other prospective plants within the enclave has the impact of increasing all the waste streams generated. The development of all the power plants is likely to have a significant effect with regards to waste.

11.6.2 For hazardous wastes, AEL's contribution to the total waste generated may be significant, particularly with regard to the end disposal site. For non-hazardous wastes, AEL is likely to contribute a relatively small amount of waste. There may be increased opportunities for re-use or recycling of waste between multiple operators.

Table 11.2. Potential Waste impacts during the Project's Construction Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Severity	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Contaminated soil (High)	Mobilisation of contamination, particularly hydrocarbons	High	Major adverse	Testing, separation and remediation or disposal of contaminated waste at suitable site.	Minor adverse
Waste materials: non-hazardous (Low)	Inert waste taken to landfill	Low	Minor adverse	Seek opportunities to provide local communities with any waste materials which may have other uses. Contractor to develop Waste Management Plan.	Minor adverse
Waste materials: hazardous (High)	Risk of hazardous waste entering environment if not properly disposed of.	High	Major adverse	Waste taken to suitable disposal site in sealed tankers if necessary. Contractor to develop Waste Management Plan.	Minor adverse

Table 11.3. Potential Waste Impacts during the Project's Operation Phase

Receptor / Resource (Sensitivity of Receptor)	Potential impact	Magnitude of Impact	Impact (no mitigation)	Mitigation/ Enhancement	Significance of residual effect
Waste materials: non-hazardous (Low)	Inert waste taken to landfill	Low	Minor adverse	Use of waste hierarchy to maximise opportunities to avoid waste, re-use of recycle, particularly with other operators.	Minor adverse
Waste materials: hazardous or containing mirror substances (High)	Risk of hazardous waste entering environment if not properly disposed of.	High	Major adverse	Waste taken to suitable disposal site in sealed tankers if necessary.	Minor adverse

SECTION 12

CONCLUSION

12 SUMMARY AND CONCLUSION

12.1.1 The ESIA has addressed the potential environmental and social impacts of the proposed Amandi Energy Combined Cycle Power Plant (including its ancillary development) and has considered the potential significant effects on a series of potential receptors. It has also considered the cumulative impacts, taking into account prospective power projects in the Project vicinity.

12.1.2 This section provides a brief summary and conclusion to the ESIA, which has considered the possible impacts on;

- Air quality;
- Noise and vibration;
- Water resources and quality;
- Ecology;
- Socio-economics;
- Soils and geology; and
- Waste.

12.2 Air Quality

12.2.1 An updated baseline air quality survey was completed at sensitive receptor locations and in areas likely to be affected by existing emission sources surrounding the Project site. The survey was undertaken for a period of 14 days in February 2015, using passive diffusion tubes for nitrogen dioxide and sulphur dioxide, and continuous optimcal measurements for particulate matter.

12.2.2 The Project has the potential to generate air quality impacts during construction, operation and decommissioning. The assessment of impacts has involved a qualitative, risk based assessment of impacts during construction/decommissioning and a quantitative assessment of impacts during operation using detailed dispersion modelling.

12.2.3 Impacts during construction and decommissioning include nuisance dust deposition, health effects and dust deposition of ecological receptors. With the implementation of mitigation measures, impacts on human receptors are considered to be negligible whilst impacts on the retained sensitive mangrove habitats surrounding the site are slight adverse but temporary.

12.2.4 The results of the dispersion modelling of exhaust emissions have been compared to Ghanaian ambient air quality standards and to international standards and guidelines (World Health Organisation/EU, cited by IFC). An initial modelling exercise was used to determine an appropriate height for the Project stack (65m). With the stack at this height, the impact of the Project is less than the IFC guideline of 25% of national standards for acceptable impacts and total pollutant concentrations, taking into account background concentrations are below the Ghanaian standards for all pollutants. As such, no health effects from emissions to air are expected with the operation of the Project using LCO.

12.2.5 In summary, the results of the atmospheric dispersion modelling have been compared to the Ghanaian AAQS. The key findings from the assessment of the Project during full load operations are:

- Taking into consideration existing, baseline pollutant concentrations and the maximum contribution from the Project, no exceedences of *any* ambient air quality standards were modelled (whether national or international);
- No significant health effects are anticipated as a result of the operation of the Project;
- Maximum process contributions are less than 10% of all relevant Ghanaian AAQS for industrial areas and less than 20% for residential areas, in all years;
- Maximum short term predicted environmental concentrations are dominated by the contribution from the Project; maximum long term concentrations are dominated by the contribution from background/baseline air quality;
- The critical metrics are, for short timescales, hourly mean nitrogen dioxide and, for long timescales, annual mean particulate matter. The latter is dominated by high background concentrations; and
- The maximum contributions of the Project to ambient pollutant concentrations at selected sensitive receptors are less than 5% of all relevant air quality standards, with the exception of hourly mean nitrogen dioxide for which they are less than 10% of the standards, including both Ghanaian national standards and more stringent international and WHO guidelines

12.2.6 This assessment is compliant with:

- Ghanaian EPA Ambient Air Quality Guidelines (AAQG)
- World Bank Group / IFC EHS Guidelines
- European Union Air Quality Directives.

12.3 Noise and Vibration

12.3.1 An updated baseline noise survey was completed at noise sensitive receptor locations surrounding the Project site using short measurements in February 2015. The survey was completed over a period of seven days to include the quieter periods during a weekend.

12.3.2 The Project has the potential to create noise effects during construction, operation and decommissioning. The magnitude of impact from all identified activities has been assessed in detail, using numerical methods.

12.3.3 Impacts during construction and decommissioning from all Project components have been assessed quantitatively based on the BS 5228 guidance. The impacts relating to construction and decommissioning activities are all temporary. Noise mitigation measures will be developed as outlined in the ESMP. These measures will ensure that potential impacts can be mitigated to an acceptable degree.

12.3.4 The impacts during operation from all Project components have been assessed quantitatively. The results of the computer noise modelling have been compared to the World Bank / IFC guideline noise limits. Additional noise mitigation has been advised in the form of an acoustic screen to the west of the Project site. Following mitigation there are no significant residual effects predicted from the operation of the Project. The inclusion of mitigation in the form of embedded mitigation and additional acoustic screening, will ensure that potential adverse impacts resulting from the Project are negligible or minor and therefore not significant.

12.3.5 This assessment is compliant with:

- BS5228 (2009): 'Noise and vibration control on construction and open sites'
- BS7385 (1993): 'Evaluation and Measurement for Vibration in Buildings'
- ISO 9613 – Noise propagation modelling
- BS7445 (2003): 'Description and Measurement of Environmental Noise'
- Ghanaian EPA Ambient Noise Level Guidelines
- World Bank / IFC Ambient Noise Limits

12.4 Water Resources and Quality

12.4.1 A review of the baseline water environment was completed at the Project site, along with detailed investigations of existing sea water quality and soil contamination. This data has been used to assess the potential impacts on the local water resources.

12.4.2 The Project has the potential to impact upon water resources. During construction, the diversion of the watercourse which passes through the Project site will have a direct impact upon this local water resources, while construction actives have the potential to impact upon the water environment through the mobilisation of sediments (potentially contaminated) which could have a temporary effect on waterbodies downstream. Through the implementation of best practice construction methodologies, all of these impacts can be mitigated and there are not expected to be and significant impacts.

12.4.3 During operation, the discharge of process water of shore will result in a minor increase in chemicals that are already present in the sea water as a result of concentration due to evaporation. There will also be a small increase in other chemicals including cadmium and mercury, however the impacts on water quality are considered to be insignificant.

12.4.4 This assessment is compliant with:

- UK H1 Guidance[15]

12.5 Ecology

12.5.1 The updated ecological assessment took place in February 2015 and was aimed at documenting plant and animal species of critical habitats of terrestrial, aquatic and

[15] There are no current Ghanaian EQS for coastal (sea) water. Similarly, the WB / IFC EHS Guidelines do not provide detailed standards.

coastal with AEL's proposed site and sphere of influence. The results of the assessment indicated low species richness and diversity with recorded species being either of Least Concern according IUCN Red list or yet to be assessed. Nonetheless, many of the plant species possess medicinal and economic values but there is no evidence of the abutting communities exploiting these values. Of ecological importance was the increased coverage of mangrove forest of the site and with the unique presence of all three mangrove species (e.g., *Rhizophora racemosa, Avicennia germinans & Laguncularia racemosa).* The results however suggest that these mangrove forest support low biodiversity with none of the fauna of any international significance. Nevertheless, mangrove forests have high ecological significance and are therefore regarded as critical natural habitats.

12.5.2 In summary, the consolidated ecological assessment indicated that adverse impact of the proposed CCGT facility will have short term moderate to low impacts with a high probability of occurrence on the ecological entities with the site and immediate sphere of influence. Overall ecological impact significance is expected to be low with the implementation of best practice guidelines for noise, vibration, air and water quality and a compensatory plan for the mangrove forest.

12.5.3 It is envisaged that it will not be possible to avoid the direct impact on the mangroves, hence a compensation plan will be adopted to include providing a net gain in mangrove habitat in the long term, although there will be temporary loss of mangrove due to a timelag of at least 5 years for the mangrove to re-establish (based upon the observed encroachment of mangrove on site between 2011 and 2015). Regular monitoring and evaluation of the replanted mangrove would be carried out to ensure early growth and establishment. Also the Project layout will be engineered that more active areas are away from mangrove forest.

12.5.4 The ecological assessment broadly applied the Guidelines for Ecological Impact Assessment in the United Kingdom IEEM, 2006, as well as IFC PS 6; all best practice from this document was applied, but given the Project's location in Ghana, a common sense approach was taken to the applicability of some methodology.

12.6 Social

12.6.1 Socio-economic baseline conditions in the vicinity of the site have been determined from a desk based study involving the review of existing information and available socio-economic studies of the region where the Project is being developed and also stakeholder engagement with local communities, governmental institutions and private sector bodies that have been carried out.

12.6.2 The receptors, comprising mostly local communities that are potentially affected by the Project have been identified; consultations have been carried out with these communities and will continue throughout all project lifecycle stages. This and other key information has been used to develop a SEP that includes a grievance mechanism. It also outlines the programme of future stakeholder that is planned.

12.6.3 From consultations with local communities thus far, the Project is viewed as positive due to the employment opportunities and wider economic benefits that it would bring to the region.

12.6.4 Information obtained has been analysed and summarised to identify the baseline socio-economic conditions, to determine the potential Project impacts, to develop the mitigation measures and to enable monitoring and evaluation of the Project.

12.6.5 The plant is to be located in an area designated for industrial development. The site has been leased, by AEL, from the Royal Family of Aboadze. PAPs have been identified that include local crop farmers, together with owners of unused infrastructure found within the site boundary. Compensation has been provided that more than covers the loss of future income and the beneficiaries continue to earn a living from other businesses. The compensation report (Appendix 9A) details how the compensation has been assessed and awarded.

12.6.6 Impacts have been identified during construction, operation and decommissioning, with the majority of the impacts occurring during the construction phase. Predicted impacts include economic displacement, effects on fishing communities, restricted access to land and the sea, noise and quality (refer to these chapters), indirect effects on tourism / landscape / visual perspective, increase in traffic, employment opportunities and growth of the local economy, increasing demands on food prices, services and infrastructure, influx of migrant workers, disruption due to crime / anti-social behaviour and higher risk of STIs.

12.6.7 Mitigation measures that are proposed include developing an employment management plan, a retrenchment plan (ahead of decommissioning / site closure), a health, safety and environment plan (including waste and dust), a traffic management plan, an oil spill response and management plan, camps to comply with IFC standards for accommodation if they are developed, worker induction training and a worker grievance mechanism.

12.6.8 The inclusion of these mitigation measures will ensure that potential adverse impacts resulting from the Project are minor or insignificant.

12.6.9 This assessment is compliant with:

- IFC Guidelines
- EIB Guidelines

12.7 Soils and Geology

12.7.1 A baseline review of the soils and geology of the area surrounding the AEL site has been undertaken in order to understand the current geological and hydrogeological, and soil conditions of the site. This has included a review of national and local geological maps, soil maps and flood risk maps.

12.7.2 A review of a previous soil contamination report produced for the adjacent VRA Takoradi T3 plant, and new soil testing carried out on the AEL site have provided a high level understanding of potential soil contamination at the Project site. Analysis has found that the levels of arsenic in the soil, and levels of phenols in the ground water exceed the target values, although the degree and source of contamination (naturally occurring or imported) is not clear. Following further testing during construction, if spoil excavated from the site is found to be contaminated it will treated on site so that it is available for re-use, or transported off site to a controlled disposal facility.

12.7.3 Having established the baseline conditions of the sites geology and soils, an assessment of the Project's impact on these assets, and the potential for soil and geology to impact on the site, and site workers has been undertaken. The findings of

the assessment include minor adverse impact on construction workers, which is reduced to negligible with the use of appropriate PPE.

12.7.4 Further minor adverse impacts are identified for geology and soils, groundwater, and vegetation, however none of these are considered to be significant.

12.7.5 All potential impacts will be mitigated through the use of best practice construction methodologies and through staff wearing appropriate PPE. All mitigation methods will be detailed within the ESMP.

12.7.6 This assessment is compliant with:

- Netherlands guidance values published in the Soil Remediation Circular of 2009

12.8 Waste

12.8.1 The construction, operation and decommissioning of the AEL Project has the potential to give rise to a number of waste streams. A number of hazardous wastes have been identified, including waste oils and chemicals during construction and sludge, residues and oils during operation. It is important that this waste is separated and taken to a suitable site for disposal, in sealed tankers if necessary.

12.8.2 For non-hazardous waste, such as construction materials or office and general waste during operation, the waste hierarchy should be applied. Where waste cannot be prevented, opportunities for re-use and recycling should be sought.

12.8.3 This assessment is compliant with:

- IFC General EHS Guidelines 1.6 (Waste Management)
- Waste Framework Directive (rWFD) (2008/98/EC)

12.9 Conclusion

12.9.1 The Project (including ancillary development) has been categorised as a Category A, according to IFC and OPIC – Environmental and Social Policy Statement. However with effective mitigation, as outlined in the ESMP, residual negative impacts can be reduced ensuring compliance with all necessary standards.