OMA Independent Power Project

Geometric Power Limited

Environmental and Social Impact Assessment

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OMA Independent Power Project

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Acronyms

°C	degrees Centigrade
AAQG	Ambient Air Quality Guideline
ACC	Air Cooled Condensers
ADMS	Atmospheric Dispersion Modelling System
AFF	Aqueous Film Forming Foam
AIS	Air-Insulated Switchgear
ASTM	American Society for Testing and Material
BOD	Biochemical Oxygen Demand
CCS	Carbon Capture and Sequestration
CDM	Clean Development Mechanisms
CEC	Cations Exchange Capacity
CEMS	Continuous Emission Monitoring System
CER	Certified Emission Reduction
CHP	Combined Heat and Power
CITES	Convention on International Trade on Endangered Species of Wild Fauna and Flora
CLO	Community Liaison Officer
cm	centimetre
CMS	Christian Missionary Service
CO	Carbon Monoxide
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
CRC	Convention on the Rights of the Child
CWMP	Construction Waste Management Plan
d	day
DA	Degraded airshed
dB LA_{eq}	'A'-weighted equivalent sound pressure level in decibels
DC	double circuit
DLN	Dry Low NOx
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
EBRD	European Bank for Reconstruction and Development
EER	Environmental Evaluation Report
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ELO	Environmental Liaison Officer
EMS	Environmental Management Systems
EPC	Engineering, Procurement and Construction
EPs	Equator Principles
EPSR	Electric Power Sector Reform
ERP	Emergency Response Plan
ESIA	Environmental and Social Impact Assessment

ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
FCT	Federal Capital Territory
FDI	Foreign Direct Investment
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
GACN	Gas Aggregator Company of Nigeria
GE	General Electric
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
GP	Geometric Power
GPS	Global Positioning System
GRE	Glass Reinforced Epoxy
GT	Gas Turbine
GTG	Gas Turbine Generator
h	hour
HIV/AIDS	Human Immunodeficiency Virus / Acquired immune Deficiency Syndrome
HRSG	Heat Recovery Steam Generator
HSE	Health Safety and Environment
HUB	Hydrocarbon utilizing bacteria
HUF	Hydrocarbon utilizing fungi
HVAC	Heating, Ventilation and Air Conditioning equipment
Hz	Hertz
IEC	International Electrotechnical Commission
IEE	Institute of Electrical Engineers
IES	Illuminating Engineering Society
IFAD	International Fund for Agricultural Development
IFC	International Financing Corporation
IFI	International Financing Institutions
IGCC	Integrated Gasification Combined Cycle
IOC	International Oil Company
IPP	Independent Power Producer
ISO	International Organization for Standardisation
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
JDA	Joint Development Agreement
JMTF	Joint Military Task Force
JV	Joint Venture
kg	kilogram
km	kilometre
KPI	Key Performance Indicator
kV	kilovolt

kWh	Kilowatt hour
LCV	Lower Calorific Value
LGA	Local Government Areas
LGC	Local Government Council
LV/MV/HV	Low/Medium/High Voltage
m	metre
m AMSL	Metres Above Mean Sea Level
MAN	Manufacturers Association of Nigeria
m bgl	metres below ground level
MCC	Motor Control Centres
MDG	Millennium Development Goals
MIGA	Multilateral Investment Guarantee Agency
MIL	Main Infrastructure Limited
MJ	megajoule
mm	millimetre
MoU	Memorandum of Understanding
MW	megawatt
MW_e	megawatts electrical
MW_{th}	megawatts thermal
Na	Sodium
NASSI	National Association of Small Scale Industries
NBET	Nigerian Bulk Electricity Trading Company
NBS	National Bureau of Statistics
NDA	Non-degraded airshed
NDDC	Niger Delta Development Commission
NEPA	National Electric Power Authority
NERC	Nigerian Electricity Regulatory Commission
NESREA	National Environmental Standards and Regulations Enforcement Agency
NFPA	National Fire Protection Association
NIPP	National Integrated Power Project
NO	Nitric oxide
NO_3^-	Nitrate
NO_x	Nitrogen oxides
NPC	National Population Commission
O/W	Oil / Water
OEM	Original equipment manufacturer
OMPADEC	Oil Mineral Producing Areas Development Commission
ONAF	Oil Natural Air Forced
OP	Operational Policy
OPGCL	Oma Power Generation Company Limited
PC	Power Centre
PC	Process Contribution
PEC	Predicted Environmental Concentration
PHCN	Power Holding Company of Nigeria

ppb	parts per billion
PPE	Personal Protective Equipment
PS	Performance Standards
PTFP	Presidential Task Force on Power
QAE	Quality Assurance Engineer
R.O.	Reverse Osmosis
rpm	Revolutions per minute
SAR	Sodium Absorption Ratio
s	second
SiO_2	Silicon Dioxide
Sm^3	Standard Cubic Meter
SO_2	Sulphur dioxide
SO_3	Sulphur trioxide
SO_4^{2-}	Sulphates
SOAEL	Significant Observed Adverse Effect Level
SPM	Suspended Particulate Matter
SPV	Special Purpose Vehicle
ST	Steam Turbine
STG	Steam Turbine Generators
TCN	Transmission Company of Nigeria
TDX	Total Dissolved Solid
THB	Total heterotrophic bacteria
THBC	Total heterotrophic bacterial counts
THC	Total Hydrocarbon Content
THF	Total heterotrophic fungi
THFC	Total heterotrophic fungi counts
TSS	Total Suspended Solids
UAT	Unit Auxiliary Transformer
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation
WMP	Waste Management Plan
WTP	Water Treatment Plant
WwT	Waste water Treatment
XLPE	Cross-linked Polyethylene
y	year
µS	Microsiemens

PART 1 – Non-technical Summary

1. The Project

1.1 Project Objectives

Geometric Power Limited (GP), an independent power producer, and its joint development partners, intend to execute a power plant project. The aim of the project is to successfully complete the design, construction, commissioning and take-over of a gas fired power plant in the Nigerian state of Abia.

This ESIA details the proposals of a three phased development plan where Phase One comprises a gas-fired station capable of producing approximately 500 Megawatt (MW) gross generating capacity, to be exported to the Nigerian electrical National Grid. Phases Two and Three include the potential configurations for upgrade to 1,125MW generating capacity. It also considers impacts associated with a 300m long stretch of overhead transmission line, to be constructed from the project switchyard to tie-in to the nearby existing network.

This ESIA presents an assessment of the potential social and environmental effects of the proposed development, including a description of the measures required to be implemented in order to avoid, reduce and where necessary, remedy any identified significant adverse effects.

1.2 The Proponent(s)

GP are an indigenous power generating company, with its headquarters registered in Abuja. They have a track record of efficient power delivery within Nigeria with the construction completion of its Phase One power plant project in Aba, Abia state. The company is engaged in power generation and distribution, having been given approval to participate in the on-going independent power production scheme of the Federal Government of Nigeria.

GP plans to develop the proposed project, as part of a joint venture with General Electric (GE). A Special Purpose Vehicle, Oma Power Generation Company Limited, has been established by the joint venture to develop this project, capitalised on a 60 / 40 basis by GP and GE respectively.

1.3 The Site and Proposed Development

The proposed Site covers approximately 22.3 hectares of rural land located within the local government areas of (LGA) Ukwa West of Abia state in southern Nigeria, north east of the settlement Asa, illustrated in Figure NTS-1.

Figure NTS-1 : Map of Abia State

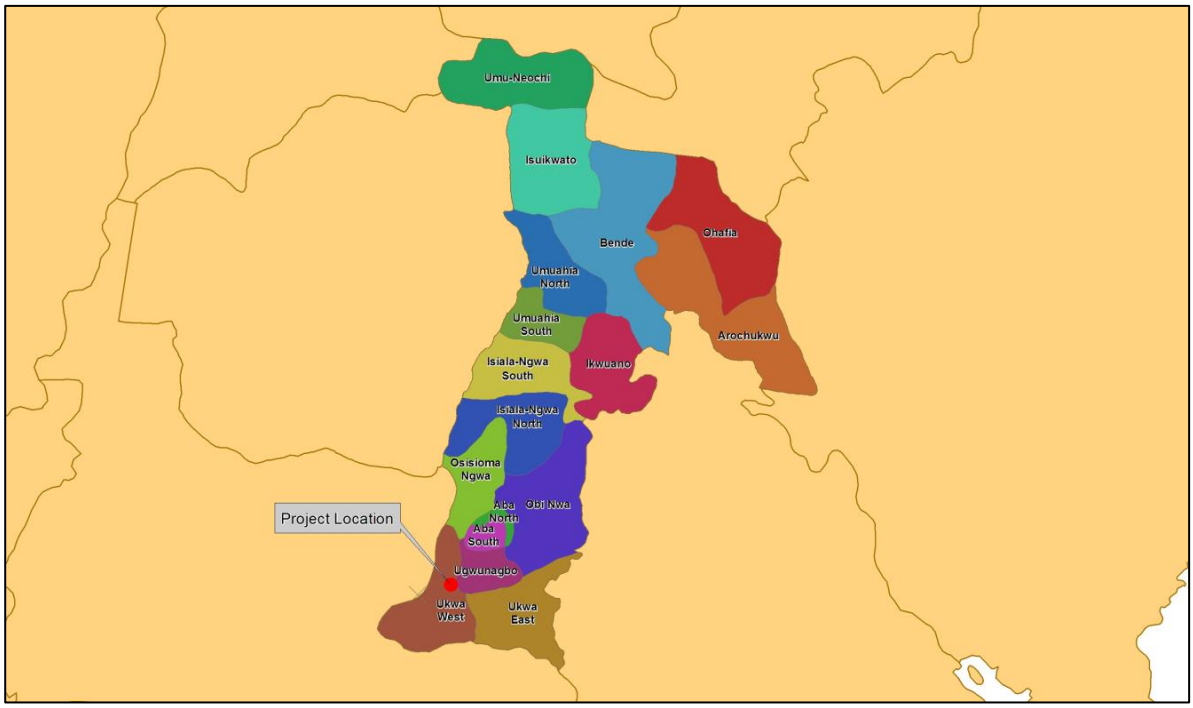


Figure NTS-1 : Map of Abia State

The proposed development would be completed in three phases, where the power plant capacity is to be increased during each development phase. Development Phases will consist of the following:

- Phase One will include four 113MW gas turbines, six electrical transformers and associated infrastructure and buildings.
- Phase Two will include six gas turbines, nine electrical transformers and associated infrastructure and buildings.
- Phase Three will introduce a further six gas turbines with the exhaust gases being directed through six waste heat boilers for energy recovery, two steam turbines situated in dedicated buildings, two air cooled condenser arrays, 11 electrical transformers and associated infrastructure and buildings.

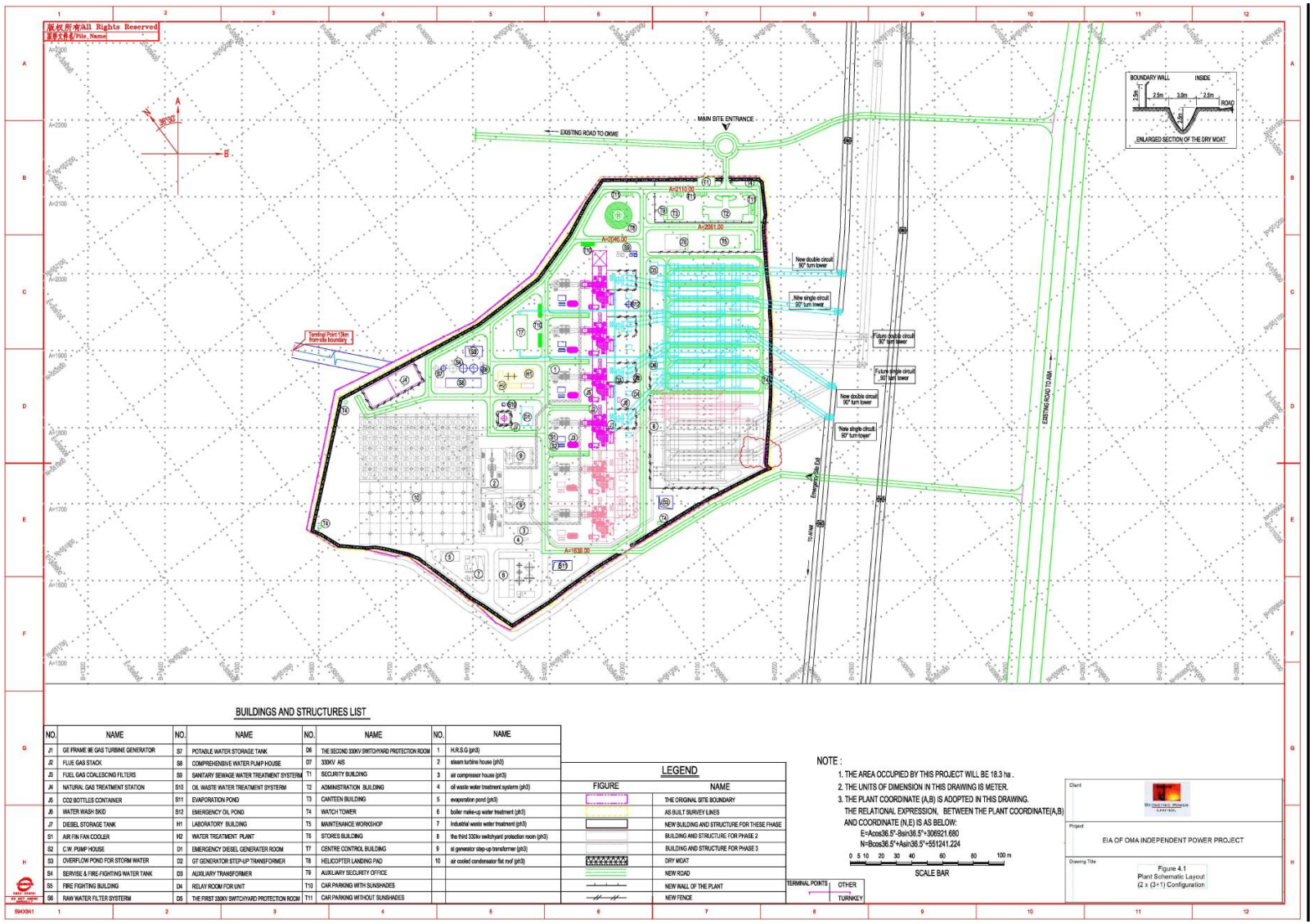
The timing of Phases Two and Three will depend on the need and economics of the expansion phases, the ability to export the electricity and the availability of adequate fuel resources.

The proposed Phase One development layout will consist of the following components (illustrated in Figure NTS-2):

- Main Equipment Area;
- Switchyard Area;
- Fuel Area;
- Auxiliary & Subsidiary Production Buildings and Structures Area;
- Administrative Management Area; and
- Accommodation Facility.

JACOBS

Figure NTS-2: Plant Schematic layout



1.4 Consultation and stakeholder engagement

Consultations were carried out with relevant stakeholders as part of the ESIA process, the result of which formed the basis for the potential impact assessment and informed field surveys. The stakeholders consulted include but are not limited to:

- FMEnv;
- Abia State Ministry of Environment;
- Ukwa West and Ugwunagbo LGAs; and
- Communities of Obehie, Orgwu (Ogwe), Ihie-Iyi, Obiga, Ngwaiyiekwe, Obuzongwa, Owo-ala, and Umuaka.

Consultation activities with local communities included formal and informal meetings, in a variety of public groups and smaller meetings. The purpose of these activities was to provide information about the proposed project and the likely implications of its development, to gather information about stakeholders' concerns, ideas and expectations, and to work towards addressing concerns through mutually agreeable mitigation measures.

Meeting venues, dates and issues raised are discussed in further detail in Section 11, Stakeholder Consultation, and associated appendices.

Over the course of the project development, consultation will be ongoing process, and a stakeholder engagement plan will be developed to facilitate and formalise this.

1.5 Policy, Legal and Administrative Framework

The project is required to comply with the relevant laws and regulations of Nigeria. The project must also meet the requirements of the World Bank Group (WBG) and the International Finance Corporation (IFC) Performance Standards and relevant Environmental Health and Safety Guidelines. The following provides a brief overview of the key applicable environmental legislation.

1.5.1 National Regulatory Framework

The basis for environmental policy in Nigeria can be found in Section 20 of the 1999 Constitution of the Federal Republic of Nigeria. The principal regulatory framework for managing the environment in Nigeria is as follows:

A. National Environmental Standards and Regulations Enforcement Agency Act 2007;

B. Environmental Impact Assessment Act 1992;

C. EIA Sectoral Guidelines of the Federal Ministry of Environment (FMEnv);

D. National Environmental Protection (Effluent Limitations) Regulation (S.1.8) 1991;

E. National Environmental Protection Regulation (S.1.9) 1991;

F. National Environmental Protection (Management of Solid Hazardous Wastes) Regulation (S.1.15) 1991;

G. National Policy on the Environment;

H. Harmful Waste Act 1988;

I. Water Resources Act 1993;

J. National Environmental Standards and Regulations Enforcement Agency (NESREA) Act; and

K. The Associated Gas Re-Injection Act No 99 of 1979.

1.5.2 International Regulations

This ESIA considers the policies, guidelines and standards of the WBG's IFC. The requirements of the WB Multilateral Investment Guarantee Agency essentially reflect those of the IFC Standards for private sector projects. The following international conventions would also apply to the project:

- Convention on Biological Diversity;
- The Ramsar Convention;
- Convention on the Trade in Endangered Species;
- UN Convention to Combat Desertification;
- UN Framework Convention on Climate Change (UNFCCC);
- Vienna Convention for the Protection of the Ozone Layer;
- Convention on the Conservation of Migratory Species of Wild Animals;
- United Nations Guiding Principles on the Human Environment;
- International Union of Conservation of Nature and Natural Resources; and,
- Kyoto Protocol to the United Nations Framework Convention on Climate Change

2. Environmental Impacts and Mitigation

2.1 Air Quality

Potential impacts on air quality from the project during construction are likely to be combustion gas emissions and dust generation arising from cars and trucks and construction equipment. Diesel exhaust from these sources is known to contain several chemicals and compounds that may be detrimental to human health over the long-term with repeated exposure where exposure of on-site workers to diesel exhaust could be significant.

Potential impacts during plant operations could arise from plant equipment and traffic associated with the project. However, results from air quality modelling for the project indicate that impacts are unlikely to

Mitigation measures focus on the design and construction scheduling of the development including using site and plant operation to minimise dust generation, the provision of tarred be significant during any of the project Phases.

Mitigation measures for construction will include dust suppression on earthworks and stockpiles of excavated material, adopting modern combustion technology for generators, and appropriately designed stacks and stack height to ensure adequate dispersion of emissions to atmosphere. Operational mitigation measures include the use of low sulphur fuel, emission control / abatement and monitoring of ambient air and stack emissions.

Overall no long-term air quality impacts are anticipated given the projects minor contribution to local air quality impacts.

2.2 Energy Efficiency and Greenhouse Gas Emissions

The greenhouse gas emissions from the project over its lifetime have been quantified and compared with Nigeria's annual carbon emissions.

Despite inherent mitigation measures in design that aim to maximise the efficiency of the plant and reduce carbon emissions, the project will still have a significant associated carbon footprint and will contribute to global greenhouse gas emissions. It is noted that the carbon emissions for the operational of the development will be significantly lower than for crude oil and coal fired power plants.

The magnitude of effect for operation is assessed as being of major significance.

2.3 Noise

An assessment of the noise impacts that are predicted to occur during the construction, operation and decommissioning of the proposed development has been undertaken. The assessment included the development of a three-dimensional noise model to assess potential operational noise impacts. A baseline noise survey was completed to characterise the existing background noise levels within and adjacent to the project site. The nearest sensitive receptors are located over 400m away from the development area.

Potential impacts of construction, operation and decommissioning on receptors of noise from earthworks and site preparation, piling, creation of hardstanding, laying of foundations, erection of structure, creation of access tracks, an increase of traffic and the operation of gas and steam turbines and associated transformers were considered potentially significant in the short-term.

In terms of plant operations, the results of modelling showed that night-time noise levels are likely to exceed residential noise standards at the nearest sensitive receptors.

A Noise Management Plan is proposed to address this along with mitigation measures to reduce operational and construction noise impacts. These would include the use of personal protective equipment for workers during construction, maintenance of all equipment on site, movement of vehicles shall be restricted to day time and noise complaints shall be logged and investigated. During operation, design measures shall be adopted to reduce plant equipment noise levels including: acoustic machine enclosures, selecting structures according to their noise isolation effect to envelop the building, using mufflers or silencers in intake and exhaust channels, using sound absorptive materials in walls and ceilings, and using vibration isolators and flexible connections.

No long term noise impacts are anticipated following implementation of these measures.

2.4 Geology, Soils, Hydrogeology and Hydrology

The geology, soil, hydrogeology and hydrology assessment comprised a desk based review of published data, ground investigations for the site of geology and hydrogeology, and consultation with local Environmental Health Departments to determine public and private water supplies, and other sensitive receptors that are hydraulically connected to the Study Area.

Local topography of the Study Area, which generally slopes north to south, serves two surface water catchments: Imo River to the east and south, and Aba River to the east (that discharges to the Imo River to the southeast of the study area). No other significant surface water features were noted within the Study Area. Both surface water catchments within the Study Area ultimately discharge to the Atlantic Ocean, 65km to the southeast of the Site, near the settlement of Ikot Abasi.

Groundwater was encountered approximately 27m below ground surface and observed to follow regional topography. Groundwater resources are used locally to support community water supplies.

Impacts of construction, operation and decommissioning of the project on receptors of geology, soil, hydrogeology and hydrology concern soil erosion, fuel/chemical contamination of soils or water resources, and remobilisation of unrecorded contaminated land. Mitigation measures include temporary drainage installation, excavated material management, fuel/chemical storage guidance and monitoring of community supply boreholes. After implementation of mitigation measures the residual impacts noted for soil and groundwater contamination from fuel and chemical spillages are assessed as being negligible.

2.5 Ecology

The Ecology assessment comprised a desk based review of published data and field visit of the Study Area.

No known areas of natural or critical habitat or archaeological significance were found within 10km of the proposed development area and during field surveys vegetation consisted of a mosaic of farmlands (mostly cassava) and fallow lands.

Potential impacts from construction of the project infrastructure on ecology would include the loss, degradation or fragmentation of wildlife habitat, loss of vegetation and the contamination of habitats. The potential impacts during operation are significantly less than construction and include only the potential contamination of habitats and groundwater from accidental release of hazardous substances.

Mitigation measures proposed during construction include limiting the extent of vegetation and habitat removal during site clearance to what is necessary and vegetation retained will be demarcated to ensure preservation. Landscaping will maximise the use of excavated materials and re-vegetation accomplished

using indigenous species of fauna. Construction work will be scheduled to minimise the construction footprint. During operation the safe storage and use of hazardous materials shall be managed to prevent accidental release.

Ecological impacts associated with the proposed project could include permanent loss of wildlife habitat on the project site, minor degradation of wildlife habitat and possible relocation to a potentially less favourable habitat, but the ecological value of the project site is considered to be low and potential impacts minor.

2.6 Waste and Hazardous Materials

The waste assessment comprised a desk based review of published data and field visit of the Study Area. Waste management within the LGA that serves the Site (Ugwunagbo) has been reported as absent with no landfills nearby that has led to fly tipping on private and public land. Lack of sewerage is commonplace and localised contaminated land is suspected from biosolids. The lack of waste management within the study area has led to infection of pests on some illegal dumping sites.

Waste during construction will be managed through the development of a construction waste management plan (CWMP) while a waste management plan (WMP) will be employed during operation. The management plans will identify opportunities for prevention, reuse, recycling and disposal of waste that is generated on Site.

Impacts from construction, operation and decommissioning of the development arising from waste have been identified as generation of excessive waste and contamination of groundwater and air quality from hazardous wastes including solvents, fuels and wastewater. A waste management plan and other mitigation measures are proposed to address potential impacts including maximising reuse of excavated materials (soils and inert rubble) in landscaping, recycling of materials; making benign waste materials (i.e. wood) available to the local community; disposal of waste hazardous liquids and gas tanks to an approved facility and the provision of portaloos/cesspits until permanent sewerage has been provided.

No long term impacts are expected following mitigation.

2.7 Socio Economics

The socio-economic baseline was established based on a desk-top study combined with a household survey and focus group discussions held in the communities of Obehie, Orgwu (Ogwe), Ihie-Iyi, Obiga, Ngwaiyiekwe, Obuzongwa, Owo-ala, and Umuaka. Settlements of primary interest for the study were those 8 located within 5km of the project site. Based on interviews with community leaders, the estimated population in this area is approximately 27,500 people, although the accuracy of this figure is difficult to verify. The main economic activity in each of the communities is farming.

Sources of potential impacts included beneficial impacts associated with employment and economic development from construction and operation of the project; occupational community health and safety impacts from increased hazards associated with more traffic, and potential accidents and emergencies arising from construction of the project or the associated transmission line; and community conflicts and health and safety issues associated with the pressures of population influx from construction and operational workers along with increased demand for services. All of these adverse effects will be addressed by the development of appropriate health and safety plans along with the development of some enhancement measures to promote positive community relations and improved opportunities for local employment.

2.8 Cumulative Impact Assessment

Within each of the environmental topics described the specific impacts of the development are addressed separately. However, the combined effect of developments in the area must also be considered as 'cumulative impacts.' This would include consideration of a power station and associated noise, air pollution, greenhouse gas and carbon emissions, habitat loss and fragmentation, socio-economic effects, contamination effects and other minor implications of the project combine with the effects of other planned development in the area.

Considering the limited footprint of the proposed development and its distance from other large scale projects physical impacts of the project on the local area are not considered to be significant. Although there are noise and air quality emissions associated with the project, the anticipated cumulative impacts to air quality and noise are not expected to be significant as industrial emissions in the local area are some distance away.

For all these reasons, cumulative impacts are assessed to be of low significance.

PART 2 – Environmental and Social Impact Assessment

1. Introduction

1.1 General

Geometric Power Limited (GP), an independent power producer (IPP), intends to execute a power plant project to export power to the Nigerian National grid. The initial objective of this project is to successfully complete the design, construction, commissioning and take-over of Phase 1 of the power plant that consists of a gas-fired simple–cycle plant of approximately 500 Megawatt (MW) gross generating capacity that will export power to the Nigerian national electrical grid. It is also intended to upgrade the Phase 1 plant, in two additional separate phases. Phase 2 will add two further simple-cycle power generation units and Phase 3 will add two combined cycle generating units to bring the total gross generating capacity to 1,125 MW.

GP, a private IPP developer in Nigeria, plans to develop the proposed project, as part of a joint venture (JV) with General Electric (GE). A Special Purpose Vehicle (SPV), Oma Power Generation Company Limited, has been established by the JV to develop this project, capitalised on a 60 / 40 basis by GP and GE respectively.

In line with GP's Health Safety and Environment (HSE) policy, Federal Ministry of Environment (FMEnv) Nigeria, procedural guidelines and in conformance to the regulations governing the environment of Nigeria, BGI Resources Limited in association with Jacobs UK Limited, was commissioned to carry out an Environmental and Social Impact Assessment (ESIA) for the proposed project, hereafter referred to as OMA power plant.

This ESIA will address Phase 1, the simple-cycle (500 MW gross generating capacity) and Phases 2 and 3, the potential configurations (625 MW gross generating capacity simple and combined cycle) for upgrade to 1,125MW generating capacity.

The ESIA will also meet the requirements of International Financing Institutions (IFIs) as generally defined in the Performance Standards for Environmental and Social Sustainability ('IFC Standards' or 'the Performance Standards) of the International Financing Corporation (IFC) that is part of the World Bank Group (WBG) and the requirements of the WBG Environmental, Health and Safety (EHS) Guidelines.

This ESIA presents a statement of the likely social and environmental effects of the proposed project and includes a description of the measures which require to be implemented in order to avoid, reduce and where possible, remedy any identified significant adverse effects.

1.2 The Proponents

GP is an indigenous power generating company with a track record of efficient power delivery exemplified by the 22 MW capacity emergency power delivered to Abuja Federal Capital Territory (FCT) from 2001 to 2004. The company has completed the development and construction of its phase 1 power plant project in Aba, Abia State, currently with an initial installed capacity of 141MW with approximately 110 kilometres of overhead lines for distribution to end users. GP's head office is located at 7 Mary Slessor Street, off Udo Udoma Crescent, Asokoro, Abuja. The company is engaged in power generation and distribution, having been given approval to participate in the on-going independent power production scheme of the Federal Government of Nigeria.

GE is a global diversified technology and financial services company, with products and services ranging from aircraft engines, power generation, water processing to medical imaging and industrial products. The company is a respected global leader in the power equipment supply and services sector. The first phase of the Oma Project will utilize 4 GE Frame 9E open cycle gas turbines.

GE has been present in Nigeria for over 10 years and is investing US$1Bn in a manufacturing facility, creating 2,300 jobs and boosting the local economy. It has a strong commitment to the Nigeria power sector, and signed a Memorandum of Understanding (MOU) with the Nigerian Government in 2012 to develop 10,000 MW over 10 years jointly with the private sector.

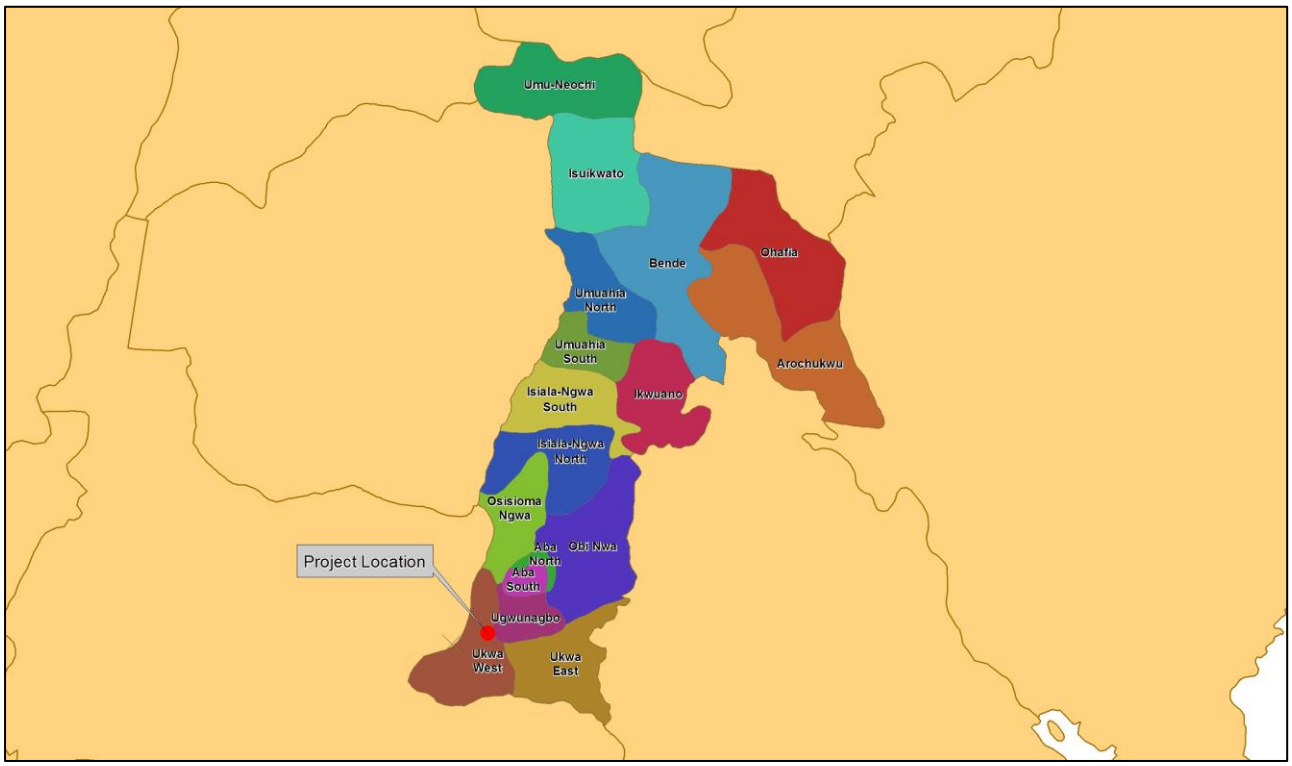
1.3 Study Location

The proposed site for the OMA power plant lies within coordinates 4º59'18"N, 7º16'42"E and 4º59'18"N, 7º17'13"E. The total land take is approximately 22.3 hectares. Further details of the land acquisition process can be found in Sections 2.4.10 and 6.2.2, and the land title exchange documents are provided in Appendix I.

The project will be sited within the Ukwa West Local Government Area (LGA) and 620m east of the Ugwunagbo LGA, of Abia State as shown in Figures 1-1 and 1-2.

Figure 1-1: Map of Nigeria

Figure 1-2: Map of Abia State



The closet Autonomous Communities are located in Ugwunagbo and Ukwa West LGAs, respectively. These communities are known as Obehie, Orgwu (Ogwe), Ihie-Iyi, Obiga, Ngwaiyiekwe, Obuzongwa, Owo-ala, and Umuaka by the local population, all of which are located within a 5km radius of the site.

A detailed site location plan is presented in Chapter Four.

1.4 Environmental and Social Impact Assessment Scope

The Environmental Impact Assessment (EIA) Act No. 86 of 1992 enacted by the Federal Government of Nigeria makes an EIA mandatory where proposed projects or activities may cause significant adverse environmental effects. The EIA Act gave the FMEnv the implementing mandate and requires mandatory application of the EIA process in all major development projects right from the planning stage. This development falls under section 13c of the Schedule (Mandatory Activities) of the EIA Act for construction of combined cycle power stations and therefore an EIA is mandatory.

An Environmental and Social Impact Assessment (ESIA) was previously prepared by BGI Resources, on behalf of Oma Power Generation Company Limited (OPGCL) for the project and was approved by the FMEnv in March 2014. In February 2014, SKM (now Jacobs UK Limited) with support from BGI were commissioned to review and upgrade the ESIA Report (including specification of any supporting action required by BGI Resources) in order to address the requirements of the EHS performance standards (PS) and guidelines of the WBG and the IFC. Since the submission of the original ESIA, the World Bank provided additional comments on the document requesting substantial revision to the structure of the document, particularly with regards to the socio-economic assessment. As a result additional socio-economic survey work was undertaken by Creekline in September 2015 in consultation with Jacobs.

Jacobs has, therefore, produced this revised ESIA to address the latest comments from the World Bank and including the revised socio-economic baseline survey data provided by Creekline and to align the revised documentation with relevant international standards as required by project Lenders. In doing so, it

is important to note that Jacobs did not undertake the baseline data collection for the original ESIA and whilst the information has been reviewed, Jacobs has not verified all data provided by BGI. Some sections of the ESIA remain as BGI's text and are based upon the technical data collected by BGI. In order to align with international assessment methodology standards and World Bank comments, the structure of the ESIA was altered and the documentation text has been significantly revised by Jacobs.

Upon approval of the ESIA from the international lenders, construction and operation of the OMA Power Plant will be required to comply with the EHS conditions set by the WBG and IFC as well as with the laws, regulations, and policies of the Nigerian Federal, State, and local governments.

This ESIA considers the various stages of the proposed development including:

- **Pre-construction Phase**: Impacts related to pre-construction activities could include road grading, equipment mobilisation, site clearance and development of the workers camp, but anticipated impacts would be minor. These impacts were considered and mitigation provided as a separate phase in the ESMP.

- **Construction Phase:** Impacts may arise from construction activities, typically the effects are short-term.

- **Operation Phase:** Impacts result from, principally but not exclusively, the plant's air and noise emissions and aqueous emissions. Such emissions are generally produced for the life of the project.

- **Decommissioning Phase:** There will be short-term impacts associated with the removal of the plant and associated infrastructure. Impacts of the decommissioning phase are similar to those of the construction phase of the project. A discussion of decommissioning phase impacts is included.

This ESIA will enable the FMEnv Nigeria and international lenders to formally comment on the proposed methodology and the environmental issues that have been identified and to confirm that any potential significant adverse environmental and/or social issues are fully addressed in the Environmental and Social Management Plan (ESMP), provided in Section 10. The ESMP will be further developed during the construction and operational environmental protection systems and will be updated as required.

1.5 Environmental and Social Impact Assessment Objectives

The main objectives of the ESIA include the following:

- To gather comprehensive baseline information and existing data of the site and surrounding area, so as to establish the environmental and social baseline conditions of the project area;

- To establish the environmental sensitivities prevalent in the project area;

- To identify, quantify and assess the likely negative and positive environmental impacts of the proposed project, including cumulative impacts, as presently designed;

- To identify, evaluate and predict the potential and associated impacts of the proposed project on the biophysical, socio-economic and cultural settings of the area with adequate interfacing and project interaction;

- To inform project design such that the best design options are selected based on environmental and social factors as well as operational and economic factors;

- To consult with project stakeholders, including local communities, so that their concerns are addressed;
- To identify health hazards that may arise from different phases of the project execution and evaluate local population exposure to these hazards;
- To recommend control measures in order to eliminate and mitigate significant impacts on the proposed project environment;
- To identify any environmental and socioeconomic issues and concerns that may, in the future, affect the successful operation of the project and advise on appropriate approaches to address them; and
- To put in place an effective ESMP to coordinate the management of the identified impacts throughout all phases of the project and to provide a framework for the project's detailed environmental management systems to be implemented.

1.6 Environmental and Social Impact Assessment Methodology

The ESIA was designed to address the surrounding environment of the project area by concentrating its investigations on the following:

- Comprehensive literature review to define the biophysical and socio-economic characteristics of the project area;
- A field sampling and survey program of the project site, to validate/supplement the information/data currently available;
- Laboratory analyses of the samples collected from the field survey/sampling program;
- Review of relevant national and international environmental regulatory requirements and good practice guiding power plant construction and operation;
- Environmental, socio-economic and health impact identification, prediction, interpretation and evaluation;
- Development of avoidance and/or mitigation measures and monitoring program as applicable to be incorporated into the ESMP; and
- Preparation of both draft and final ESIA reports in line with the FMEnv Nigeria, Department of Petroleum Resources (DPR) guidelines and IFC and WBG EHS Performance Standards and Guidelines.

The purpose of the ESIA is to identify and assess the impacts of the project on the environment, as well as develop appropriate mitigations measures for effective management of adverse impacts. The study approach involved a blend of multidisciplinary standard methods from environmental science, engineering and social sciences in order to obtain data/information for impact identification, and to establish avoidance and mitigation measures. The ESIA involved a literature review, baseline/field data acquisition, consultations, impact identification and assessment and the development of appropriate impact avoidance/mitigation measures incorporated into an ESMP framework.

Literature Review

A literature review was undertaken to acquire information on climate, geology, soil, vegetation, health, socio-economics and other environmental components of the proposed project area. The materials

reviewed include textbooks, articles, journals, maps, photographs and previous EIA reports. References are included in Appendices II and III where relevant. Examples include, *but are not limited to*, the following:

- Climate
  - Nigeria Meteorological Agency (NIMET)
  - UNFCCC (2014) 2nd National Communication submitted by Nigeria, February 2014
- Geology, groundwater and soils
  - Niger Delta Environmental Survey (NDES) (1997), Environmental and Socio Economic Characteristics
  - Grossman and Reinsch, 2002
- Vegetation
  - Nigeria National Biodiversity Plan, 2010, 104pp (www.cbd.int/doc/world/ng/ng-nbap-01-en.boc)
  - Important Bird Areas in Africa and Associated Islands: Priority Areas for Conservation, Newbury and Cambridge, UK, Birdlife Conservation Series No.11 (www.birdlife.org/datazone/userfiles/file/IBAs/AfricaCntryPDFs/Nigeria.pdf)
- Health
  - National Agency for the Control of AIDS (http://www.naca.gov.ng/)
- Socio-economics
  - Census data from the National Population Commission, Nigeria (http://www.population.gov.ng/index.php/censuses)
- Air quality
  - Journal articles including: Huang et al., 2009; Peavy, et al., 1985; Chineke and Chiemeka 2009; WHO, 1976; Rao & Rao, 2005; Davis and Masten 2004.

Baseline/Field Data Acquisition

Field data acquisition was carried out to ground-truth existing information and obtain additional data to better characterize the environmental and socio-economic baseline conditions of the project area. Field data to support the environmental and socioeconomic status of the project area was acquired during a field data gathering program carried out between 11th to 13th July, 2012 (wet season) and 12th and 15th February, 2013 (dry season). Data was acquired on vegetation, wildlife, soil, air quality/noise, ground water, hydrobiology, socio-economics and health. Additional surveys were undertaken in April 2014 to identify the location of local community water supply boreholes.

Consultation

Consultations were carried out with relevant stakeholders to ensure that their views and opinions concerning the proposed project and its associated and potential impacts are integrated into the ESIA

process. Some of these stakeholders were consulted during the scoping stage, prior to the start of the field studies. Socio-economic consultations with the host communities were also carried out to create awareness and integrate the communities' opinions and concerns into the ESIA process. The result of such consultations forms the basis for the potential impact assessment which is an integral part of this ESIA report. The stakeholders consulted include but are not limited to:

- FMEnv;
- Abia State Ministry of Environment;
- Ukwa West and Ugwunagbo LGAs;
- Ogwe Community of Ukwa West LGA; and
- Ihie-Iyi, Community of Ugwunagbo LGA.

The consultation process is a key component of the ESIA process and the ESMP, and will continue throughout the construction and operational phases of the project.

Potential and Associated Impact Assessment and Mitigation

In each of the environmental topic areas, professional judgement and (where relevant, e.g. for air quality) the results of modelling analysis are used in combination with relevant guidance to assess and evaluate the significance for each effect. Effects are considered to be major, minor or negligible and can be negative or positive. Where positive impacts are identified mitigation is not required however positive impacts will be enhanced where possible. Further details on the criteria applied to the assessment of potential impacts are provided in Section 7 of this ESIA.

1.7 Structure of the Report

The structure of this ESIA report is as follows:

- Non-technical Summary: This provides an overview of the project, potential environmental impacts and proposed mitigation and monitoring strategies, using non-technical language.
- Section 1, Introduction: This section provides an introduction to the project, the project proponent and an overview of the project objectives.
- Section 2, Policy, Legal and Administrative Framework: This section summarises the key elements of national, local, and international legislation and standards that apply to the proposed project.
- Section 3, Project Justification: This section provides a description the project's justification and presents the need/value and the envisaged sustainability of the project as well as the development alternatives considered
- Section 4, Project Description: This section presents a description of the proposed project activities including engineering/detailed design, project management and operations philosophies and the project execution schedule.
- Section 5, Physical Environmental Baseline: This section presents the baseline environmental conditions of the project area as identified by desk-based studies and supplemented by site visits.

- Section 6, Socio - Economic Baseline: This section presents the socio economic baseline conditions of the project area as identified by desk-based studies and supplemented by site visits.

- Section 7, Environmental and Social Impact Assessment Methodology: This section details the criteria applied to the assessment of potential impacts arising from the proposed project elements described in the Section 4. It provides definitions of impact magnitude and significance as they apply to the potential effects on environmental and social aspects.

- Section 8, Associated and Potential Impacts: This section presents the likely impacts of the project elements on the identified social and environmental aspects.

- Section 9, Mitigation Measures: This section proffers mitigation and enhancement measures, and alternatives for the identified adverse impacts. A summary of the residual impacts post mitigation is provided.

- Section 10, Environmental and Social Management Plan: This section presents the social and environmental management, mitigation and monitoring measures, including roles and responsibilities, identified by the ESIA process as required to be undertaken during project implementation and operation to implement the mitigation actions, reduce adverse environmental and social effects to acceptable levels and to enhance potential benefits.

- Section 11, Stakeholder Consultation: This section presents the consultation that has been conducted for the project and includes a proposed plan for consultation moving forward.

1.8 Input from International Consultants (Jacobs UK Limited)

An ESIA was previously prepared by BGI Resources for the project. This was submitted to the FMEnv and approval was granted in March 2014**.** Since the submission of the original ESIA, Jacobs has been commissioned to align the documentation with relevant international standards and thus this document has been prepared in accordance with Environmental Impact Assessment (EIA) Act No. 86 of 1992 and also to meet good international industry practice.

In making these amendments, Jacobs has generally used the data provided by BGI Resources, supplemented by additional information provided by BGI resources and OMA and has not undertaken additional technical studies. Jacobs was, however, also responsible for preparing the air quality and noise technical assessments contained in the updated ESIA and the socio-economic assessment work that was re-scoped and baseline survey information provided by Creekline in September 2015 in consultation with Jacobs.

The ESIA is intended to enable the reader to understand the nature of the proposed development and to evaluate the likely environmental effects. The ESIA therefore acts to aid the decision-making process and to present information in a readily accessible form.

2. Policy, Legal and Administrative Framework

2.1 Overview

Relevant identified legislation, regulations, policies, guidelines and standards from Nigeria and International treaties, standards and guidance will be considered in the development of the ESIA.

2.2 Regulatory Constraints

Based on available information, there are no environmental regulatory constraints that would restrict development and implementation of the proposed project. Furthermore, no known rare, threatened or endangered species were identified as located in or adjacent to the proposed project area. There are no communities or indigenous people present on the site that will be affected or require relocation as a result of the proposed OMA Power Plant.

2.3 Nigerian Government Administrative Subdivisions

There are essentially three tiers of governance in Nigeria. The first tier is the Federal Government of Nigeria which is divided into 36 states and a Federal Capital Territory. The next two tiers of governance are the States which are further sub-divided into 774 LGAs.

The constitutional framework for environmental management remains highly centralized. The federal and state governments are given the primary responsibility for developing and implementing the legislative framework for environmental management. At the state level, relevant institutions exist for the enforcement or implementation of environmental policies. The major cross-sectoral regulator of the environment at the federal level is the FMEnv. For effective coordination between the federal and state agencies, the FMEnv has offices in each of the 36 states, each headed by a senior personnel designated as “Controller of the Environment,” whose function is to liaise with the headquarters of the Ministry in Abuja, regarding developments in the environmental sector in the state of his/her posting. Responsibilities on environmental issues in the states lie with the State Ministries of Environment whose functions include: liaising with the FMEnv to achieve the National Policy on Environment; and, co-operating with FMEnv and other National Directorates/Agencies in the performance of environmental functions including raising environmental education / awareness of the citizenry.

The primary responsibility of LGAs is economic planning and development. LGAs do not enact laws, but can enforce requirements that pertain to natural resource conservation provided such requirements do not run counter to those of either the state or federal government. LGAs are required to ensure that laws derived from the upper two tiers of government are not compromised in their areas of jurisdiction. Another tier of government, albeit an informal one, exists beneath the LGAs. Most rural communities have traditional or cultural governance organizations composed of elected individuals within the community such as village elders, chiefs, or traditional heads who exercise influence over the local population. Though not provided for in Nigeria’s constitution, they nevertheless serve to resolve social-economic issues within their respective communities.

2.4 Federal Environmental Management Framework and Corresponding Agency Jurisdictional Authority

This section presents the principal regulations that will govern the proposed OMA Power Plant. The specific provisions within each piece of legislation that has relevance to the OMA Power Plant is also identified and discussed along with the corresponding regulatory agency responsible for implementing the regulation. Moreover, the environmental performance criterion to be used in the environmental analysis is identified.

The basis for environmental policy in Nigeria can be found in Section 20 of the 1999 Constitution of the Federal Republic of Nigeria. Pursuant to Section 20, provisions for the protection and improvement of the environment and safe guarding of water, air, land, forests and wildlife in Nigeria are provided. The principal regulatory framework for managing the environment in Nigeria is as follows:

A. National Environmental Standards and Regulations Enforcement Agency Act 2007;

B. Environmental Impact Assessment Act 1992;

C. EIA Sectoral Guidelines of the Federal Ministry of Environment (FMEnv);

D. National Environmental Protection (Effluent Limitations) Regulation (S.1.8) 1991;

E. National Environmental Protection Regulation (S.1.9) 1991;

F. National Environmental Protection (Management of Solid Hazardous Wastes) Regulation (S.1.15) 1991;

G. National Policy on the Environment;

H. Harmful Waste Act 1988;

I. Water Resources Act 1993;

J. National Environmental Standards and Regulations Enforcement Agency (NESREA) Act;

K. The Associated Gas Re-Injection Act No 99 of 1979; and,

L. Others.

2.4.1 National Environmental Standards and Regulations Enforcement Agency Act 2007 (NESREA)

The National Environmental Standards and Regulations Enforcement Agency (NESREA) Act repealed the Federal Environmental Protection Agency Act (FEPA Act) and established the National Environmental Standards and Regulations Enforcement Agency. NESREA is an agency of the FMEnv. It is responsible for enforcing compliance with all environmental standards, rules, laws, policies and guidelines for all industrial sectors except the petroleum sector. It is also responsible for development of biodiversity conservation and sustainable development programs and coordination and liaisons with relevant stakeholders within and outside of Nigeria on matters pertaining to environmental policies, regulations, laws and standards. Although the NESREA Act repealed the FEPA Act, it nonetheless retained subsidiary legislation made pursuant to that Act.

This legislation is still applicable under NESREA and is as follows:

1. National Environmental Protection (Effluent Limitation) Regulations;
2. National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Waste) Regulations; and
3. National Environmental Protection (Management of Solid and Hazardous Waste) Regulations.

2.4.2 National Environmental Protection (Effluent Limitations) Regulation (S.1.8) 1991

This regulation makes it mandatory for industries generating wastes to install anti-pollution and pollution abatement equipment on site. The regulation is specific to each category of waste generating facility with respect to limitations of solid and liquid discharges or gaseous emissions into the ecosystem. Appropriate penalties for contravention are also specified in the regulation.

2.4.3 National Environmental Protection Regulation (S.I.9) 1991

The National Environmental Protection (Pollution Abatement in Industries Producing Waste) Regulation of 1991 regulates the release of toxic substances, requirement for pollution monitoring unit, machinery for combating pollution and contingency plan by industries. It also provides that industries producing wastes should submit lists and details of chemicals used by such industries to FMEnv as well as permissible limits of discharge into public drains. It details protection of workers, requirements for environmental audit and penalty for contravention. Paragraph 15 (2) of S.1.9 states that no oil in any form shall be discharged into public drains, rivers, lakes, seas, atmosphere or underground injection without the permit issued by FMEnv or any organization designated by the ministry. Paragraph 17 of the same section also states that an industry or a facility which is likely to release gaseous, particulate, liquid or solid untreated discharges shall install into its system, appropriate abatement equipment in such a manner as may be determined by the agency.

2.4.4 National Environmental Protection (Management of Solid Hazardous Wastes) Regulation (S.1.15) 1991

This regulation spells out the requirements for groundwater protection, surface impoundment, land treatment, waste piles, landfills, incinerators, etc. It also describes the hazardous chemical products and dangerous waste constituents. Specifically, S.1.15 provides a comprehensive list of Wastes that are classified as being dangerous to the environment. It also gives detail on the contingency planning and emergency procedure to be followed in case of sudden release of any of these hazardous wastes into the environment.

2.4.5 National Policy on the Environment

The overall goal of achieving sustainable development in Nigeria is the main aim of the National Policy on Environment [1989]. The policy details implementation strategies for the various sectors such as the human population, land use and conservation, water resources management, forestry/wildlife protected areas, marine and coastal resources, sanitation and waste management, toxic and hazardous substances mining and mineral resources, agricultural chemicals, energy production and use, air pollution, noise pollution, working environment [occupational, health and safety]; settlements recreational space, greenbelts monuments and cultural property. The policy also provides for public participation, institutional arrangements, legal basis, obedience to international treaties and obligations. The provisions of the policy include:

- Monitoring for all Nigerians, a quality environment for their health and well-being, conserving and using the environment and natural resources for the benefit of present and future generations;
- Restoring, maintaining and enhancing the ecosystems and ecological process essential for the functions of the biosphere to present biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
- Raising public awareness and promoting understanding of essential linkages between the environment and development and to encourage individual and community participation in the environmental improvement efforts; and
- The co-operation in good faith with other countries, international organization / agencies to achieve optimal use of trans-boundary natural resources and effective prevention or abatement of trans-boundary environmental pollution while stipulating an environmental problem-solving approach predicated on an integrated, holistic and systemic view.

2.4.6 Environmental Impact Assessment Act No 86 of 1992

The Environmental Impact Assessment Act (EIA Act) establishes the EIA as an action-forcing document which ensures that the policies and goals defined in the Act are infused into the proposed project. The purpose of the EIA is to provide a full and fair discussion of the significant environmental impacts resulting from the project, and to inform the decision-makers and the public of reasonable alternatives which will avoid or minimize any adverse impacts.

The FMEnv is responsible for administering and enforcing this law. The law empowers FMEnv to monitor and certify in writing, environmental assessments on all projects for which an EIA is mandatory pursuant to Schedule E of the Act.

In September 1995, FEPA published the EIA Sectoral Guidelines for Oil and Gas Industry projects. These guidelines are intended to assist in the proper and detailed execution of EIA of oil and gas projects in consonance with EIA Act of 1992. The FMEnv EIA procedural flow diagram is presented in Figure 2-1.

The Act requires an EIA to be developed for some power generation and transmission projects. In reviewing the Act, the sections of applicability (or closely applicable) to the proposed project, i.e. those that require development of an EIA, are those entailing the construction of a combined cycle power station.

2.4.7 EIA Sectoral Guidelines of the FMEnv

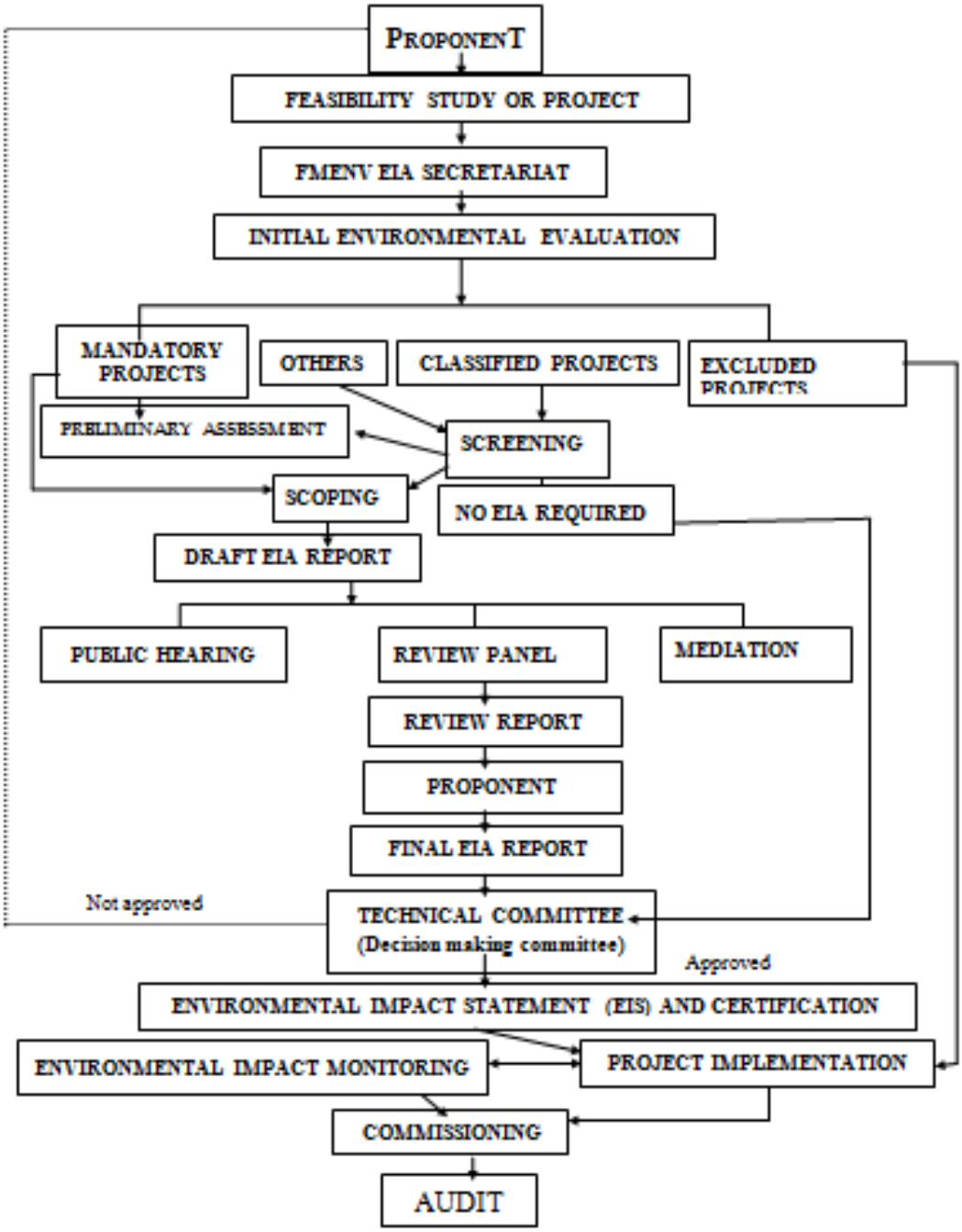
Federal Environmental Protection Agency (FEPA) now FMEnv was established by Act 58 of 1988 to monitor and prevent the pollution of the environment following the Koko toxic wastes dump incident. This empowered FEPA to prepare Environmental Guidelines and Standards as instruments for prevention of environmental pollution. This Act also gives specific powers to FMEnv to facilitate environmental assessment of projects.

In addition, FEPA regulations S.1.8, S.1.9 and S.1.15 of 1991 provided guidelines and standards for the following:

- Solid and Hazardous waste management;
- Effluent limitations; and
- Pollution abatement in industries and facilities generating wastes.

The FMEnv management procedure is shown in Figure 2-1.

Figure 2-1: FMEnv EIA Management Procedure



2.4.8 Harmful Waste Act 1988

The Harmful Waste Act prohibits the purchasing, selling, importing, storage, carrying, depositing or dumping of harmful wastes on any land or territorial waters (reference the Territorial Waters Act 1967) within Nigeria. Such acts incur severe penalties. The Act defines harmful wastes as "any injurious, poisonous, toxic or noxious substance, and in particular includes nuclear wastes emitting any radioactive substance if the waste is in such quantity, whether with any other consignment of the same or of different substance, as to subject any person to the risk of death, fatal injury, or incurable impairment of physical and mental health."

2.4.9 Water Resources Act 1993

The Water Resources Act vests in the Federal Government of Nigeria the right to control the use of all surface water and groundwater in the nation. Pursuant to this Act, the Minister of Water Resources may prohibit or regulate the carrying out of any activity on land or water that may interfere with the quantity or quality of any water in any watercourse or groundwater. The Act allows anyone to acquire the right, i.e. a license from the Minister, to use or take water from any watercourse or any groundwater for any purpose in accordance with the Act and any regulations pursuant thereto. The Act further empowers the Minister to impose a fee on the issuance of such license.

During the preliminary engineering phase, the project will obtain any license, as required pursuant to Section 13(a) of the Act, to install the groundwater wells as described in the project description in Section 4 of this ESIA.

2.4.10 Land Management

The Land Use Act of 1978 nationalised land-holding in Nigeria. The Act entrust all land to the State, excluding land vested to the Federal Government or its agencies. The State Governor holds such land in trust for the people and is thus responsible for its allocation in all urban areas to individual residents or businesses in the State. With respect to non-urban areas, similar powers are conferred to Local Government Councils (LGCs). The legal status of land users in Nigeria is thus one of occupancy rather than ownership.

Pursuant to Part II Section 9 of the Act, the Governor may issue a certificate of occupancy when any entity or person is in occupation of land under a customary right of occupancy and applies in a prescribed manner. The terms, conditions and annual fee pursuant to the certificate of occupancy are enforceable against the holder and successors.

Pursuant to the Joint Development Agreement (JDA) signed between the co-developers of the OMA Power Plant project, GP is responsible for ensuring that the project site is procured and provided to the project company. The project site procurement was commenced by the initial majority shareholder of the project SPV, which is Main Infrastructure Limited (MIL).

In 2013 the project site was procured from the owners of the land and fenced and secured by GP. The registration process at the Land Registry in Umuahia, Abia State is currently being completed. The registration of the land with the Land Registry is a part of the process that will culminate in the issuance of the Certificate of Occupancy by the Abia State Governor. Issuance of the Certificate of Occupancy can take a significant period of time due to the Governor often personally signing the Certificates and extended delays in the processing of the application by the Land Registry. The JDA allows for the valuation and transfer of the project site to the project SPV at financial close of the project. The land title exchange documents are provided in Appendix I.

Further details on land acquisition and compensation are provided in Section 6 of this ESIA.

2.4.11 Criminal Code

The Nigerian Criminal Code makes it an offence punishable with up to 6 month's imprisonment for any person who:

- Violates the atmosphere in any place so as to make it noxious to the health of persons in general dwelling or carrying on business in the neighbourhood, or passing along a public way; or
- Does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, whether human or animal.

There are also other regulations including:

- Wild Animals Preservation Act Cap 132 LFN 1990;
- Explosives Regulations, 1967; and
- Natural Resources Conservation Act Cap 286 LFN 1990.

2.4.12 Laws Protecting Flora and Fauna

Nigeria's National Forestry Policy was approved in 2006. The legislation to support this Policy known as the National Forestry Act is currently under review. Once passed, the National Forestry Act will be administered by the Federal Department of Forestry which is a parastatal agency of the FMEnv. Limited information available on the draft Forestry Act indicates that its goal is to economically exploit forests resources in a sustainable manner with careful consideration given to biological diversity and ecosystem protection.

Parks, Game Reserves and other Protected Areas: There are three categories of protected areas in Nigeria established to protect flora and fauna. These categories are the National Parks, Game Reserves and Forest Reserves. At the national level, the mandate for wildlife conservation and protected areas management is the responsibility of the National Parks Service, an agency within the FMEnv. There are seven national parks spread across the country. These parks receive the highest level of protection in accordance with the National Parks Service Act of 1999, Act 46. A variety of game reserves are managed by the states in which they reside in an effort to preserve wildlife species. States also manage innumerable forest reserves with the intention of preserving trees and other plant species along with associated wildlife. There are no National Parks within 10km of the proposed project.

Endangered Species (Control of International Trade and Traffic) Act; Nigeria acceded to the Convention on International Trade on Endangered Species of Wild Fauna and Flora (CITES) in 1974. The treaty's goal is to ensure that international trade in specimens of wild animals and plants do not threaten their survival. In accordance with Nigeria's obligations under CITES, the government enacted the Endangered Species (Control of International Trade and Traffic) Act. This seeks to control and in some cases prohibit the trafficking or trade of special status species, as defined by the Act, including the commercial exploitation of such species. The project will not involve the trafficking of "special status species" as defined by the Act.

The proposed project will use the International Union for the Conservation of Nature's (IUCN's) "Red List" to determine the species to address in this environmental analysis. This is discussed in Section 5.9 of this ESIA, which evaluates the baseline species composition in line with the Red List.

2.4.13 State Environmental Management Framework

The different States within Nigeria have the power to enact laws to protect the environment within their respective jurisdiction. The applicable State regulations have been taken into cognizance as part of the proposed project. Some of the functions of the State Ministry of Environment include:

- Liaising with the FMEnv to achieve the National policy on Environment,
- Co-operating with FMEnv and other National Directorates/Agencies in the performance of environmental functions including environmental education / awareness to the citizenry,
- Responsibility for monitoring waste management standards,
- Responsibility for general environmental matters in the States, and
- Monitoring the implementation of EIAs and other environmental studies for all development projects in the States.

Abia State Basic Environmental Law, 2004 and 2013 as Amended: This study took cognisance of the Abia State relevant laws and policies. Among which is the Abia State Basic Environmental Law, 2004 and 2013 as Amended. The Agency shall, subject to this law, perform the following functions:

- The Environmental Monitoring Division shall perform the following functions:
  - Management and control of reference laboratories;
  - Analytical Services;
  - Environmental research and studies;
  - Oil and gas contamination, monitoring and evaluation; and
  - Monitoring of standard, testing and sampling of industrial effluents.
- The Environmental Inspectorate Division shall perform the following functions:
  - Environmental Management System;
  - Environmental quality coordination (air, water, noise, radiation and hazardous substances);
  - Quality standard development;
  - Enforcement and control of Regional movement;
  - Pollution control;
  - Monitoring of persistent organic pollution of hazardous toxic substances;
  - Standards enforcement; and
  - Interventional (matters and convention).
- Environmental Impact Assessment Division (EIA) and Environmental Evaluation Report (EER) shall perform the following functions:
  - EIA processing/guideline development;
  - Hazard and risk analysis;
  - Effluent control;

- Industrial Compliance and Hygiene; and
- Urban and rural Land use information and plans regulation and quality.

Abia State Public Health law (CAP 139, 2005): Also relevant to this project is the Abia State Public Health laws cap 139, 2005. Particularly, in Section 13 sub section 1 of the law states that any person who by any act or default causes or suffers to be brought or to flow into any well, stream, tank, reservoir, aqueduct or pond used or intended to supplying water for man or beast or into any conduit communication therewith any deleterious substance or commits any act whereby such water is or may be fouled shall be liable to a fine of N1,500 and a further sum of N200 for everyday during which the offence continued after conviction.

Sub section 2 further states that such penalty may be recovered during the continuance of the offence or within one calendar month after it has ceased.

2.4.14 International Treaties on the Environment

Nigeria has ratified numerous international treaties on the environment. Under Nigerian law it is necessary to incorporate a treaty into domestic legislation before it can have the full force of law. In many cases, the ratified treaties have yet to be implemented into the laws of Nigeria. As such, the courts in Nigeria may not enforce them.

The following environmental treaties have been ratified by Nigeria and have implementing legislation in-place that will apply to the project, including:

- Convention on Biological Diversity;
- The Ramsar Convention;
- Convention on the Trade in Endangered Species;
- UN Convention to Combat Desertification;
- UN Framework Convention on Climate Change (UNFCCC);
- Vienna Convention for the Protection of the Ozone Layer;
- Convention on the Conservation of Migratory Species of Wild Animals;
- United Nations Guiding Principles on the Human Environment;
- International Union of Conservation of Nature and Natural Resources; and,
- Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Although not yet implemented in Nigerian law, the international conventions specified above have been taken into consideration in the preparation of this Study Report.

Convention on Biological Diversity: The purpose of this convention is to ensure the conservation and sustainable use of biodiversity. Nigeria signed the convention on 13th June 1992 and ratified the same on 29th August 1994. A number of institutions and organizations have been designated to carry out activities that could facilitate the implementation of the Convention on Biological Diversity in Nigeria. The FMEnv coordinates the activities of these institutions. The provisions of this Convention have been integrated in many laws in Nigeria.

The Ramsar Convention: The Ramsar Convention came into force for Nigeria on 2nd of February 2001. The Ramsar Convention on Wetlands is primarily concerned with the conservation and Management of Wetlands. Parties to the convention are also required to promote wise use of wetlands in their territories and to take measures for the conservation by establishing nature reserves in wetlands, whether they are included in the Ramsar list or not. The proposed development is not located on wetland habitat *per se*, rather it is sited on fallow farmland and cassava plantation; with no water courses or standing water noted within or close to the proposed development area.

Convention on the Wetlands of International Importance as Waterfowl Habitat: This convention is also referred to as Ramsar Convention. Its main objective is to promote conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world. Nigeria acceded the Convention on 2nd October 2000.

Convention on International Trade on Endangered Species of Wild Fauna and Flora 1974: implemented by the Endangered Species Act; seeks to control and in some cases prohibit the international trade in wild plants and animals that are at risk of extinction as a result of trade. The Convention seeks to control trade not only in live species but also in dead specimen and their derivatives.

United Nations Convention to Combat Desertification: The above Convention was adopted on 17th June 1994 in Paris and came into force on 26th December 1976. Nigeria ratified the Convention on 24th June 1997. The purpose of the UNCCD is to address the problem of the degradation of land by desertification and the impact of drought particularly in arid and dry semi-humid areas.

United Nations Convention on Climate Change (UNFCCC): The convention on climate change was signed in 1992 during the Rio Earth Summit but put into force in 1994. The primary purpose of the convention is to establish methods to minimise global warming and in particular the emission of the greenhouse gases.

Vienna Convention for the Protection of the Ozone Layer: The convention was instituted in 1985 and encourages intergovernmental cooperation on research, systematic observation of the ozone layer, monitoring of CFC production and the exchange of information. It places general obligations on countries to take appropriate measures to protect human health and the environment against adverse effects resulting from human activities which tend to modify the ozone layer.

The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in September 1987, and was intended to allow the revision of phase out schedule on the basis of periodic scientific and technological assessments. The Protocol was adjusted to accelerate the phase out schedules. It has since been amended to introduce other kinds of control measures and to add new controlled substances to the list.

Convention on Conservation of Migratory Species of Wild Animals: This convention also known as the Bonn Convention of 1979 was adopted on 23rd June 1979 and came to force on 1st November 1983. It is intended to ensure that migratory species of wild animals spelt out on Appendix I and II (of the Convention) to that convention are protected from extinction. The Convention requires intergovernmental cooperation to ensure that the species are allowed to migrate as their nature and habit is preserved, and stipulates actions for the conservation and management of migratory species including habitat conservation.

United Nations Guiding Principles on the Human Environment: The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development. Ten of these Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles relevant to the proposed project are summarized below;

- **Principle 2:** The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

- **Principle 3:** The capacity of the earth to produce vital renewable resources must be maintained and, wherever practicable, restored or improved.

- **Principle 6:** The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon the ecosystems. The just struggle of the peoples against pollution should be supported.

International Union for Conservation of nature and Natural Resources (IUCN) Guidelines (1996): The World Conservation Union – IUCN Red List of threatened animals provides taxonomic, conservation status and distribution information on species that have been evaluated using the IUCN Red List categories. This system is designed to determine relative risk of extinction and the main purpose of the Red List is to catalogue the species that are regarded as threatened at the global level i.e. at risk of overall extinction. The 1996 Red List also included information on species that are categorized as extinct, species that cannot be assessed because of insufficient data, and certain species in the lower risk category. Nigeria as a member categorizes species using the Red List.

Kyoto Protocol: The Kyoto Protocol requires signatories to the United Nations Framework Convention on Climate Change (UNFCCC) to reduce their greenhouse emission levels to 5% below 1990 levels by the year 2012. The Protocol came into force on 16th February 2005, after it received the pre-requisite signatures. However, major countries like United States, China, India and Australia are not signatories to the Protocol. Nigeria is not a signatory to the Protocol, however have undergone accession, an act by which a State signifies its agreement to be legally bound by the terms of a particular treaty. It has the same legal effect as ratification, but is not preceded by an act of signature.

Note that In February 2014, Nigeria submitted its 2nd National Communication to UNFCC. This document includes Greenhouse Gas (GHG) reporting requirements and adaptation strategies for dealing with the effects of climate change. As such it is directly relevant to this project and has been considered in relevant aspects in the ESIA and ESMP development.

2.4.15 Agenda 21

Nigeria continues to implement Agenda 21 to support sustainable development through the integration of environmental concerns into the national development policies, plans and programmes.

2.4.16 Millennium Development Goals (MDGs)

Whilst there is no mention of energy in the eight MDGs, energy services is inevitably an essential input to achieving all the eight goals. This is due to the fact that in order to implement the goal accepted by the international community, to halve the proportion of people living below the poverty line by 2015, access to affordable energy services is a prerequisite.

2.4.17 Convention on the Rights of the Child

The Convention on the Rights of the Child (CRC), 1989 is the most comprehensive compilation of International legal standards for the protection of the human rights of children. The CRC is also the most widely ratified international human rights treaty, ratified by all countered in the world, with the exception of two. The Convention acknowledges children as individuals with rights and responsibilities according to their age and development (rather than the property of their parents or as victims), as well as members of

a family and community. Underlying the Convention are four main principles: non-discrimination, the best interests of the child, the right to life, survival and development and the right to participate.

The CRC reaffirms children's basic human rights to health, shelter and education. Special emphasis is placed on safeguarding family unit and the reunification of families (Articles 8, 10, 20). Another fundamental right enumerated in the Convention is the child's right to education and the obligation of states to make primary education free and compulsory for all children (Articles 28, 29). Education has also been identified as an effective and essential form of protection for displaced children. For example, displaced children in school may be more protected from the risks of military recruitment, exploitation and abuse. Educational and recreational activities, like sports, can also help children recover from the trauma of conflict and displacement (Internal Displacement Monitoring Centre, 2004).

2.4.18 Convention on the Elimination of all forms of Discrimination against Women

The Convention on the Elimination of all forms of Discrimination again Women places explicit obligations on states to protect women and girls from sexual exploitation and abuse.

Universal Declaration of Human Rights (Article 7), the UN Charter (Articles 1, 13, 55 and 76) and the International Covenant on Civil and Political Rights (Article 24) reaffirm the freedoms and rights of all children, including internally displaced children.

2.4.19 Forced Labour Convention

Each Member of the International Labour Organisation which ratifies this Convention undertakes to suppress the use of forced or compulsory labour in all its forms within the shortest possible period.

With a view to this complete suppression, recourse to forced or compulsory labour may be had, during the transitional period, for public purposes only and as an exceptional measure, subject to the conditions and guarantees hereinafter provided.

2.4.20 Minimum Age Convention

Each Member for which this Convention is in force undertakes to pursue a national policy designed to ensure the effective abolition of child labour and to raise progressively the minimum age for admission to employment or work to a level consistent with the fullest physical and mental development of young persons.

2.4.21 Discrimination (Employment and Occupation) Convention

Each Member for which this Convention is in force undertakes to declare and pursue a national policy designed to promote, by methods appropriate to national conditions and practice, equality of opportunity and treatment in respect of employment and occupation, with a view to eliminating any discrimination in respect thereof.

2.4.22 United Nations Convention against Corruption

This United Nations Convention concerns the threats posed by corruption to the stability and security of societies which undermine the institutions and values of democracy. The Convention also aims at tackling the links between corruption and organised and economic crime. The United Nations Convention against Corruption is the first global instrument on the prevention of, and fight against, corruption. It provides a comprehensive framework and a variety of important minimum standards for all participating States.

The Convention applies to the prevention, investigation and prosecution of corruption and to the freezing, seizure, confiscation and return of the proceeds of offences.

2.5 Electrical Power Sector Regulatory Framework

The major power utility company in Nigeria, the National Electric Power Authority (NEPA), now known as the Power Holding Company of Nigeria (PHCN) is owned by the Nigerian Federal Government. Until the recent privatization it has been the main electric power monopoly for the generation, transmission and distribution of a centralized power grid.

2.5.1 Electricity Act, 1976

This provides for the regulation and control of power generation, transmission, supply and use of electrical energy in Nigeria. This Act is enforced by the Power Holding Company of Nigeria (PHCN). The relevant parts to the OMA power plant project include: Parts III, IV, V, VI, VII,VIII, IX and X.

- Part III: Regulations prescribing the issue of a private license and governing a licensee;
- Part IV: Regulations appertaining to electricity apparatus;
- Part V: Safety regulations for supplies and users of electrical energy and equipment as affecting new installations;
- Part VI: Regulations appertaining to overhead lines restrictions to placing electrical lines above the ground;
- Part VII: Stipulates protection for substations and transformers;
- Part X: Electrical lines and apparatus general other than consumer installations; and
- Part XI: Supply to premises of consumers/consumers' installations.

Relevant parts of these regulations are:

Part III

Application for a license [Regulation 22(3)]

i. Every application for a license whether for sole source or supply or emergency supply shall be in writing and in the form set out in the Schedule thereto, and shall be accompanied by the fee prescribed by regulation 40(1) of the Electricity supply regulation as amended from time to time and together with a prepared plan.

ii. In schedule II, the supply authority in the area concerned shall be consulted to say whether they can undertake the functions of the said application either at all or within a reasonable time in the case of sole source of supply or whether they have any objection in the case of generating plant installed for emergency purposes only.

iii. Where the application involves the placing of any works or electric lines on or across, under or over, any public place, the applicant shall furnish evidence at the time of his application that:

- Notice in writing shall be served on the following:

- The Local Authority concerned;
- The Local water Supply authority;
- The Director of Telecommunications; and
- The owner of any other electrical line interested in the proposed work.

➢ That the proposed works are not objected to or are approved subject to certain conditions being observed.

The purposes of Regulations 22(3), it shall be sufficient if certified copies of any notice served and any counter notice received by the applicant are attached to the application.

Regulations 23-24 concern license terms, conditions that may lead to plant shut down, prohibitions of electricity sale, suspension and license revocation and penalties.

Part IV

- Regulations 36-40 appertain to design standards; safety; maintenance; reports on accident, interruptions and breakages; and license fees respectively.

- Regulations 41 - 44 give specifications for the proper earthling of all equipment, which require earthling.

Part V

This part stipulates safety regulations and uses of electrical energy, and equipment affecting new installations. It deals with conditions of direct-current supply with earth return in Regulation 41, system earthing in 42, Delta and star-connected systems with earthed and isolated neutrals in 44 and 45 respectively.

Part VI

- Regulation 94 stipulates the standard requirements on insulation for cable whether a.c. or d.c. and for all voltages, while 95 lists regulations on trenching and protection of cables from damage, giving the depth at which the cables should be laid (1 meter minimum) and a minimum distance of 300mm between cables. It also requires that cable should be laid in sifted soil or sand to prevent damage by stones and protected against mechanical damage with interlocked tile sufficiently wide to give a minimum overlap of 50mm of each side and 150mm above the cables. The cable routes shall also be indicated at surface level with cable marker at suitable intervals, particularly at positions where the cable changes direction.

- Regulation 96 requires protection of cables at a point at least 50cm below ground where cables enter or leave the ground, while 97 requires that all proposals in respect of railway crossing be submitted to General Manager in accordance with regulation 64 which requires the Licencee to serve a written notice to appropriate authorities prior to placing electric line(s) other than a service line in the proximity of railway line.

Part VII

- Regulation 101 of this part stipulates their provisions requiring the following:

  i. That outdoor substations and switch stations be efficiently protected by fencing not less than 2.5metres which shall be earthed separately from the substation earth;

ii. Appropriately labelled danger notices shall be displayed on the Licensees works;

iii. Any metal work accessible from the ground, shall be connected to an earth mat, situated such that the operator is situated within its area; and

iv. Suitable provision shall be made to guard against danger of the system becoming accidentally charged above its normal voltage by leakage, or contact with the system at the higher voltage.

v. Section 2 of the same regulation gives provisions for sub-stations situated inside a building. It requires the mandatory removal of oil from the oil-receptacle for oil-immersed transformers or switches to guard against the danger of fire as a precaution and that spare oil be stored in an area away from any such substation or switch station.

- Regulation 102 requires the protection of all transformers by primary fuses or overload circuit breakers adjacent to the transformer.

Part VIII

- Regulation 104 deals with automatic protection and isolation of circuits. It requires that:

i. Means be provided at the origination of every main circuit to automatically cut off the supply of energy in the event of:

- The passage of current of such magnitude and duration as would be liable to damage the line or its associated joint and fitting.
- Leakage of current to earth in excess of the amount permitted by the regulations.

ii. The means provided in compliance with Regulation 104(1) shall be circuit breakers constructed and installed in conformity with the relevant Nigerian Standard and they shall be capable of interruption, without damage to the equipment or danger to the operator, system short-circuit currents likely to be handled under conditions of use to which they are subjected and further shall similarly withstand without damage to the equipment or damage to the operator, the currents flowing if closure is made on a line or circuit which is short circuited.

iii. Every automatic device shall be provided with means so that it can be locked in the “off” position to prevent unauthorized interference. During the time that the device is locked in the “off” position the relevant keys for the lock shall be kept in safe custody as prescribed by Regulation 75(3).

- Regulation 105 gives general conditions as to transformation and control for energy at high voltage being transformed, converted or otherwise controlled in sub-or switching – stations for which the following provisions shall be effective:

i. Sub-and switch stations shall preferably be erected above ground, but where necessarily constructed underground there shall be due provision for ventilation.

ii. Outdoors substations and switch stations shall be enclosed within a chain link or woven wire or mild steel unclimbable fence.

iii. Fire – resisting casing on the premises of a consumer preferable of metal connected with earth shall completely enclose all electric lines and so secured to prevent access to electricity charged parts by an unauthorized person. It also requires appropriate danger

notice on the works stating the Licensees name, address and telephone number at which an officer will be in attendance at all times.

- Further construction details for specified cases are captured in Regulation 106, while 107 gives precautions against fire risk. Precautions are the draining way of any oil, which may leak, from tanks, receptacles or chamber in switching station using oil-immersed transformers and provision for extinguishing any fire, which may occur. It also prohibits the storage of oil in any station.

- Regulation 108 makes provisions for faults between transformer windings.

Part IX

- Regulations 109 - 111 appertain to switch boards, connection with earth, power stations, 114 spell out regulations for horizontal clearance in passage ways, power-houses and sub-stations enclosures, 116 deals with notice on electric shock treatment and 119 gives precautions against excess leakage.

- Regulation 120 gives provisions, which apply to connection with earth of high voltage systems.

Part X

- Contained in part X are regulations 121 - 134. Relevant legislation is contained in Regulations 121; standard construction of electric lines; 122 - 123: protection against energy; precaution against shock and fire; protection from lightning and precautions against metal works becoming electrically charged respectively.

- Regulations 127 - 129 concern insulation or protection, receptacles for electric lines and apparatus and underground shafts.

- Regulations 133 appertains to placing of electric cables below ground, requiring the licensee not to place cables on the opposite side of the streets to the telegraph line unless the Director of Electrical services expressly authorizes in writing a relaxation of these requirements.

- Regulation 134 requires the exchange of plant between the licensee and Director of Telecommunications for any existing works placed below ground.

2.5.2 Electricity Amendment Act 1998

The electricity amendment Act No. 28 of 1998 was the legislative backing to commence the deregulation of the electricity sector in Nigeria. Hitherto NEPA had the statutory responsibility to generate, distribute and supply power in Nigeria. This Act promulgated by the Federal Government of Nigeria clearly demonstrates the readiness to allow competition in the power sector of Nigeria. By this Act it is expected that both national and international investors interested in the sale of electricity will be willing to compete favourably in power generation, distribution and supply. This Act automatically abolishes all the monopoly previously enjoyed by NEPA.

Section (2) of this Act amends the electricity Act among other things to make it clear that licenses under the Act may be granted to any person, other than the NEPA, a state Government or any of its agencies. Section (3) sates that a person granted licenses under subsection (1) of this section shall be subject to the terms and conditions of the license and have the same rights and obligations as the Authority, a state Government and/or agencies. Section (4) states that the issuance of a license under this Act shall not be deemed to give to the licensee a monopoly of the exclusive right to supply electricity within the area authorized by the license.

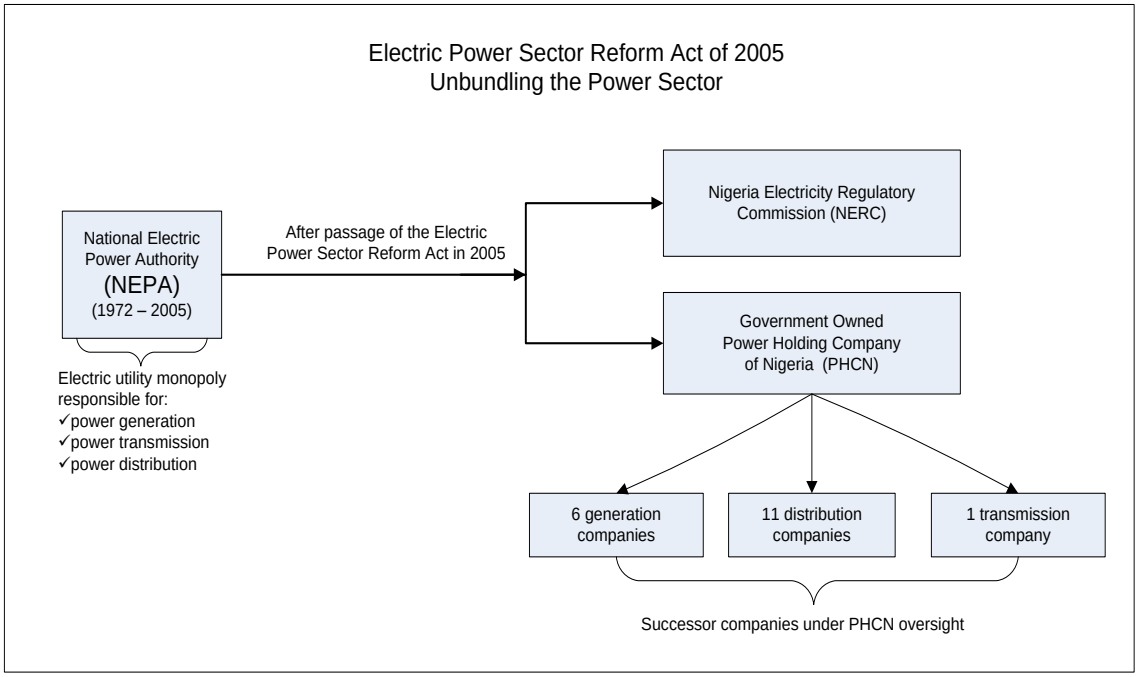
2.5.3 Electricity Power Sector Reform Act (2005): The Nigerian Electricity Regulatory Commission (NERC)

In order to engender greater efficiency and sustainability, the government instituted a series of reforms that commenced in 2005 with the passage of the Electric Power Sector Reform (EPSR) Act, refer to Figure 2-2. The EPSR Act led to the restructuring of the existing power utility into six separate generation companies, eleven distribution companies and one Transmission Company all of which are owned by PHCN in the interim and will eventually be privatized in the medium to long-term. The EPSR Act also established an independent regulatory agency known as the Nigerian Electricity Regulatory Commission (NERC). NERC's function is to promote efficient growth of the power sector based on free market economic principles. NERC's powers include tariff setting and regulation; development and approval of operating codes required for safe, secure and reliable operation; supervision of market rules; performance monitoring; and overseeing the orderly transformation of the power sector to a more competitive environment.

The primary instrument adopted by NERC for regulatory control is licensing. The EPSR Act provides that no person except in accordance with a license shall engage in the business of electricity generation, transmission, system operation, distribution or trading. The regulatory license establishes conditions for operations, reporting, license revocation and license fee and operating levy.

The NERC licenses that will be required by the proposed OMA Power Plant project are a power generation license and a systems operation license which is essentially a license to monitor, control and introduce the power into the grid, pursuant to the EPSRA Act Part IV Sections 64 and 66, respectively. NERC requires a captive power generation license for generators that produce one megawatt of electricity or more for their own consumption. The proposed project will also adhere to all other applicable NERC regulatory requirements throughout its duration.

Figure 2-2: Electric Power Sector Reform Act of 2005



2.6 International Financing Guidelines and Standards

The project will be required to comply with the applicable standards of international financing institutions. Compliance with Equator Principles III (EPs) is a requirement of many commercial banks for new project financing with total capital costs of US $10 million or more. The EPs are a voluntary set of standards for project reporting and determining, assessing and managing social and environmental risk in project financing. It is expected that this project will source funding from organisations that are signatories to these principles which include:

- Review and Categorise based on International Finance Corporation (IFC) criteria;
- Social and Environmental Assessment;
- Applicable Social and Environmental Standards;
- Action Plan and Management System;
- Consultation and Disclosure;
- Grievance Mechanism;
- Independent Review;
- Covenants Requiring Compliance;
- Independent Monitoring and Reporting; and,
- Public Reporting Process and Experience.

The EPs relate to good practice with specified applicable social and environmental performance standards and generally require compliance with the performance standards and guidelines of the IFC, dependent upon the economic status of the country. For this project to comply with the EPs, the IFC Performance Standards (2012), the General EHS Guidelines (2007) and the EHS Guidelines for Thermal Power Plants (2007) will apply.

This ESIA study will examine in detail all relevant Nigerian legislation and international conventions and standards and their applicability to the project.

2.6.1 World Bank Operational Policies

The World Bank has developed 10 environmental, social and legal Safeguard Policies that are used to examine potential environmental and social risks and benefits associated with World Bank lending operations to prevent and mitigate undue harm to people and their environment during the development process. These policies provide guidelines for the identification, preparation, and implementation of programmes and projects, and provide a means for stakeholders to participate in and inform the project design. These safeguard policies include Environmental Assessment (Operational Policy, OP 4.01); Natural Habitats (OP 4.04); Forestry (OP 4.36); Pest Management (OP 4.09); Physical Cultural Resources (OP 4.11); Involuntary Resettlement (OP 4.12); Indigenous Peoples (4.10); Safety of Dams (4.37); Projects in International Waters (OP 7.50); and Projects in Disputed Areas (OP 7.60).

The policies relevant to the Oma project are Operational Policies 4.01, 4.03 and 4.04 that are summarised below.

Environmental Assessment (Operational Policy, OP 4.01)

The objective of OP 4.01 is to ensure that Bank-financed projects are environmentally sound and sustainable, and the decision-making is improved through appropriate analysis of actions and of their likely environmental impacts. This policy is triggered if a project is likely to have potentially adverse environmental risks and impacts in its area of influence. OP 4.01 covers impacts on the natural environment (air, water and land); human health and safety; physical cultural resources, and trans-boundary and global environment concerns.

Thus the construction and operation of a thermal power plant is likely to have environmental impacts, which require mitigation.

Performance Standards for Private Sector Activities (Operational Policy, OP 4.03)

The aim of this policy is to facilitate Bank financing for private sector led economic development projects by applying environmental and social policy standards that are better suited to the private sector, while enhancing greater policy coherence and cooperation across the World Bank Group.

Natural Habitats (Operational Policy, OP 4.04)

This policy recognises that the conservation of natural habitats is essential to safeguard their unique biodiversity and to maintain environmental services and products for human society and for long-term sustainable development. The Bank therefore supports the protection, management and restoration of natural habitats in its project financing, as well as policy dialogue and economic and sector work. The Bank supports and expects borrowers to apply a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development. Natural habitats are land and water areas where most of the original native plant and animal species are still present. Natural habitats comprise many types of terrestrial, freshwater, coastal and marine ecosystems. They include areas lightly modified by human activities, but retaining their ecological functions and most native species.

The proposed power plant is not considered to cause the loss or degradation of natural habitats and therefore this policy is not considered applicable to this project. The habitats present were found to be modified habitats, areas which have been subject to human activity such as vegetation clearance and or agriculture. Some areas of the site where the farmland has been left fallow have begun to regenerate, however tree species diversity remains low.

For project-related conditions, the more stringent standard, be it Nigerian, Company or World Bank, will apply.

2.6.2 International Finance Corporation (IFC) Performance Standards and EHS Guidelines

The IFC Performance Standards establish a private regulatory framework in respect of labour and working conditions; environmental practices; workplace health & safety; community health, safety and security; land acquisition and involuntary resettlement; relations with indigenous communities, and; preservation of cultural heritage. IFC Performance Standards are set out to help in carrying out the policies set out in the Operational Policy on Environmental Assessment (OP 4.01) and related documents. The Performance Standards define client's responsibilities for managing their environmental and social risks, provide guidance on how to identify risks and impacts and help avoid, mitigate and manage risks and impacts as a way of doing business in a sustainable way (including stakeholder engagement and disclosure obligation of the client in relation to project –level activities). The eight Performance Standards (2012) whose requirements are to be met by the project throughout its life cycle are as follows:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 7: Indigenous Peoples; and,
- Performance Standard 8: Cultural Heritage.

Since no indigenous people will be affected by the project or require relocation as a result of the proposed project, Performance Standard 7 is not relevant to this project and is not considered further in this ESIA. The remaining seven Performance Standards are considered to be relevant to the project, and the ESIA of OMA Power Plant has considered these throughout the life-cycle of the project.

IFC has also produced EHS Guidelines, which are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). IFC uses the EHS Guidelines as a technical source of information during project appraisal activities.

The EHS Guidelines relevant to the OMA Power Plant are:

- General EHS Guidelines; and,
- EHS Guidelines for Thermal Power Plants.

In addition to the express guidelines of the IFC Standards and EHS Guidelines, clients must meet the requirements of local and international laws, regardless of whether such laws are regularly or consistently enforced. In this way, the IFC Standards/ guidelines require the client to operate beyond minimum compliance with laws and regulations where such laws and regulations fall below the IFC Standards. Of particular relevance to this project, more specifically, detailed environmental, health and safety guidelines exist for Thermal Power Plants.

2.6.3 Multilateral Investment Guarantee Agency (MIGA) Performance Standards

Multilateral Investment Guarantee Agency (MIGA) is a member of the World Bank Group. Our mission is to promote foreign direct investment (FDI) into developing countries to help support economic growth, reduce poverty, and improve people's lives. MIGA's Performance Standards address:

- assessment and management of environmental and social risks and impacts
- labour and working conditions
- resource efficiency and pollution prevention
- community, health, safety, and security

- land acquisition and involuntary resettlement
- biodiversity conservation and sustainable management of living natural resources
- indigenous peoples
- cultural heritage

These Performance Standards help MIGA and its clients manage and improve social and environmental performance through an outcomes-based approach. The desired outcomes are described in the objectives of each Performance Standard, followed by specific requirements to help clients achieve these outcomes through means that are appropriate to the nature and scale of the project and commensurate with the level of social and environmental risks (likelihood of harm) and impacts. Central to these requirements is a consistent approach to avoid adverse impacts on workers, communities, and the environment, or if avoidance is not possible, to reduce, mitigate, or compensate for the impacts, as appropriate.

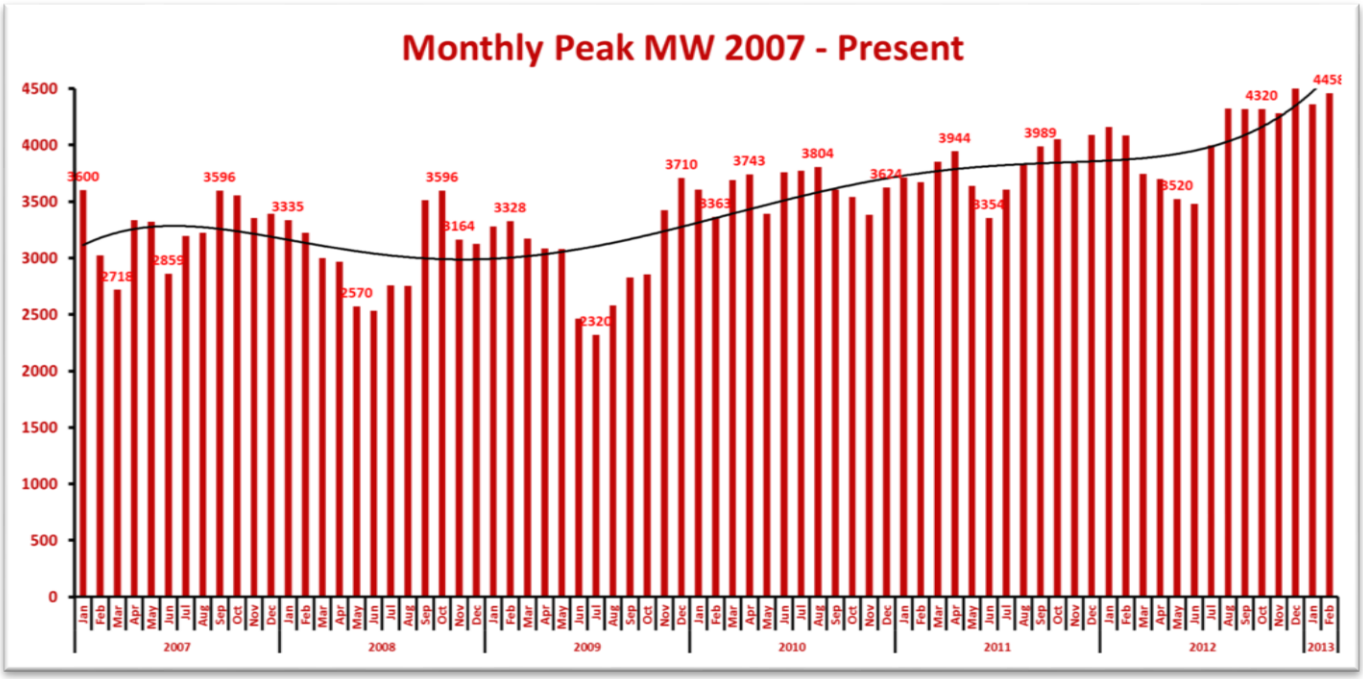
3. Project Justification

3.1 General

The Nigerian power sector is characterised by a huge shortfall between supply and demand on the interconnected system resulting in massive load shedding and power cuts. The available power is less than 41% of the total installed capacity. The Manufacturers Association of Nigeria (MAN) and the National Association of Small Scale Industries (NASSI) have estimated that their members spend an average of about N2billion (about $12 million) per week on self-power generation.

As in 2010, the available capacity of Nigeria's state-owned electricity utility had remained at about 3,000 MW for the previous two decades. According to the Presidential Task Force on Power, self-generation of electricity (from diesel and petrol generators) was estimated at a minimum of 6,000 MW, which is more than twice the average output from the grid during 2009. Monthly peak MW demand supplied between 2007 and 2013 is shown on Figure 3-1.

Figure 3-1: System Peak Demand Supplied 2007 - 2013



Although this shows an increase from around 3,000MW to nearly 4,500MW over the 6 year period, the Nigerian System Operator estimates that unsuppressed demand in August 2013 is actually around 12,800MW.

Nominally, installed generating capacity is much higher than demand supplied at over 9,000MW, but in practice the maximum dependable capacity is only around 6,000 MW due to a significant amount of plant being in a poor state of repair. In August 2013, the Nigerian System Operator reported that only 4,900 MW was actually available. The difference between that and the 6,000 MW is due to gas constraints, transmission constraints and the need to carry 660 MW spinning reserve on the system to cover plant trips. Without that, a trip could cause total system collapse.

To boost the nation's electricity generation and supply in order to meet the demand for electric power, the Federal government has issued licenses to IPPs. Geometric Power Limited is among those licensed as IPP in the country. In line with increasing its portfolio of energy technologies and services to match the growing need for alternative energy sources, GP has identified an opportunity to provide electric power to the national grid to boost the nation's supply in order to meet consumption needs. This will contribute to efficient power supply, creation of employment opportunities, skills acquisition and enhancement as Nigerians are engaged in various aspects of the project. This project may have the added benefit of reducing environmental pollution in the event that dependence on more polluting hydrocarbon powered generators such as diesel (for homes and businesses, needed due to current intermittent supply) may be lessened. The proposed project will also result in enhanced compliance to the Nigerian Local Content requirement since the project will be planned and executed in-country, with the aim of engaging and equipping as many Nigerians as possible with appropriate resources. Nigeria's available gas resources will be utilized and monetized as a result of the proposed project.

The need, benefits and sustainability (economic, technical and environmental) of the proposed IPP project are presented in this chapter, together with the project development alternatives considered.

3.2 Need for the Project

Tractebel completed a formal forecast of future electricity demand for Nigeria in 2008. This took into consideration an estimated unsuppressed peak demand in 2007 of 5,100 MW and, depending on the scenario and the methodology, projected the 2020 demand as being in the range 8,400 to 16,000 MW.

In 2010, the Presidential Task Force on Power (PTFP) reviewed this forecast and disputed the estimated unsuppressed 2007 demand which had been contested by various stakeholders including the Distribution Companies in particular. The view was taken that the unsuppressed demand was considerably higher and a value for 2008 of 8,500 MW was adopted. Based on this together with a projected average annual growth rate of 11%, almost equivalent to Tractebel's high growth scenario, a new forecast was prepared in 2011 as shown in Table 3-1 below.

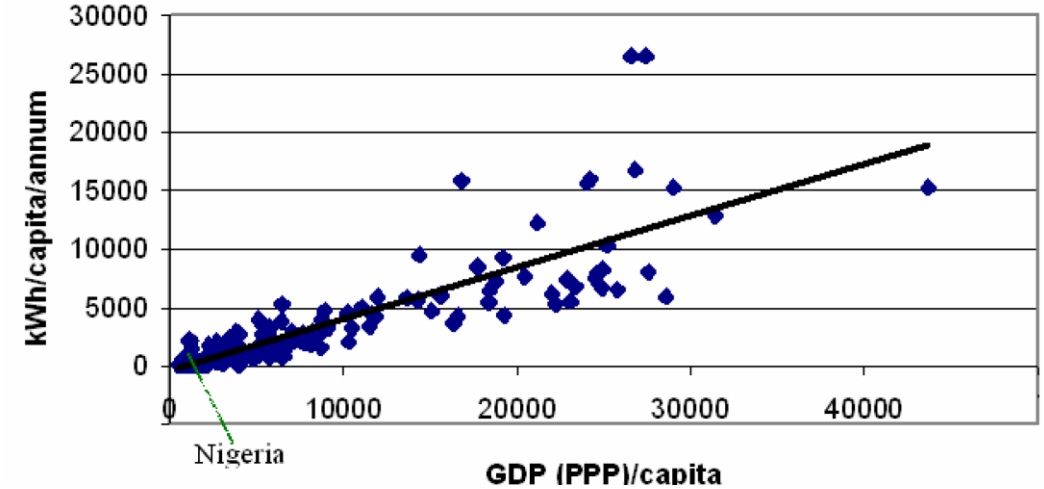
Table 3-1: PTFP Unconstrained Demand Forecast (MWs) 2011

Year	2008	2010	2011	2012	2015	2020	Average annual growth
LAGOS	2,475	3,049	3,385	3,757	5,138	8,659	11%
NORTH CENTRAL (NC)	1,630	2,008	2,229	2,474	3,384	5,702	11%
NORTH EAST (NE)	480	646	749	869	1,357	2,849	11%
NORTH WEST (NW)	1,090	1,343	1,491	1,655	2,263	3,813	16%
SOUTH EAST (SE)	860	1,079	1,208	1,353	1,901	3,321	11%
SOUTH SOUTH (SS)	1,170	1,468	1,644	1,841	2,586	4,558	12%
SOUTH WEST (SW)	795	980	1,087	1,207	1,651	2,781	12%
TOTAL	**8,500**	**10,573**	**11,793**	**13,157**	**18,280**	**31,684**	**11%**

This forecast is more consistent with the estimated demand published by the Nigerian System Operator. However, in practice this is very much a theoretical exercise because until reliable supplies can be made available, considering installed capacity as well as lack of gas supply and transmission constraints, none of these forecasts can be met.

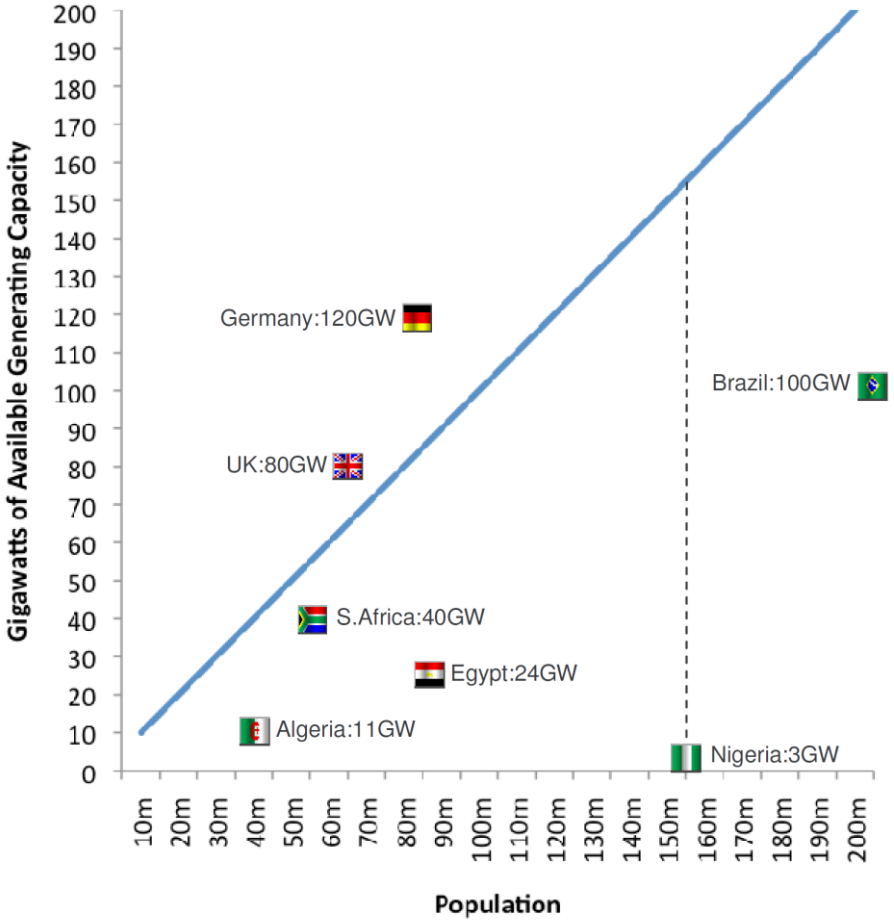
It is difficult to have any appreciable level of certainty about whether or not 11% is a reasonable annual growth figure. However what can be clearly demonstrated is that recorded electricity demand in Nigeria is not being met due to the lack of a constant supply of electricity. One approach in estimating demand is to link the energy demand to GDP, and Figure 3-2 compares Nigeria against 134 other countries.

Figure 3-2: Electricity Consumption and GDP in 134 Countries



Another measure is available generating capacity measured against size of population as shown in Figure 3-3.

Figure 3-3: Comparison of Available Generating Capacity Against Population for Different Countries



On both these measures it is clear that the present levels of unsuppressed demand are well below international norms, and the reality is that for the next few years, actual demand will be a function of available generating capacity. This means that there is currently not enough supply capacity to satisfy demand in the country.

This appears to have been recognised by the PTFP who set an ambitious target of having 40,000 MW of generating capacity available by 2020 when the forecasted demand has been estimated at around 31,600 MW.

Present generating capacity is made up of the privatised thermal power plants, government owned hydro plants (which are concessioned to private entities) and some independent power projects (IPPs). There is also the Government's National Integrated Power Projects (NIPP) programme which is funded and owned by the three tiers of government (Federal, States and LGAs.). These facilities are currently being constructed and will be operated via Operations and Maintenance contracts, when commissioned, prior to the privatisation of these power stations.

The installed and available capacities of all these plant are summarised in Table 3-2 along with future requirements to 2020 based on the 40,000 MW vision. The capacities of the existing power stations have been included on the basis of their installed capacity, although their actual capability is at present less. It is the Government's intention that these power stations should be refurbished by their new owners and the full design capacity recovered.

Table 3-2: Summary of 2020 Generation Requirements

Category	Installed Capacity (MW)
Existing Hydro	1,900
Existing Thermal	5,005
Existing IPPs	1,759
NIPP	4,775
TOTAL	13,439
2020 Target	40,000
Shortfall	26,561 (3,000 per year)

The 1,125 MW capacity OMA Power Plant represents a modest proportion of the future generation requirements and the project is justified on a supply and demand basis, even if a significant number of other new projects are commissioned.

The plant is to be connected directly into the Transmission Company of Nigeria (TCN) high voltage transmission system. The transmission is considered to be acceptable from a technical viewpoint. According to the transmission operation studies described in Section 6 of the project feasibility report, the

plant can be incorporated into the system without the need for reinforcement, even for Phase 3. Therefore, the location and transmission system is deemed to be acceptable from an existing capacity perspective, and the TCN transmission reinforcement works are still scheduled to be completed as planned.

Due to the insufficient, erratic and unreliable nature of power supply by existing utilities in Nigeria and the current liberalization/reform of the sector, the proposed power plant in its totality is needed to:

- Generate and supply power to the National Grid;
- Improve the reliability of electricity supply to the nation; and
- Stimulate industrial development within the country and improve the employment opportunity base of its inhabitants.

3.3 Benefits of the Proposed Project

In addition to benefits already described above, the proposed OMA Power Plant project is designed to optimize the following benefits:

- Continuing the technological advancement in plant design and power generation within Nigeria;
- Generation of low cost and more secure source of power, compared with expensive temporary diesel generation;
- Availability of a stable electric power supply both for new and existing industrial establishments that are connected to the grid;
- Providing security of supply which contributes to supporting conditions for local small and medium scale industrial/business development and investment opportunities;
- Utilizing gas for electricity generation and supply of efficient power in a more environment friendly manner compared with more polluting and inefficient thermal generation including light/heavy fuel oil, coal and diesel;
- Provision of permanent employment opportunities for Nigerians;
- Improving international relations and foreign exchange earnings through attraction of foreign investors; and,
- Contributing to the overall long-term growth and business development targets of Nigeria.

3.4 Envisaged Sustainability

3.4.1 Economic and Commercial Sustainability

The proposed power plant is envisaged to be economically and commercially sustainable throughout its design life span. This is because of:

- The availability of the volume of gas to be negotiated with an International Oil Company such as TOTAL E & P Nigeria and the Gas Aggregator Company of Nigeria (GACN);

- The proximity of the likely delivery point of the gas, Imo River, to the proposed OMA IPP plant site; and,

- The revenue that would accrue from power generation, which would serve for payment of staff, procurement of maintenance facilities, servicing of loans and dividends for investors.

3.4.2 Technical Sustainability

GP along with its joint development partner, GE, will ensure the technical sustainability of the proposed project by applying their proven expertise and track record in overseeing the project development and implementing the design, construction and operation of the project. Furthermore, the project will successfully adopt and apply best available technologies, and contractors will be required to adhere strictly to internationally and nationally acceptable engineering design and construction standards and codes of practice at all stages of development. Several energy-efficiency measures (such as use of high efficiency turbines) will be incorporated into the design to reduce fuel gas consumption that will greatly enhance the technical sustainability of the project whilst at the same time reducing environmental effects such as resource usage and emissions. Relevant design standards are provided in Appendix V.

The Plant will be sourced through international competitive bidding and each phase is likely to be constructed on a turnkey basis under one Engineering, Procurement and Construction (EPC) contract. The EPC contractor will develop operating manuals and appropriate documentation detailing the proper operation and maintenance of the planned facilities. These materials will be used as the basis for providing facility-specific training to relevant personnel prior to start-up to further ensure technical sustainability of the project.

3.4.3 Environmental Sustainability

The environmental sustainability of the project is reflected through the following:

- The beneficial use of natural gas rather than diesel as a primary fuel source for the plant. This is a major environmental consideration and advantage that will reduce air pollution;

- The use of energy efficient technology that will minimise environmental impacts and resource usage in line with the requirements of IFC PS3;

- In order to further enhance the environmental viability of the project, the findings of the ESIA as well as the avoidance/mitigation and monitoring measures identified will be integrated into the project and implemented throughout its lifetime.

A detailed Environmental and Social Management System (ESMS) will be developed from the ESIA ESMP (Section 10) and implemented in the course of the project.

3.5 Alternatives Development and Analysis

Alternatives are different means of completing the proposed project while still meeting the purpose and need for the proposed activity. Furthermore, the alternatives analysis is intended to address other means of completing the proposed project that could avoid or minimize adverse impacts that would be associated with the proposed project.

A variety of alternatives were proposed and have been analysed for the power plant project development. The technical engineering and economic feasibility, together with the environmental, health and safety concerns, flexibility for loading operations and expansion, regulatory and stakeholder requirements, cost effectiveness and ease of operation and maintenance of the system through its design life have been important considerations in the assessment of alternatives.

3.5.1 Alternative Sources of Electricity Generation

The suitability of generation technologies has been assessed against the following criteria:

- Readiness/ availability;
- Size;
- Reliability;
- Environmental performance; and
- Compliance with local and national policy.

The summary of the key issues identified by the criteria in relation to the power generation options available in Nigeria is given in Table 3-3 below.

Table 3-3: Summary of Key Issues around Available Fuel Types[1]

Fuel Type	Location	Positive	Negative	Availability
Gas	Imo River Ohuru Gas Fields in Ukwa East LGA	• Available in Abia State. • Relatively low cost fuel option when available. • Significant local resource in Abia State. • Nigeria is the largest holder of natural gas proven reserves in Africa and the ninth largest holder in the world. • Generators are very compact. • Produces less CO_2 than coal or oil. • Clean and reliable resource.	• Finite resource. • Susceptible to price fluctuation risk. • Extensive and expensive pipeline would be required. • Produces CO_2.	Available: Long-term solution
Coal	Three billion tonnes of indicated reserves in 17 identified coal fields and over 600 million tonnes of proven reserves in-country (although not in Abia State)[2]	• Relatively low cost fuel option. • Significant resource available in-country. • Generally provides continuous baseload power. • Is not susceptible to weather-related generation fluctuations. • Proven technology. • By-products of burning coal can be reused in other industries.	• Finite resource. • Not sustainable as coal reserves are limited. • Susceptible to price fluctuation risk. • Produces highest CO_2 per kWh (twice as much carbon dioxide when compared with natural gas). • Release higher level of harmful emissions, including a higher ratio of carbon emissions, nitrogen oxides (NOx) and sulphur dioxide (SO_2) and ash particles. • Requires disposal of significant volumes of ash by-product. • Coal can have significant sulphur and lesser heavy metals and organic content. • A major cause of acid rain if high sulphur levels in coal. • Mining of coal results in the destruction of habitat and scenery, and can result in community displacement.	Available: Long-term solution
Liquid Fuel	In-country resource	• Available in-country. • Generators are very compact. • Produces less CO_2 than Coal.	• Finite resource. • Not sustainable as hydrocarbon reserves are limited. • Reserve estimates have been stagnant as exploration activity has been low. • Susceptible to price fluctuation risk. • Expensive and short-term option. • Produces CO_2. • Fuel oil spills can cause severe pollution, particularly from pipeline sabotage. • Some oils contain high levels of sulphur.	Available: Short to medium-term solution
Energy from Waste	Has to be near reliable sources of solid waste (i.e. industrial waste or municipal waste scheme)	• Energy generation is combined with waste disposal/reduction.	• Effectively not currently available due to lack of sufficient institutional capacity. • Affected by in-country instability and supply disruptions. • Produces high CO_2 and NO_2 emissions. • Requires disposal of potentially toxic combustion residues. • Toxic materials can include trace metals (lead, cadmium, mercury) and organics including dioxins and furans can be emitted unless combustion is controlled and post-combustion clean-up is implemented.	Not currently available: Medium to long-term solution
Geothermal Power	Geothermal resources available in-country (none identified in Abia State)	• Sustainable. • No significant environmental impacts. • Non-polluting. • Generally provides continuous baseload power. • Is not susceptible to weather-related generation fluctuations.	• It can only be developed in selected volcanic areas where geothermal systems are present. • Transmission infrastructure and investment required. • Limited geothermal resource site currently known in-country, although none in Abia State.	Available in-country (but not in Abia State): Medium to long-term solution, though limited areas known
Hydropower	Contributes approx. 7% of Nigerian electricity	• Renewable resource • Proven technology	• Climate dependent and prone to generation shortfall during droughts • Can be susceptible to climate change. • Major hydropower systems can have significant adverse environmental and	Available

[1] Nigeria - U.S. Energy Information Administration
[2] Federal Republic of Nigeria, Nigeria Resources

Fuel Type	Location	Positive	Negative	Availability
			social impacts • Potential for flood risk	
Solar Power	Throughout Nigeria	• Sustainable. • Proven technology. • Size and location of solar fields is flexible, essentially limited only by demand and transmission infrastructure.	• High energy (and CO_2) intensity manufacturing process. • Efficiency and output is weather dependent. • Conventional peaking (likely diesel) capacity would be required for low sun conditions. • Daytime production only. • Relatively high cost electricity option that would likely require feed in tariff support to develop significantly.	Available: Long-term solution, but limited capacity due to current technology costs and lack of feed in tariff support
Wind Power	Locations dependent on wind potential and grid connection potential.	• Sustainable. • Non-polluting. • It is a proven technology.	• Efficiency and output is weather dependent. • Conventional peaking (likely diesel) capacity is required for low wind conditions. • Locations for application limited on wind speed and ability to interconnect to the grid. • Lack of country policy, legal or regulatory framework.	Available: Medium to long-term solution.
Conventional Nuclear Power	No in country source of fuel material	• A large amount of electrical power can be produced by a moderately sized station. • Accidents are rare. • Modern plants are low emitters. • Produces relatively small waste quantities.	• Highly expensive option - especially capital and maintenance costs. • Long lead time in planning and construction (approximately 10 years). • Obvious dangers regarding radiation release. Few accidents, but consequences could be catastrophic. • Decommissioning also expensive and highly skilled technical process. • Safe long term disposal of nuclear waste is problematic and contentious. • A plant would be a potential terrorism target.	Not available: Long-term solution with 10 year lead time.

Table 3-3 indicates that natural gas is the preferred option as it is an available long-term resource. It is a cleaner, more cost-effective and reliable option than the conventional coal and oil power generation within Nigeria. Furthermore, it is not affected by the weather/climate uncertainty issues associated with wind and hydropower.

3.5.2 Alternative Technologies for Natural Gas Generation

The core criteria used for considering and choosing between technological/design alternatives for natural gas generation are as follows:

- Overall safety of the personnel working in the proposed project facility and the public living in the vicinity of the project area;
- Environmental impact of the proposed project with respect to its effects on air quality, underground water, soil, geographical terrain, vegetation, wildlife, socioeconomics, noise and other environmental aspects;
- Potential impacts to communities, their health, lifestyle and activities such as businesses, transportation, recreation, etc.;
- Best available/practicable technologies that is not only familiar, but also acceptable within the applicable area in order to ensure effective operation, maintenance and sustainability;
- Feasibility of construction, operation and maintenance in view of satisfactory and cost effective practices;
- Availability and reliability of fuel supply for the proposed plant operation such as the use and volume of natural gas or diesel requirements;
- Mitigation, management and monitoring requirements that will ensure safe and environmentally sound operations;
- Acceptance by stakeholders with due considerations of technical, environmental, regulatory and cost implications of implementation and maintenance of proposed project; and,
- Other institutional, regulatory, national and international requirements of proposed project.

Based on the above, the summaries of technological/process considerations for natural gas generation are as follows:

Steam Turbine Power Plant

The steam turbine has as its advantages high overall electrical generating efficiencies of up to 75% when utilised in a combined heat and power (CHP) application through the reuse of the waste heat. However, there are no potential sources for waste heat so CHP is not an option and typical upper limits of steam turbine efficiencies are around 37%.

Other disadvantages include cost, slow start up times, the risk of corrosion of the pipes and other factors dealing with heat transfer in the steam turbine. The efficiency of a steam turbine is limited by the maximum temperature of the steam produced and is not directly a function of the fuel used. Significant cooling is required for steam condensation and auxiliary stations, which needs either large water quantities (which are not available at the site) or more inefficient air cooling.

Cooling can produce significant waste heat which if not utilised in cogeneration reduces overall efficiencies and can have negative environmental impacts if cooling water is disposed into surface waters, increasing the temperature of the receiving water body. The equipment takes a lot of energy to heat up, therefore increasing start up times, and is usually heavy compared to other engines like gas, diesel, or electric.

Based on the considerations of need for expensive high-pressure boilers and other equipment, slow start up times, poor part load performance and low electrical efficiencies of operating the steam turbine alone, this option was rejected.

Simple Cycle and Combined Cycle Gas Turbine Power Plant

The simple cycle gas turbine is simpler to install, operate and maintain. It is capable of producing large amounts of useful power for a relatively small size and weight. Since motion of all its major components involve pure rotation (i.e. no reciprocating motion as in a piston engine), its mechanical life is long and the corresponding maintenance cost is relatively low. Although the gas turbine must be started by some external means (a small external motor or other source, such as another gas turbine or diesel generator), it can be brought up to full-load (peak output) conditions in minutes as contrasted to a steam turbine plant whose start up time is measured in hours.

A major disadvantage of the gas turbine in simple cycle is that as the waste heat is not recovered, leading to thermal efficiency in the range of 33%. Operating in combined cycle mode with a heat recovery steam generator will increase the thermal efficiency to about 55%.

Gas Turbine Generator (GTG) Sizing and Selection

The GTGs are critical long lead equipment for the project. The sizing and selection considered the following:

- Frame 6 is too small for the service, capable only of delivering about 40MW per unit. Using this option will imply procurement of several units in order to meet the required capacity. This would equally result in incremental requirement of resources and utilities for its operations and maintenance. It would also mean more complicated processes of operations and maintenance for the several systems that would be involved. Higher fuel consumption by the several units will lead to consequent increase in emissions and discharges. This will subsequently raise the monitoring, mitigation and other regulatory compliance requirements.

All of these will result in excessive cost that may not be effective for sustainable operations of the proposed project.

- Frame 7E is designed to operate 3,600 rpm (60Hz) whereas Nigeria requires a 3,000 rpm machine that can generate power at 50Hz. It therefore was unacceptable.

- Frame 9E proved efficient for stand-alone power plant because of its ability to deliver the required net generating capacity of up to 500MW from phase 1 with minimal units generating capacity in the order of 113MW each. Other added advantages include its life cycle and cost efficiency. It is also widely utilized in Nigeria making it a very familiar technology both with the power regulatory and generation companies as well as other operating companies and maintenance engineers within the country. The lower capital cost involved in comparison to its higher power delivery, operations and maintenance requirements all add up to make it a cost efficient option. It is not the latest in terms of technology. However, the need to provide a plant that is reliable, familiar, and widely used in Nigeria further qualified it as the preferred option.

Additional Technology Considerations

The use of low-sulphur fuel.

The proposed project will use natural gas, an existing domestically abundant fuel stream to generate electricity for domestic use. The use of natural gas offers a number of environmental benefits over other sources of energy, particularly other fossil fuels. For example, coal and oil are composed of much more complex molecules with a higher carbon ratio and higher nitrogen and sulphur contents. This means that when combusted, coal and oil release higher levels of harmful emissions, including a higher ratio of carbon emissions, NOx and sulphur dioxide (SO2). Combustion of coal and fuel oil also releases particulate matter to atmosphere. The combustion of natural gas, on the other hand, releases negligible quantities of sulphur and nitrogen oxides (about 60% less than plants that use coal assuming emission reductions measures are not employed), virtually no ash or particulate matter, and lower levels of CO.

The use of modern combustion technology and effective combustion to minimise the generation of NOx and CO emissions.

The proposed OMA Power Plant will employ technology recognized as being the most appropriate for power production on the scale proposed. The net efficiency for the natural gas-fired simple cycle power plant option (e.g. Phases 1 and 2) will be approximately 33%. As a benchmark, coal and oil generation units are typically only 30 and 35% efficient, respectively. Efficiency will increase to up to 54% through the addition of the waste heat boilers and steam turbine generators when operating in combined cycle mode in Phase 3.

Emission control / abatement.

The IPP will utilise Dry Low NOx (DLN) technology to minimise emissions of NOx and to ensure emissions meet the IFC emission standard of 25ppm.

Appropriately designed stacks and stack height to ensure adequate dispersion of emissions to atmosphere.

Per the air quality analysis conducted for the project for Phases 1 and 2, the proposed stack height of 40m is demonstrated to lead to minimal increases in ambient concentrations of NOx and CO at nearby receptor locations. The stack height is approximately 20m higher than any other structure on the site for Phases 1 and 2.

3.5.3 Summary of the Preferred Alternative for the Proposed Project

After detailed evaluations of the merits and demerits of the various options highlighted above, the GE Frame 9 simple cycle gas turbine power plant was adopted for implementation due to its cost effectiveness, acceptable cycle efficiency, minimal environmental effects, and also the relatively lower cost of operation and maintenance. The simple cycle machines to be deployed for Phase 1 and Phase 2 will be converted to combined cycle during Phase 3 which will significantly increase the overall efficiency of the plant.

3.6 Site Location and Alternatives

The following criteria were used to determine the most suitable site for the location of the power plant:

- Sufficient land available to construct and operate a generating facility of this size;
- Its proximity to GP's existing power plant and worker accommodation facilities;
- Distance to the Imo River gas gathering facility and the availability of sufficient gas quantity at this location for transportation to site;
- Availability of electric transmission/evacuation capacity;
- Avoidance of environmentally and socially sensitive areas;
- Compatibility with surrounding land uses; and
- Community acceptance and support.

The location for this development was chosen above two other potential locations considered for the siting of the power plant. A summary of the outcome of this assessment is provided below.

- **Site 1**: A site adjacent to the current GP power plant at Umuojima-Ogbu was also considered for the siting of the power plant. The available land at this site did not meet the size required for the construction and operation of all three phases of the proposed generating facility and thus was rejected.
- **Site 2:** A greenfield site, located in Ihie-Iyi, along the PH-Aba Expressway was also considered. Although this site met some of the criteria noted above, it failed to meet all of the key requirements for siting the power plant. The situation of the site in relation to the overhead transmission lines was also considered. On the basis of these factors, Site 2 was also rejected.

Additional details of land management in the development area are provided in Section 2.4.10 above, and in the Socio-economic baseline, Section 6. The present site chosen for the power plant meets all the criteria set for this project.

3.7 "No Action" Alternative

No action is a possible alternative. It is assumed to be equivalent to a "No Build" alternative. In that case, potential environmental disturbances that would result from the construction activities and the operations of the plant will be avoided. No land will be taken, anticipated social conflicts due to congregation of people with diverse background, understanding, and perspectives will also be eliminated. "No Action" will prevent the safety and health challenges that could lead to accidents, dusts and noise, all arising due to heavy traffic associated with the project. In addition, the adverse

economic impacts on those who derive their means of livelihood from and within the proposed project area will equally be prevented.

Currently, there is only one power plant in Abia State with sufficient power for Aba industries with limited spare capacity for other residents of Aba and environs. The power situation in Abia State and the nation as a whole is grossly inadequate implying stunted or non-development of businesses and human capital due to high operating cost outlay. Adopting the 'no action' alternative would entail continually enduring the frequent outages, excessive low voltages and power surges with the associated dangers and environmental concerns such as increased emissions due to the use of diesel generators by individuals and business entities for self-generation. Also, with this option the benefits outlined in Section 3.3 above, will be forfeited. This option was therefore rejected.

3.8 Conclusion

With due considerations to optimal safety, security, environmental, technical and cost implications, the chosen and recommended options for the proposed OMA Power Plant project provides the best balance between operational, economic, social and environmental conditions in comparison to the other sites.

3.9 Cumulative Impacts

The various impacts of this proposed project on the environmental aspects have been identified and appropriate mitigation measures proposed for applicable conditions. The anticipated cumulative impacts to air quality and noise are expected to be synergistic rather than additive, over the life of the project. This is in consideration of the numerous expected benefits, especially with respect to reduced emissions due to lowered dependence on hydrocarbon-powered generators.

From an environmental perspective, the main considerations regarding cumulative impacts of a power station would include:

- Noise;
- Air pollution;
- Greenhouse Gas and Carbon Emissions,
- Habitat loss and Fragmentation; and
- Collision of bird species with power lines.

Currently it is understood that there are two other power stations in the area: the Aba Power Plant (also owned by GP), located 20km away, and the Alaoji Power Plant (owned by the Niger Delta Power Holding Company) which is a combined cycle gas turbine plant., located 10km away. Therefore because of the distance noise effects from the plant are unlikely to be synergistic and there is not likely to be a cumulative impact on nature conservation interests in the area due to noise.

The air quality assessment indicated that there will be little or no change in the air quality as a result of the operation of the proposed power station. Given that the closest plants are located some distance away and that the main air emissions of concern would be short-term exceedances and given the fact that it is unlikely that exceedances from two plants would occur simultaneously, cumulative impacts are likely to be less than significant. Therefore it is considered likely that there will not be any significant cumulative impact on air quality.

In terms of the impact on Nigeria's annual carbon emissions, according to the US Department of Energy the total carbon emissions from the consumption of energy in 2012 were 86,398 kt CO2. The calculated annual carbon emissions from the power plant from all 6 Frame 9 Gas Turbines (Phases 1 and 2) is 3,350 kt CO2, adding 3.9% to the total annual carbon emissions of the country.

Due to the distance between the two power stations and the limited footprint of each power station, habitat fragmentation and loss of former farm land is not considered to be significant, in terms of the nature conservation interest of the species and habitats present.

The OMA power station is not anticipated to significantly contribute to bird collisions with power lines on a cumulative basis, as it is situation on former farming land, over 10km away from the nearest wetland habitat and area where large birds would be expected to be present.

4. Project Description[3]

4.1 General

The proposed project is the OMA Power Plant jointly developed by GP and GE. The project is to be located in Ugwunagbo LGA state of Abia State, Nigeria. The project will be developed in three phases. The initial objective of this project is to successfully complete the design, construction, commissioning and take-over of Phase 1 of the power plant that consists of a gas-fired simple–cycle plant of approximately 500 Megawatt (MW) net generating capacity that will export power to the Nigerian national electrical grid. It is also intended to upgrade the Phase 1 plant, in two additional separate phases. Phase 2 will add two further simple-cycle power generation units and Phase 3 will add two combined cycle generating units to bring the total net generating capacity to 1,125 MW.

This ESIA will address both the simple-cycle (500 MW net generating capacity) and the potential configurations (simple and combined cycle) for upgrade to 1,125MW generating capacity. The Project will support the Federal Government of Nigeria's objective to reliably increase domestic power generation in order to promote economic growth and development.

This chapter presents the proposed OMA Power Plant project's engineering design, construction, operation and decommissioning activities. These include the design codes and standards (see Appendix V), the design concepts, operating philosophy and schedule for the project.

4.2 Design Concept

The overall technical philosophy for the OMA Power Plant project is to have a well operated, efficient, reliable, durable and environmentally friendly power generating plant. In order to achieve this, various concepts were considered for the different components of the proposed project, before arriving at the current design.

The power plant will be constructed in three phases to arrive at an eventual combined cycle plant:

- Phase 1 with approximately 500MW net capacity in open cycle;
- Phase 2 adding approximately 250MW of capacity in open cycle; and,
- Phase 3 adding 375MW of capacity by conversion to combined cycle, bringing the total net capacity to 1,125MW at site conditions.

The timing of Phases 2 and 3 will depend on the need and economics of the expansion phases (as defined by the Power Purchase Agreement with the Nigerian Bulk Electricity Trading Company, NBET), the ability to export the electricity (which depends on progress with transmission line upgrades by TCN), and the availability of adequate fuel resources (natural gas purchase contract GACN/International Oil Company (IOC)).

The key elements of the design concept are summarised as follows:

- Civil engineering works, gas turbine generation units and the associated ancillaries, electrical and control equipment including the process systems for the power station including a black start diesel generator set;

[3] The language in this section consists of the original BGI text and has not been authored directly by Jacobs.

- Installation of fuel gas system and gas supply pipeline between the site and the existing gas gathering facility at Imo River (note that impacts of the gas pipeline will be addressed in a separate ESIA which will be prepared for approval by Federal Ministry of Environment);

- Construction of groundwater boreholes, water treatment facilities, pumping, tankage and installation of water supply reticulation serving the closed-circuit auxiliary cooling water system of the gas turbines, generators and steam turbines (Phases 1 to 3), makeup water for combined cycle water-steam cycle (Phase 3), service water system, wastewater treatment system, an independent fire-fighting system and potable water system for the power station;

- 330kV air-insulated switchgear (AIS) switchyard within the power station site.

- A 300m long, 330kV double circuit (DC) overhead transmission line to be constructed from the project switchyard to tie-in to the nearby 330kV double circuit line running from Afam to Alaoji (Figure 4-3). This is required for Phases 2 and 3.

- Ancillary works such as administration and security buildings, workshops, equipment and spares store, roads and car-parking, communication system (within the power station), and security fencing, accommodation facilities and gate-house for the proposed power station.

Separate to this project, in order to reinforce the 330kV grid and to enable the export of the full capacity of the power plant, TCN is re-enforcing the ITU, UYO and EKET 132/33kV substations whilst the Eket-Uyo-Itu-Calabar 132kV lines will be re-stringed in a double circuit bare conductor lines for more power to be transported to the load centres within the two states. This approach will further reduce the total losses witnessed with or without OMA Power Plant. Construction of the 12 NIPP 330kV circuits is planned to be completed quickly to enable power to flow to the east and the north eastern States of Gombe and Adamawa based on the schedule with TCN.

Applicable codes and Standards

The conceptual design of the proposed project was based on the practices recommended by a consistent set of internationally recognised codes and standards that shall be applied to all aspects and components of the proposed OMA power plant project. Standards are provided in Appendix V.

Environmental Consideration

The conceptual design process of the proposed OMA power plant project considered environmental and engineering concerns in implementation. These primarily focussed around control of effluents and contamination, solid wastes, noise and air emissions and health and safety. Associated aspects of the project design are discussed in relevant sections below.

Site Area, Topography and Hydrologic Data:

Ground Elevation	=	52-54m
Slope (gradient)	=	2 – 4 %
Area of Site	=	22.3ha
Groundwater Level	=	26-27m below ground level (bgl)
Road Elevation	=	55m

The elevation of the site varies from 52 to 54m above mean sea level (m AMSL) and the ground surface generally slopes from northeast to southwest.

4.3 Facility Design/Plan

The major considerations in the design of the facility layout were safety in operation and maintenance, accessibility and movement, and minimum separation distances. Other considerations were provisions for expansion at each phase of the project, compact arrangement, room for effective functionality, and measures to avoid or minimize adverse environmental effects upon the surrounding environment, optimizing of visual aesthetics, particularly the greenbelt of the plant area. The total area for the project is 22.3 ha. The design life of the power plant will be twenty-five years.

Operational accommodation will be provided on-site for up to 10 shift workers on site. Construction worker accommodations will also be developed on site. Details of the proposed construction worker accommodation and mitigation and monitoring associated with the construction workers' camp are detailed in Section 6 and subsequently in the ESMP, Section 10.

4.3.1 Highway and Plant Transportation

Access to the proposed project site shall be via the existing road network and the A3 Aba to Port Harcourt motorway, which is understood to be in good condition. Improvement works will be carried-out to the short (c.300m) stretch of road from the A3 up to the site boundary.

A ring-road system will be provided within the site boundary and shall service all the buildings and houses, so as to meet traffic and other requirements of production, daily life and fire-fighting. The road within the plant area shall be the urban type with concrete curbing and a general width of 7.5m.

Significant impacts on the road network are not anticipated given that the site is served by a major national motorway route from the port where plant and equipment is likely to be imported. An assessment of the potential impacts on the transport network will be undertaken prior to construction, in order to consider current traffic flows at that time. This is included as an action in the ESMP.

4.3.2 Water Supply, Treatment and Distribution Systems

Raw Water System

The plant will meet its total water needs by drawing raw water from local boreholes and treating it according to the various uses within the site. The raw water will be drawn from the boreholes and forwarded into the supply system by use of dual redundant raw water pumps. The raw water is then pre-treated by being passed through dual redundant clarifiers. The waste effluent of the clarifiers will either be routed to the effluent treatment plant or drained to the rainwater drainage system depending on final composition. The treated raw water is then passed to dual above-ground storage tanks which serve as dual purpose service and firewater storage for use in the service and firewater systems, as well as providing a reservoir for further demineralization treatment as necessary for process and potable water.

Service Water System

The pre-treated water is stored in dual tanks which are designed to maintain a reserve quantity solely for firefighting purposes, whilst primarily providing a buffer capacity which feeds the suction side of a set of dual redundant service water forwarding pumps located in the main water supply pump-house.

The service water pumps provide a feed to the demineralization water treatment plant via the dedicated clarified water tank, plus a pressurised supply to the plant service water network. The service water network provided wash-down water to plant areas such as the plant and machinery houses, the drainage run-off of which passes to the oily water collection areas and then to the treatment facilities.

Treated effluent from the oily water treatment facilities is drained to the plant evaporation pond, whereas the oily waste will be removed from the oily water treatment facilities by suction tanker and transported off site for disposal.

Bird netting will be installed as humane physical barrier to block birds from entering the evaporation pond. The pond net will be heavy duty, designed for use in harsh chemical environments. This is included as an action in the ESMP.

Demineralised Water System

The water treatment plant (WTP) receives clarified water and produces demineralized water by a combination of dual-media and carbon filters followed by reverse osmosis (R.O) units fed by high pressure pumps. The demineralized produce water is stored in dual storage tanks local to the WTP in order to provide suction to the dual redundant demineralized water forwarding pumps.

The demineralised water forwarding pumps feed the demineralized water distribution system which supplies a number of consumers around the plant. Main consumers of demineralised water are the make-up demand of the auxiliary closed-cooling water, gas turbine washing system usage plus other plant water losses.

The WTP also provides potable water in order to meet the plant demand for drinking, sanitary and miscellaneous usage.

The demineralization process results in waste effluent due to back-washing of filters and R.O. membranes, plus the R.O. waste concentrate. The waste effluent is drained to the plant evaporation pond, whereas sludge from R.O membranes in the raw water treatment plant will be transported off site by an appropriately licensed waste contractor to a licensed facility. This is included as an action in the ESMP.

Potable Water System

Treated water of potable quality is produced by the WTP and stored in the plant potable water tank. The tank is treated with a disinfectant and provided in a reservoir of potable water to be used in the pressurised potable water consumer network.

Drainage water from the sanitary facilities within the plant is taken by the sanitary waste water treatment system, from where the treated effluent is discharged to the storm water drainage system.

Liquids are disinfected so that all concentrations are within IFC EHS Guidelines and the Nigerian effluent limits whichever is more stringent prior to discharge to the storm water drainage system.

Solids from sanitary waste will be trucked off site along with sludge from R.O membranes in the raw water treatment plant.

Fire Water Supply System

A fire water system is provided throughout the plant, fed by pumps located in the fire water pump house. In plant areas where oil contamination of fire water run-off is possible, the drainage water is led to the plant oily water treatment units. Otherwise the fire water run-off drains to the rain water collection system.

4.3.3 Drainage Systems

Drainage for the project will be treated via two separate systems. Spills will be routed to the evaporation pond from the raw water demineralisation plant and the separated water stream from the o/w separator. A separate sanitary treatment plant will be developed for the project.

The drainage system for discharged water will be designed in accordance to the standards of FMEnv and the Federal Ministry of Works and Housing. All liquids from the project will be disinfected so that all concentrations are within IFC EHS Guidelines and Nigerian standards and then discharged to the storm water drainage system.

Completely independent collection and drainage systems will be constructed for rain, industrial wastewater and domestic sewage from the OMA Power Plant project.

Solids from sanitary waste will be trucked off site along with sludge from IO membranes in the raw water treatment plant. Contractors have not yet been selected, but Oma and AECOM have confirmed that there are appropriately licenced waste collection, processing and disposal contractors/facilities to allow management of waste in line with Nigerian and international standards.

Rain Drainage System

The rainwater storm drainage system will be designed with sufficient capacity to accept a 1 in 10 year frequency storm, plus an appropriate additional factor to allow for potential increase in rainfall frequency/intensity due to climate change.

The system will be gravity flow drainage ditches constructed with reinforced concrete and will drain hardstanding areas of the site uncontaminated with oil. The drains will be “V” form or rectangular and located on either side of the road so that in rainfall weather, rain will flow smoothly into the drainage ditches following the ground gradient into a retention reservoir for evaporation and absorption into the ground.

The design of the discharge outfall from the storm drainage system has not yet been confirmed. However, it will be designed in order to prevent any detrimental impacts to adjacent lands, down gradient from the outfall (e.g. erosion around the outfall and creation of gullies, associated additional sediment generation or increased overland flows due to rapid transmission of rainwater on new hardstanding). The ESMP includes an action to finalise the drainage discharge design considering good international industry practice whilst ensuring that the design appropriate for the climatic conditions of the site, given the intensity of wet season rains in Nigeria.

In addition to the storm water drainage system, the design of earthworks will also be configured to divert any surface storm water away from the critical areas of the plant where practicable.

Industrial Wastewater

The industrial wastewater of the power plant shall consist of potentially oily wastewater; effluent from the water treatment plant, a small amount of blowdown water from the closed-loop auxiliary cooling system and sanitary waste, wash wastewater from the workshops. These waste streams shall be pumped into a waste water treatment (WwT) facility (through separate pipes) for treatment before discharge into the rain drainage system. For oily-waste water, this will be suitably treated in oil-water separator/wastewater treatment before discharge into the drainage system. The system shall include an observation pond with sufficient capacity to provide adequate retention time to arrest any accidental breakthrough of oil or other potential contaminant spills and to allow testing.

All discharged effluent will be treated in line with relevant Nigerian effluent limits and IFC EHS standards prior to discharge into the storm drainage network.

Discharge from the WTP R.O and filtration system will be discharged to an evaporation pond with impermeable HDPE lining. Here the effluent will settle/evaporate with accumulated solid material being removed periodically and discharged by licenced contractor (to be identified by the EPC contractor following appointment). The capacity of the pond is currently anticipated at 900m3, sufficient for an effluent demand of 5 m3 per hour for 7days, which is sized for Phase 1 and 2. Overflow from the pond will be routed to the effluent treatment system before being discharged into the storm drainage system following treatment to international standards. The exact volume and design of the evaporation pond shall be finalized based upon detailed meteorological data for rainfall, solar radiation and evaporation. Additional capacity will be installed for Phase 3 as required.

The main sources of oily wastewater will be oil-contaminated water from hardstanding around GTGs , emergency diesel generators /diesel oil storage, oil tanks of transformers, lubrication system and maintenance workshop. All potentially oily wastewater from these areas shall be collected and treated in the oily WwT system.

This will consist of an oil / water (O/W) separator which will settle and skim oil residues from the water and pump the waste oil to a storage container. Water from the O/W separator will be pumped to the WTP for removal of potential contaminants. Discharge water will be suitably treated to meet the IFC EHS guideline limits for effluents.

Domestic Sewage Drainage

Sewage from water closets and urinals will be channelled into a reinforced concrete underground septic tank that will be constructed at the site. Digested sewage from the septic tank will pass through a drainage pipe into the water treatment plant where it will be treated in line with IFC EHS guidelines. The maximum treatment capacity is about 5m3/h. Treated water from domestic sewage treatment station will then be discharged into the storm water system.

4.3.4 Piping and Culverts Arrangement

The main piping shall not cross/extend to the reserved site. All pipes shall be coordinated to have linkages with each other and with reasonable crossings where necessary within the plant layout.

4.3.5 Landscaping Design

The plant shall be designed and developed as far as practicable to be sensitive to the aesthetic quality of the surrounding environment. The space between buildings and house entrance/fronted area shall be re-vegetated with native grass and shrubs.

Small native ornamental trees alternating with shrub and flowers shall be planted on both sides of the main and branch roads, while native climbing green-plants (especially the ivy) shall be grown to climb upon the walls and fences of suitable administration buildings. Also, sheltered forest formation of trees shall be grown on all sides of the power plant. The main entry square of the OMA Power plant site area as well as the administrative areas (the landscape zone) shall be planted with indigenous evergreen trees and shrubs, arbors, flowers, etc.

The grass and shrubs shall be grown in all the spare areas, excluding the main equipment, switchyard and the oil tank areas. The switchyard and the oil tank areas shall be covered with cobblestones while the main equipment area shall be covered with concrete, for maintenance purposes.

Soil type is the key element to affect the growth of the plants thus; organic soil stripped from topsoil shall be reused for the landscaping. The backfill soil thickness for the landscape shall not be less than 300mm.

4.3.6 Soil and Foundations

One of the key objectives of the civil design is to minimize the volume of earthwork and to prevent the rainwater outside the power plant area flooding onto the site and to facilitate rainwater drainage from the site.

Site preparation work will comprise the levelling of the working areas 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.

Shallow Foundations

The natural soil near the ground surface on site comprises soft to firm clay and clayey silty sand in some places. Graded crushed stone in 600mm thickness will be used to fill over the clay to get more bearing capacity mainly for single level structures. This foundation can support loads from structures that are not sensitive to settlement. The shallow foundation depth is –1.50m. Wide strip foundations will be considered if the bearing capacity of the soil is low.

Pile Foundations

For heavier equipment or structures, bearing piles shall be required where the soil at normal foundation level cannot support ordinary pad, strip, or raft foundation or where structures are sited on deep filling which is compressible and settling under its own weight. All significant structures, such as the gas turbine generator, steel gantry etc, shall be constructed using pile foundations.

Considering local conditions, precast piles shall be used for the foundations. The settlement of gas turbine/generator foundation shall not be more than 100mm, and the bank error not more than 0.0015L (L - length of side). The bearing capacity of each pile would be more than 60tons, which shall be confirmed by static load tests after installation or dynamic pile analysis during driving.

Raft Foundations

Raft foundations shall be considered for the diesel tank (discussed below) and associated bunded (spill containment) structure. Depending on the soil condition, draining concrete will be used to treat the foundation soil.

4.3.7 Ventilation and Air Conditioning

The control room and electronic equipment room shall be maintained at 19 – 22°C temperature range with relative humidity of 50 ± 10%. Air conditioner units will be installed at the control room, electronic equipment room and necessary other buildings. In order to protect the sensitive electronic equipment the air quality circulated within these rooms, air change and filter function will be set for the air conditioning system. No refrigerants containing unacceptable ozone depleting substance will be used.

The distribution room will be equipped with a ventilation system to aerate the room and reduce indoor heat. Natural ventilation and mechanical draft ventilation system shall be applied. A combination of natural ventilation and mechanical draft systems will be adopted for other locations that demand ventilation, if natural ventilation alone cannot fulfil the requirement.

4.3.8 Workers' Camp

A construction workers' camp is planned for development either on the project site prior to construction, but it is also expected that many of the workforce will come from the local communities and will not require accommodation on site.

Permanent facilities on site will also be constructed for the operational phase. This will include beds for temporary (not permanent dwellings) use by up to 10 persons at any one time (e.g. shift workers or visiting staff). All permanent staff will live among the local community.

The workers' camp will comply with IFC PS and EHS requirements for worker facilities including sufficient washing and sanitary facilities and management of wastes and effluent. The camp will also include the necessary amenities such as a dining hall and kitchen. On-site first-aid and emergency services will be provided. Other services and infrastructure will likely include a water treatment plant, sewage treatment plant, power generation, fuel storage, miscellaneous storage and fire-fighting equipment.

Security at the workers' camp would consist of a combination of security managers and local guards. Perimeter security, entry control points as well as roving security patrols will likely be used. Security services would be procured and operated in line with the requirements of IFC PS2 and PS4 regarding occupational and community health, safety and security.

A worker management plan including worker's rights and a code of conduct will be completed as an action within the ESMP. Should additional land outside of the site be required for development of the worker's camp and/or permanent housing, associated environmental and social elements would be considered in a separate study.

4.4 Principal Features of the Power Plant

The proposed power plant shall be constructed, over a period of time, in three distinct phases:

- Phase 1 shall utilize four (4) Frame 9E General Electric gas turbines giving an installed gross capacity of 500MW that will generate approximately 500MW of net electric power operating in open (simple) cycle configuration. This phase will also include the main site civil works, a 330kV AIS substation, all buildings and WTP required. The gas turbines will be operated on natural gas only; this gas will be provided from a terminal point at the Imo River. The pipeline will be designed to meet the fuel gas requirements of the fully developed project (up to Phase 3). (Note that impacts of the gas pipeline will be addressed in a separate ESIA which will be prepared for approval by FMEnv for the IPP). Generated electricity will be exported via the 330kV switchyard and the national transmission system.

- Phase 2 shall further increase capacity by the addition of two (2) Frame 9E General Electric gas turbines, operating in open cycle; this will increase the plant generating capacity by approximately 250MW.

- Phase 3 plant configuration will be an additional steam cycle conversion generating approximately 375MW of additional electrical power. In this final phase of development, the 6 existing gas turbine generator sets are integrated into a combined cycle configuration. This requires the addition to the plant of waste heat boilers and steam turbine generators.

In Phase 1 and Phase 2 plant configurations, the gas turbines indicated above are each capable of producing about 113 MW of electricity (in simple-cycle operation).

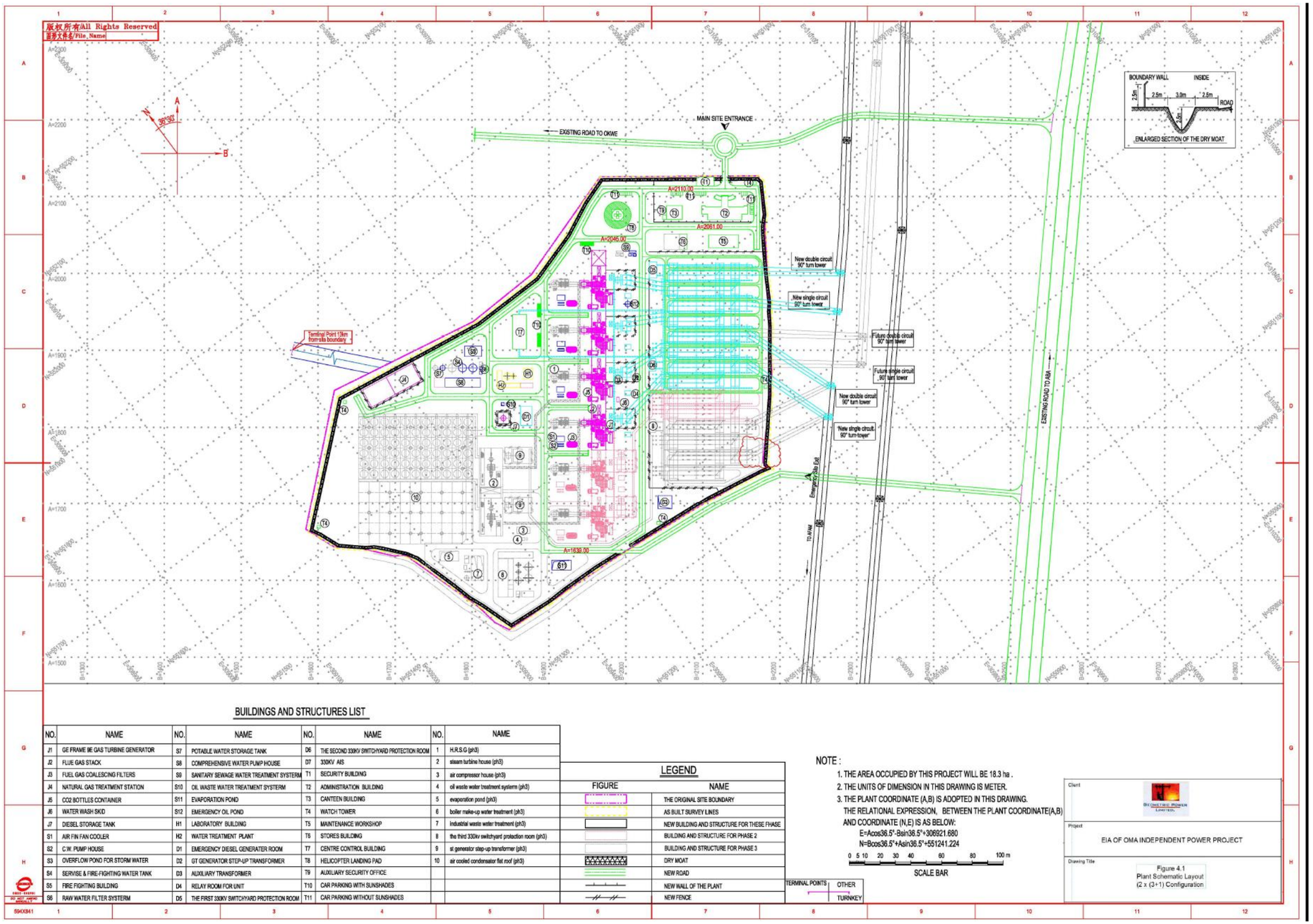
The total plant Combined Cycle configuration is a "2 x (3+3+1)" arrangement (Figure 4-1). In this there are two units, each unit consisting of three gas turbines, three waste heat boilers and one steam turbine. The two steam turbines will be capable of producing about 338MW in total; this ensures that the project will deliver 1,125MW and that there is sufficient space on the site to locate all three phases of the project. Alternatives such as 3 x (2+2+1) i.e. three units, each consisting of 2GTs, 2HRs & 1ST,

would require more land, since there would be an additional air cooled condenser and additional steam turbine and would therefore be more costly.

The development will have grid black start capability. This includes approximately 10 MW black start unit to provide independent supply to the power plant, i.e. to provide sufficient electrical power to the plant for auxiliaries and to start up a large gas turbine in the event of a total power loss on the grid. The Gas Turbine Generators will be capable of closing the generator circuit breakers onto a dead bus bar and thus capable of initiating a “black start” of the local grid system.

The total electrical output of OMA power plant project (including the 10 MW black start unit) will therefore be approximately 1022.5MWe at rated site conditions (or approximately 1135MW at the ISO conditions) with a thermal input of approximately 2300MWth.

Figure 4-1: Plant Schematic Layout (2 x (3+3+1) Configuration



NO.	NAME	NO.	NAME	NO.	NAME	NO.	NAME
J1	GE FRAME 9E GAS TURBINE GENERATOR	S7	POTABLE WATER STORAGE TANK	D6	THE SECOND 330KV SWITCHYARD PROTECTION ROOM	1	H.R.S.G (ph3)
J2	FLUE GAS STACK	S8	COMPREHENSIVE WATER PUMP HOUSE	D7	330KV AIS	2	steam turbine house (ph3)
J3	FUEL GAS COALESCING FILTERS	S9	SANITARY SEWAGE WATER TREATMENT SYSTERM	T1	SECURITY BUILDING	3	air compressor house (ph3)
J4	NATURAL GAS TREATMENT STATION	S10	OIL WASTE WIATER TREATMENT SYSTERM	T2	ADMINISTRATION BUILDING	4	oil waste water treatment systerm (ph3)
J5	CO2 BOTTLES CONTAINER	S11	EVAPORATION POND	T3	CANTEEN BUILDING	5	evaporation pond (ph3)
J6	WATER WASH SKID	S12	EMERGENCY OIL POND	T4	WATCH TOWER	6	boiler make-up water treatment (ph3)
J7	DIESEL STORAGE TANK	H1	LABORATORY BUILDING	T5	MAINTENANCE WORKSHOP	7	Industrial waste water treatment (ph3)
S1	AIR FIN FAN COOLER	H2	WATER TREATMENT PLANT	T6	STORES BUILDING	8	the third 330kv switchyard protection room (ph3)
S2	C.W. PUMP HOUSE	D1	EMERGENCY DIESEL GENERATER ROOM	T7	CENTRE CONTROL BUILDING	9	st generator step-up transformer (ph3)
S3	OVERFLOW POND FOR STORM WATER	D2	GT GENERATOR STEP-UP TRANSFORMER	T8	HELICOPTER LANDING PAD	10	air cooled condensator flat roof (ph3)
S4	SERVISE & FIRE-FIGHTING WATER TANK	D3	AUXILIARY TRANSFORMER	T9	AUXILIARY SECURITY OFFICE		
S5	FIRE FIGHTING BUILDING	D4	RELAY ROOM FOR UNIT	T10	CAR PARKING WITH SUNSHADES		
S6	RAW WATER FILTER SYSTERM	D5	THE FIRST 330KV SWITCHYARD PROTECTION ROOM	T11	CAR PARKING WITHOUT SUNSHADES		

The plant's gas turbines will primarily burn Nigerian natural gas fuel in combustion chambers from where the hot combustion gases expand through the gas turbine, which in turn drives an electrical generator to generate electricity. The hot exhaust gases from the gas turbine contain recoverable energy that will be used to generate high pressure steam in the Heat Recovery Steam Generator (HRSG) that then powers the steam turbine generators to be provided under Phase 3.

The spent steam leaving the steam turbines will be condensed and the resultant condensate returned to HRSG for reuse. Since there is no large source of water such as seawater or a river in the vicinity of the plant to provide sufficient water for cooling, air cooled condensers will be adopted to condense the steam through the use of large finned tube banks and arrays of forced-draught cooling fans.

Gas will be brought to the site with a purpose built 12km long, 18" diameter, natural gas pipeline from Imo River gas gathering facility. In the event of an interruption to or decline in the gas supply, or maintenance of the pipeline, an alternate gas line supplying gas to an adjacent Geometric Power gas turbine power plant is currently being investigated by GP.

On a day-to-day basis, water will be required in order to provide high quality make-up to the water/steam cycle associated with the steam turbine generators. This water will be taken from site water wells and will require filtering and demineralisation in the water treatment plant. Phase 3 of the project will result in OMA power plant generating in combined cycle mode with an overall thermal efficiency of approximately 48% based on the lower calorific value (LCV) of the fuel. This efficiency rating does not take into account the potential for added efficiency if it proves technically and economically feasible to provide heat to surrounding industries/facilities. At this stage no such facilities have been identified.

4.4.1 Proposed Plant Layout

The proposed power plant will be developed in Phases 1, 2 and 3 on the land area of approximately 22.3 ha.

Main Equipment Area: The main equipment area will be evenly spread around the plant and will contain the gas turbine generators, HRSG's, steam turbine generators and the air-cooled condensers.

Switchyard Area: The 330 kV switchyards will be located to the south-east of the main equipment area. This zone will include the transformers, electrical control room, utility control room and diesel generator room.

Fuel Area: The area includes the fuel gas treatment stations, fuel gas meter station, distillate oil storage tank, fuel oil pump room, oily wastewater treatment room and foam fire-fighting room. The fuel gas meter station shall be located at the west of the main equipment area separated from the main equipment area by a road. The distillate oil storage tank and fuel oil pump room, oily wastewater treatment room and foam fire-fighting building shall be located to the west of the main equipment area.

Auxiliary & Subsidiary Production Buildings and Structures Area: The area includes the water pump and tank, water treatment station, compressed air room and deep well pump room. The area is located in the west corner of the power plant site and the main equipment area. The water treatment room shall be located next to the gas turbine (GT) units.

Administrative Management Area: The area includes the office building, parking area, workshop, warehouse and domestic sewage treatment station. The office facility for OMA power plant shall be located within the vicinity of the power plant, in the north east of the site area.

Accommodation Facility: Employee operational and maintenance housing communities and first aid facilities are planned to be located at a site, 100m away from the power plant site. Housing on the Geometric Power plant site at Umuojima-Ogbu, less than 20km from the OMA plant site shall initially be provided for key operational staff.

Schematic Diagrams/Layouts: The site location is shown in Figure 4-2 while Figure 4-4 shows a typical layout of a one block (3 x 1) combined cycle plant. The gas turbine is shown in Figure 4-5.

4.4.2 Thermo-Mechanical System

The thermo-mechanical system of the power plant includes the gas turbine generators, fuel gas system, fuel oil system, air compressor, maintenance and laboratory equipment and all connecting piping. Phase 1 comprises four units GE Frame 9E. These units are well tested throughout the world and in countries with the same climatic conditions as Nigeria. Also, in Nigeria, more than 70% of generating thermal power units as well as power plants being developed uses the GE Frame 9E.

Six (6) units of frame 9E's turbines will be installed: four (4) units in Phase 1 and two (2) units in Phase 2.

GE Frame 9 Unit

The Frame 9 unit (Model PG 9171E) is provided by GEEPE, Belfort, France.

The PG 9171 E model is an impulse/reaction, single shaft, heavy-duty outdoor unit with a turbine speed of 3,000 rpm. Under design conditions the generator is rated at 113.55MW using fuel gas. Under ISO conditions, the output is 126MW without water injection using fuel gas.

Figure 4-2: Area Plan of the Proposed OMA Power Plant Site

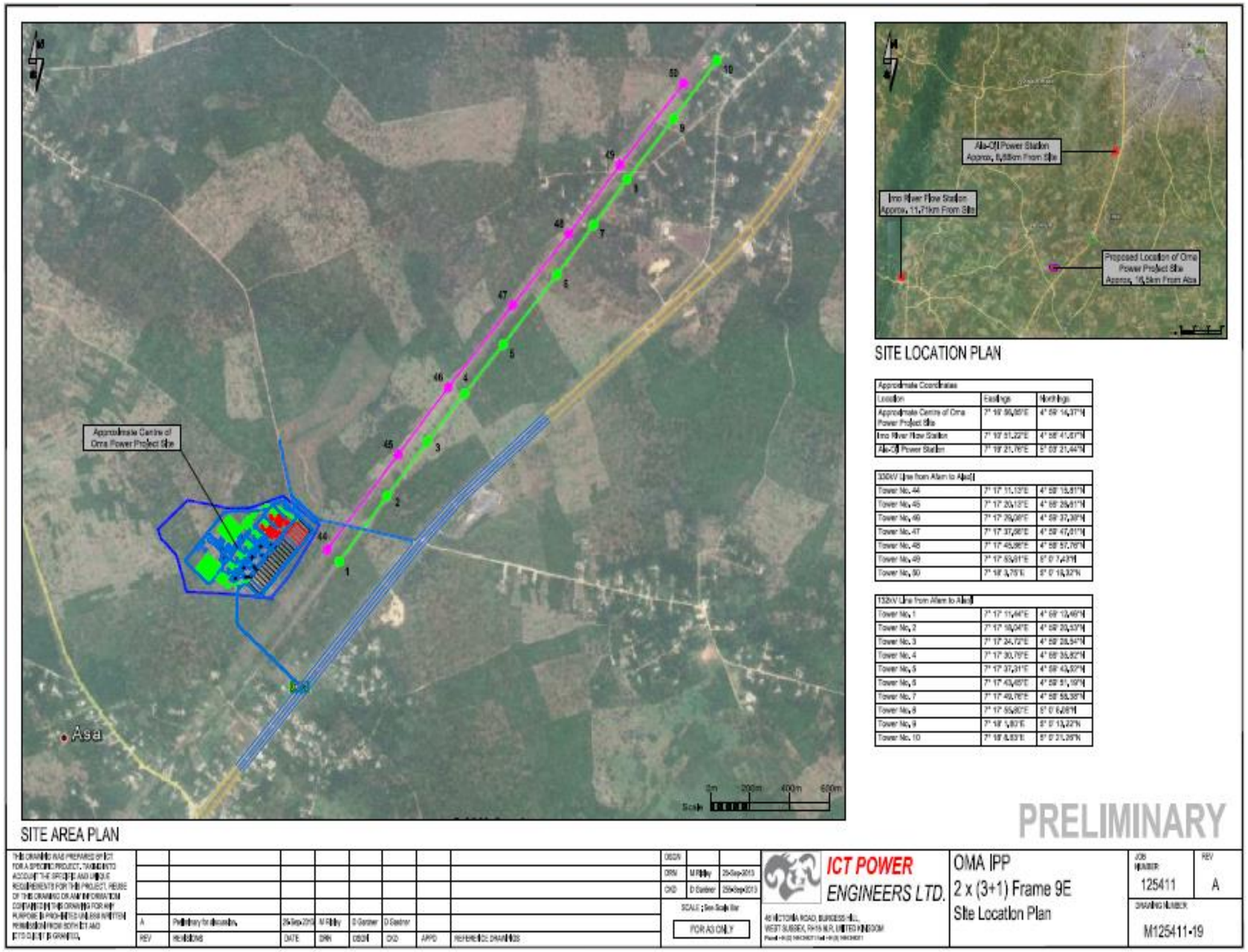


Figure 4-3 : Transmission Line Route

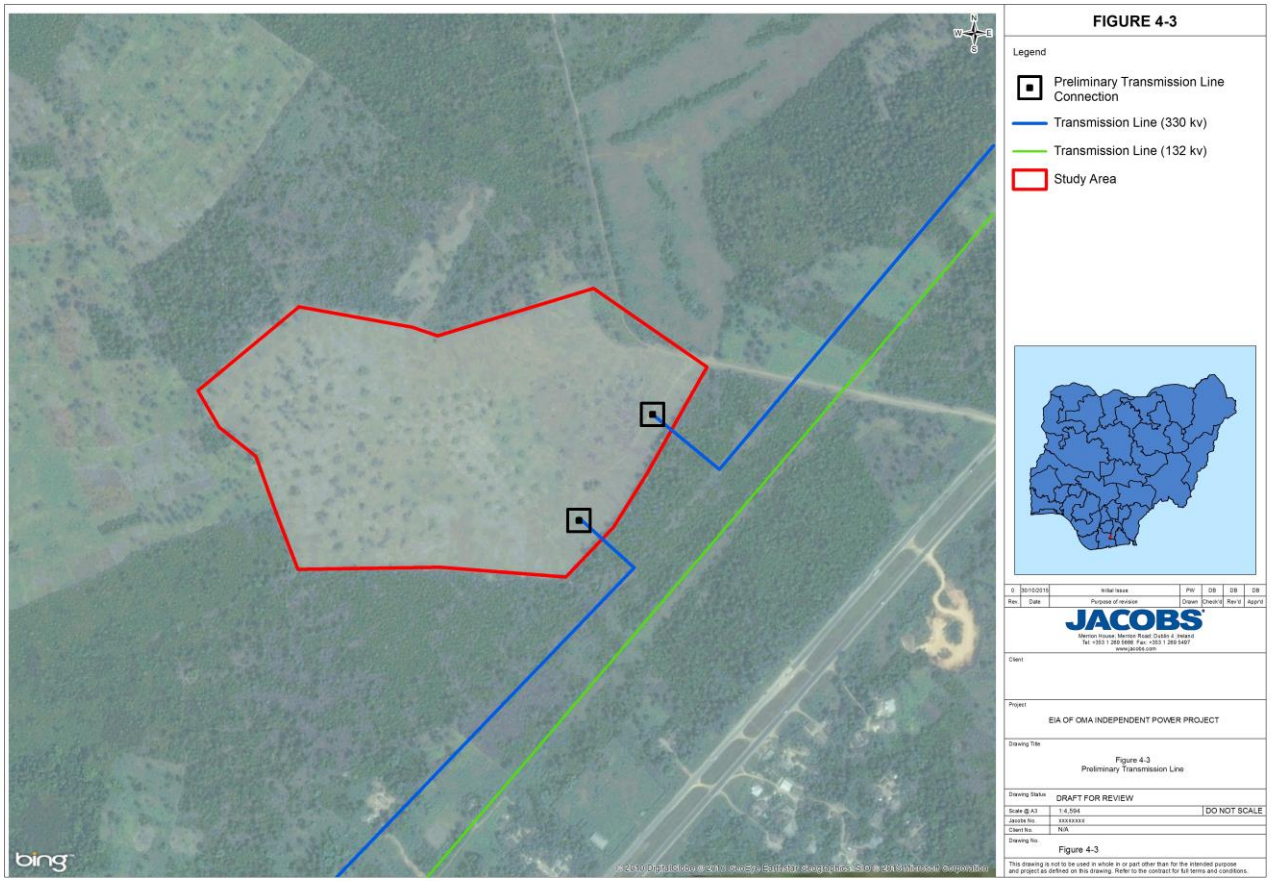
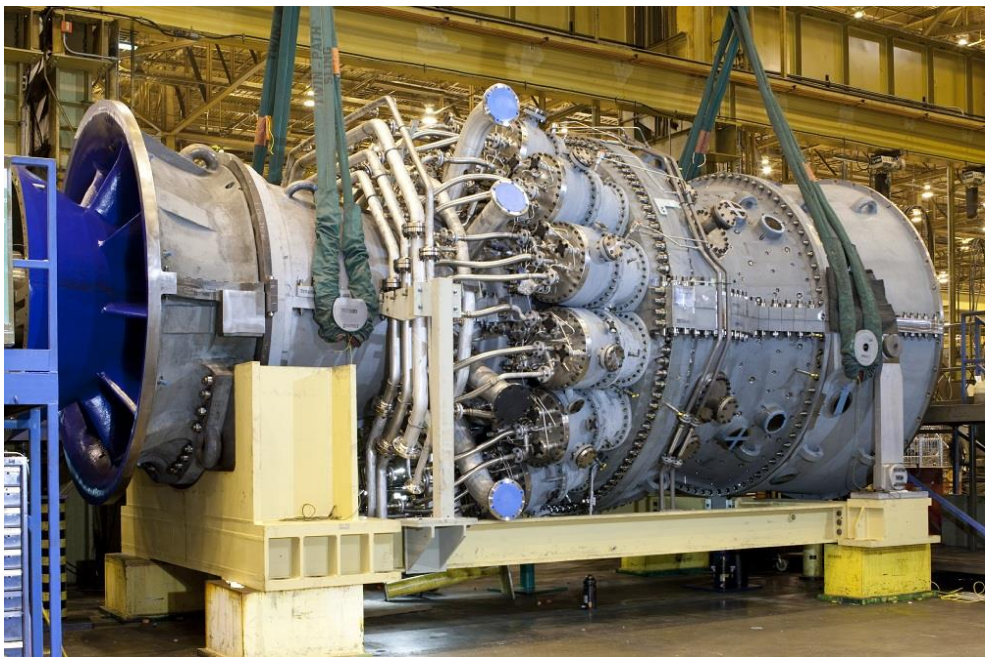


Figure 4-4: Typical Layout of one block (3 x 1) combined cycle plant (photo from Darlington Downs, Australia)

Figure 4-5: GE Frame 9E Gas Turbine



The GTG system includes the exhaust stack, air inlet filter, compressor wash skid, hitec dosing skid, cooling water pump skid, fire-fighting system, CO2 container, pulse air receiver, air inlet duct and acoustic enclosure, wastewater, waste oil drainage and demineralised water pumps.

The emission data of the gas turbines under unit fired natural gas and ISO conditions are provided in Tables 4-1 and 4-2. The data presented is as collated by Jacobs (issued to OPGCL by email 11/06/14) and agreed by OPGCL by email on 17/06/14.

Table 4-1: Emission Data for Phase 1

No	Parameters	Units	Phase 1 and 2 Frame 9E Simple Cycle	Source / Notes	Phase 2 Frame 9E Combined Cycle (with HRSG)	Comments
1.1	NOx	ppmvd	25	"ABA GPL Phase II-emissions.pdf" and confirmed in "JE30865_Oma_Information Requirement for ESIA-update-020514.doc"	25	Same as simple cycle
1.2	NOx as NO_2	kg/hr	58.3		58.3	Same as simple cycle
1.3	NOx	mg/Nm^3, dry 15% O_2	51.3		51.3	Same as simple cycle
2.1	CO	ppmvd	80	JE30865_Oma_Information	80	Same as simple

No	Parameters	Units	Phase 1 and 2 Frame 9E Simple Cycle	Source / Notes	Phase 2 Frame 9E Combined Cycle (with HRSG)	Comments
				Requirement for ESIA-update-020514.doc		cycle
2.2	CO	kg/hr	113.6	Calculated from 100 mg/Nm3 and vol flow at reference conditions (315.7 Nm3/s)	113.6	Same as simple cycle
2.3	CO	mg/Nm^3, dry 15% O_2	100	JE30865_Oma_Information Requirement for ESIA-update-020514.doc	100	Same as simple cycle
3.1	O2 content of flue gas	%	13.73	ABA GPL Phase II-emissions.pdf (Base load)	13.73	Assumed same as simple cycle
3.2	Moisture content of flue gas	%	7.11		7.11	Assumed same as simple cycle
4.1	Stack heights	mtrs	40	Advised by client email	42.7	Assumed to be minimum of 5m above waste heat boiler building
4.2	Stack inside diameter	mtrs	5.5	Exhaust Stack info.doc	4.2	Estimated by Jacobs
4.3	Exhaust gas temperature	^oC	555	"M125411-24-Rev-B-Oma-2x(31)-Combined-Cycle-Major-Atmospheric-Emissions.pdf"	130.4	"M125411-24-Rev-B-Oma-2x(31)-Combined-Cycle-Major-Atmospheric-Emissions.pdf"
4.4	Exhaust Flow	Nm3/s, dry 15% O_2	315.7	Calculated from NOx emission rate and concentration (58.3/51.3)*(1000/3600)	315.7	Same as simple cycle
		m3/s	848.2	Calculated from exhaust flow at reference conditions (315.7 Nm3/s) and adjusting for temperature (555 oC), moisture (7.11%) and Oxygen (13.73%)	413.2	Calculated from exhaust flow at reference conditions (315.7 Nm3/s) and adjusting for

No	Parameters	Units	Phase 1 and 2 Frame 9E Simple Cycle	Source / Notes	Phase 2 Frame 9E Combined Cycle (with HRSG)	Comments
						temperature (130.4 oC), moisture (7.11%) and Oxygen (13.73%)
4.5	Exhaust gas velocity	m/s	35.7	Calculated from stack diameter of 5.5m and vol flow of 848.2 m3/s	29.8	Calculated from stack diameter of 4.2m and vol flow of 413.2 m3/s

Table 4-2: Exhaust Gas Analysis % Volume

Parameter	Frame 9
Argon	0.85
Nitrogen	70.99
Oxygen	12.59
Carbon Dioxide	3.39
Water	12.19

Fuel Gas System

The natural gas fuel for Phase 1 will be piped approximately 12km from the existing Imo River gas gathering facility, via an 18" pipeline through a fuel gas flow check meter and a fuel gas-receiving skid before the gas enters the gas turbine generator. Provision will be made to allow any item of equipment and associated piping to be taken out of service for maintenance, purging and flushing without shutting down the turbines. To ensure the fail-safe protection of the plant, emergency shut-off valves will be installed at each fuel gas treatment station inlet and outlet. The system will include a nitrogen purging system to facilitate evacuation of gas from the pipeline for repair and maintenance work, purging of air and nitrogen blanketing.

Energy Balance

The Energy balance of the proposed Phases 1 and 2 and the combined cycle is outlined in Figures 4-6 and 4-7 respectively.

Air Compressor System

The air compressor will be provided for Phase 3 only. The facilities provided will include two instrument air compressors, two driers and an external air storage tank.

Maintenance Workshop Equipment and Laboratory Equipment

In order that certain maintenance and testing can be performed in the plant a maintenance workshop and laboratory will be provided. The workshop will be fitted with machine tools and equipment while the laboratory will have testing and analysing equipment.

Figure 4-6: Energy Balance Phase 1

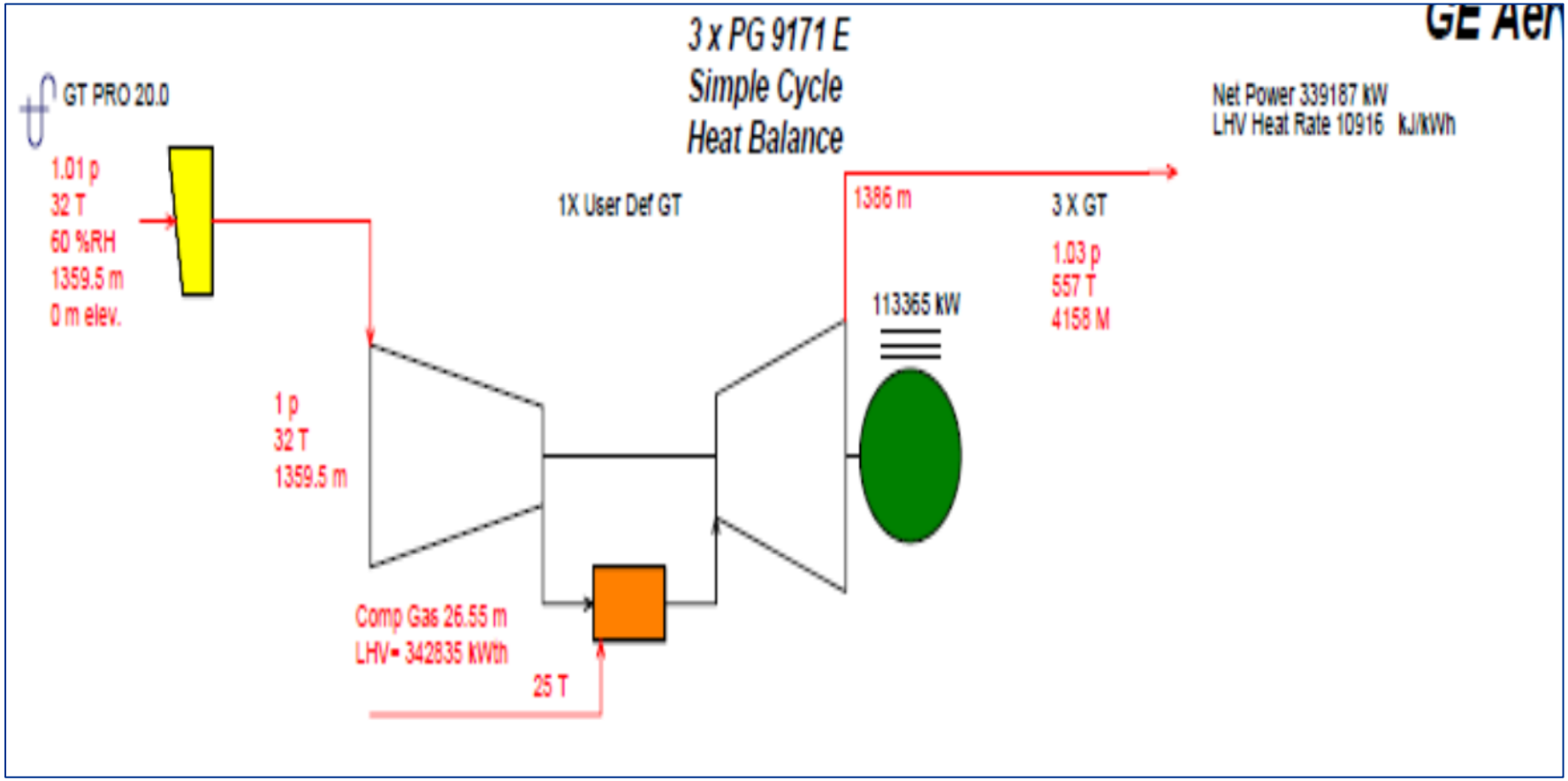
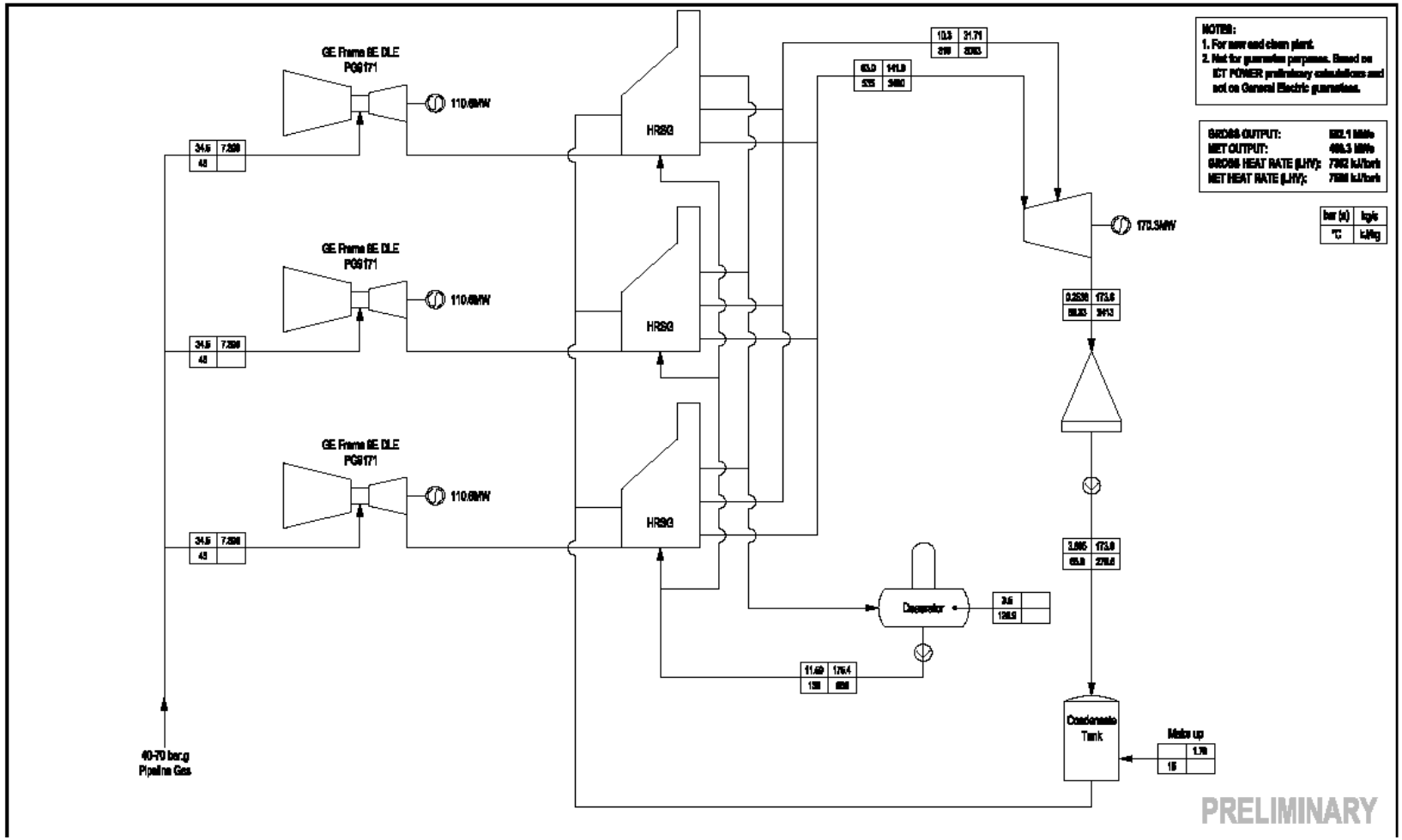


Figure 4-7: Energy balance for one block of combined cycle



During maintenance activities, oily wastes, metal spare parts, wood and cardboard packing waste etc. will be generated. These wastes will be disposed of as detailed in the site ESMP.

4.4.3 Chemical System

The chemical systems to be installed will be those associated with the various plant water systems.

Closed Circuit Cooling System

A closed circuit cooling water system shall be used for cooling the ancillaries of all phase 1 and phase 2 gas turbines. The closed circuit cooling water system will contain treated i.e. demineralized water. The circulating water transmits the heat from the ancillaries such as lubricating oil coolers and dissipates the heat to atmosphere via air-blast coolers employing finned tube banks and forced draft fans. These systems will have self-contained Chemical dosing systems with corrosion inhibitors and oxygen scavengers. Space shall be reserved for a demineralization system, to provide the necessary high purity water for gas turbine water injection for NOx abatement, should this become necessary, and/or for make-up water for Phase 3 HRSGs and associated closed circuit cooling water systems.

Raw Water Treatment Plant

The water treatment plant will consist of the following: a raw water break tank, treated water storage tanks, three 50%-duty demineralisation streams, dual-media filters, activated carbon filters high-pressure pumps, forwarding pumps, an automatic effluent neutralising system, a control panel and all interconnecting pipe work.

The plant will treat all non-oil effluent produced by the power plant to the more stringent of the Nigerian or World Bank / IFC EHS guidelines for Thermal Power Plants. The treatment process to be used involves filtration, followed by R.O. demineralisation.

Gas Turbine dry low NOx combustion technology will be deployed.

Oily Wastewater

Oily wastewater from the various production areas of the power plant shall be collected and treated through the oily wastewater treatment system. Oily wastewater is first treated through an oil water separation tank, which acts as a pre-separator where most of the oil is removed and pumped to a separate waste oil storage tank where it will then be pumped out and disposed of by licenced contractors.

The separated wastewater is then further treated through a two-stage treatment system where the oil concentration will be reduced to less than 10mg/l as required by the Nigerian environmental guidelines and IFC EHS guidelines. Oil concentration monitoring instrument shall be mounted at the outlet of wastewater discharge pump. If the oil concentration exceeds the stated maximum, oily wastewater shall be cycled to the inlet of oil water separator. In the final stage of the process, the tested and treated wastewater shall be discharged into storm drainage ditches.

4.4.4 Electrical System

The installed capacity in the power station will be approximately 1012.5MW (minimum) after Phase 3 is completed. Four sets of GE Frame 9 gas turbine generators shall be installed in Phase One and two sets in Phase two. Phase Three includes the addition of two steam units in combined cycle configuration. All the power generated shall be transmitted to the national grid via a 330kV twin DC circuit line running from project site in Ogwe to Afam – Alaoji as well as Alaoji – Ikot Ekpene 330kV

DC transmission lines. The connecting transmission lines and substations will be constructed by the project developer under an agreement with Transmission Company of Nigeria (TCN) for a refund of the associated costs. A small amount of power will be made available for station use, most probably 11-33kV.

No new transmission lines will be constructed for phase 1. The proposed transmission line required for phases 2 and 3 will be 300m long and run from the proposed power plant project switchyard to tie-in to the nearby 330kV double circuit line running from Afam to Alaoji (see Figure 4-3) and will comprise a minimum number of pylons (approximately 2-4). The transmission line will lie within the middle of two existing transmission lines.

Under the FMEnv Environmental Impact Assessment Act No 86 of 1992 (see Section 2.4.6) there is no mandatory requirement to provide an EIA assessment for this length of transmission line. There is similarly no requirement to undertake a formal EIA under other internationally recognised EIA acts, for example the European Union Directive 2011/92/EU, for a short stretch of transmission line such as this, and associated with and adjacent to larger development projects.

Nonetheless, considerations of the environmental and social issues associated with the proposed transmission line are included within Section 8.

4.4.5 Generator Auxiliaries

For each Phase 1, Phase 2 and Phase 3 units, the generator step up transformers shall be connected via a 330kV step up transformer to the 330kV switchyard bus bars.

The system shall consist of the following main components: medium voltage (MV) cross-linked polyethylene (XLPE) cables bus duct, MV cable terminals, tee terminal connections to the auxiliary transformers, tee terminal connections to the generator outlet surge absorber and voltage transformer cabinets. The bus duct assembly shall be rated to accept the full peak output of the generators over the entire ambient temperature range.

The generator circuit breaker shall consist of the following main components: Tee terminal connections to the unit auxiliary transformers, tee terminals to the generator outlet surge absorber and voltage transformer cabinets. The circuit breakers are vacuum type and shall be installed at the unit switch room. When the GTG set starts up, the generator circuit breaker shall be switched on first and the auxiliary power supply shall be fed from the power network through the main transformer and unit auxiliary transformer. Then the generator output synchronizes to the switchyard and the generator circuit breaker shall be switched off. The generator circuit breakers shall be manufactured and tested in accordance with International Electrotechnical Commission (IEC) publications 56 and 71 and with Institute of Electrical Engineers (IEE) standards.

4.4.6 Power Transformer

The transformers shall be of three-phase, 50Hz and outdoor-arranged, double windings with star connections for the high voltage and delta connections for the low voltage windings. The transformers are cooled with forced and oil-air cooling system (ONAF).

The main transformers shall be supplied, erected and tested in accordance with the following standards and codes: IEC publication 60 - High Voltage Test Techniques, IEC publication 71 - Insulation Co-ordination, IEC publication 76 -1~5- Power Transformers, IEC publication 137 - Bushings for Alternative Voltage above 1kV, IEC publication 185 - Current Transformers, GB 6451-86 - Technical Parameters and Methods for Three Phase Oil-immersed Transformers.

The step-up transformers shall be set on a concrete foundation. Oil containment shall be provided as part of the Oil Spill Prevention System. Fire detection/alarm system and protection systems shall be provided.

Transformers will be on hard surfaced areas with containment walls to contain any loss of transformer oil.

Power Plant 330kV Switch Yard (for Phases 1 & 2)

Concept design for the project is fixed, and currently includes 330kV AIS high voltage (HV) switchyard using a double bus-bar connection system. The switchyard system shall consist of the following components: circuit breakers, isolators with earthing switch, capacitance voltage transformers, current transformers, and lightning arrestors. Detailed design for the project is subject to EPC Contractor appointment and could result in some refinements to Phases 2 and 3.

Phases 1, 2 & 3 Switchyard

- Gas Turbine(GT) & Steam Turbine (ST) circuits main 11/330kV transformer incoming line bays
- 2 circuits outgoing line bays to Alaoji substation
- Capacitance voltage transformers and lightning arrestors

Auxiliary Power System

The auxiliary power systems shall be 6.6kV, 3.3kV and 400/230V. Only the 400/230V system shall be neutral point directly grounded.

Each GTG set shall be equipped with one auxiliary transformer. Each Unit Auxiliary Transformer (UAT) primary side shall be connected with the generator outgoing auxiliary branch circuit breaker through XLPE cable. The auxiliary branch circuit breaker shall be installed in the unit switch room.

Power plant uses such as the lighting system, integrated pump house, wastewater treatment, oil waste water treatment station, circulating cooling water treatment station, circulating water pumps shall each be fed by a separate unit power centre (PC).

The auxiliary power system includes the following major items of equipment:

- Unit auxiliary transformers
- 3.15kV switchgear
- Low voltage (LV) auxiliary transformers
- LV power centre
- LV motor control centres (MCC)

Emergency Power System

Under normal operating conditions, power for the starter motor of the GT units is provided from the auxiliary power 6.6kV (for the Frame 9E) bus bar from the power grid through the main transformer and the auxiliary transformers. When the auxiliary power fails, the starter motor shall be fed from the

Black start generator/s. There shall be an electrical interlock between the circuit breaker of the Black start generator and the emergency power centre incoming circuit breaker.

The Black start generator set(s) will be initially 2 off 1000kW, 3-phase, 4-pole and Wye-connected. The rated voltage of the generator will be 3.15kV or 415V and the frequency, 50Hz. The rated power factor is 0.8. The generator(s) will have a rotating speed of 1500 rpm and shall be water/air-cooled.

The 3.15kV or 415/240V emergency power centre will be installed in the diesel generator house. The emergency power centre bus shall employ a single bus connection. The diesel generator shall be connected to the 3.15kV (415V) emergency power centre bus bar via a high current air circuit breaker.

The emergency power system will be augmented to provide black start capability for the CCGT power plant (phases 1& 2), and final capacities would be up to 10MW (this may be only Diesel engines or in combination with a small Gas engine).

Uninterruptible Power Supply System

Direct current (DC) power for the GTG control packages is provided by 125V Nickel-Cadmium or valve controlled regulated lead acid battery sets. These provide power for the gas turbine DC drives and for control supply for the generator and turbine control panels. Two 220V battery sets and chargers will be furnished to supply power to DC drives and the control for 330kV substation and auxiliary power system. The valve controlled regulated lead acid battery will utilize 220V battery sets. The batteries will be stored in a ventilated room with spill containment under the batteries.

A radial and loop network will be used for the DC distribution system. For important DC loads, two feeders from different DC bus will be installed. In order to ensure continuous DC power, feeders will be loop designed.

A DC insulation monitoring device will be equipped with each bus to detect on line if DC system is grounded and which feeder is grounded. The monitoring device will also monitor the voltage and current for the DC system and send alarm signal to the remote with relay output contact or port RS-232.

Lighting System

The lighting system shall meet the illumination requirements for power stations recommended by the Illuminating Engineering Society (IES).

Normal lighting shall be fed from the 415/240V LV power plant auxiliary systems. Emergency lighting shall be fed from the 220V DC power supply from the emergency lighting changeover panel installed in the central control room. If the AC power source fails, the emergency lighting power shall automatically change to the 220V DC power source. The control room lighting shall be permanently fed from the 220V DC system.

Lightning Protection System

The lightning protection system shall protect buildings and equipment from damage by lightning and shall include the following major components:

- lightning rods;
- lightning conductors;
- down conductors; and

- Copper or brass plates.

Lightning rods shall be installed on all major buildings and equipment. The design shall be in accordance with National Fire Protection Association (NFPA) 780, UL 96A Standards. Those structures requiring lightning protection shall be determined during the detailed design.

In the switchyard area, overhead steel lightning arrestors supported on the steel structure shall be used to provide lightning protection.

4.4.7 Earthing System

All outdoor equipment such as metal enclosures, cabinets, boxes, steel structures, and fencing shall be adequately connected to the plant grounding system. The switchyard area shall be fenced and surfaced with crushed aggregate for personnel safety.

The earthing system shall consist of the following major components:

- earth grid and earth loop conductors with terminals for attachment to metallic structures and selected equipment;
- earthing rods or earth detecting wells; and
- Earthing conductors to plant equipment.

4.4.8 Fuel Source and Composition

Fuel Source: The natural gas will be supplied to Phase 1 and Phase 2 by 18” (457mm) underground pipeline connecting an IOC such as TOTAL E&P’s gas gathering facility at IMO River, pressure reducing station, gas metering and treatment stations to the proposed site at a delivery pressure of 35 bar gauge. The approximate length of pipe is 12km. Other facilities to be installed may include dedicated filters, pressure let down station and a slug catcher.

However, should the available fuel gas pressure not meet the GTGs requirements then the installation of an electric drive gas compressor station and a gas storage tank within the project area shall be considered. A spur line to the 12” line supplying gas to the GP’s power plant at Osisioma may be included as gas supply backup should the dedicated line not be available for maintenance reasons.

Fuel Composition: The final fuel composition for the power plant is not yet confirmed. However, the typical composition of natural gas likely to be used for power generation for the proposed OMA power plant project is presented in Table 4-3. The fuel low heating value (LHV) is about 35.4MJ/Sm^3 (megajoules per standard cubic meter), where Sm^3 is the volume under the condition of 101.32kPa pressure and 15°C temperature. Should the natural gas contain lower methane, then the installation of a stripping plant will be negotiated with the gas suppliers to enable the gas conform to the levels presented in Table 4-3.

Table 4-3: Natural Gas Analysis - Composition of the Fuel Gas for OMA Project

Component	F	Percentage Mole
Nitrogen	N_2	0.1001
Methane	CH_4	94.1421
Carbon dioxide	CO_2	0.6488
Ethane	C_2H_6	2.6609
Propane	C_3H_8	1.1019
I- Butane	C_4H_{10}	0.3561
n- Butane	C_4H_{10}	0.4708
neo-pentane	C_5H_{12}	0.0056
I-Pentane	C_5H_{12}	0.1531
n-Pentane	C_5H_{12}	0.1109
Hexane +	C_6^+	0.2496
Total		**100**
Water Vapour by Volume (VPM)	Vmp	64.0
Specific gravity		0.6099
Gross calorific value	MJ/m^3	42.4663
Net calorific value	MJ/m^3	38.3494
$C_5 – C_6$+ as Condensate		0.5192
Water Vapour Pressure	mmHg	0.048
Molecular weight	MW	17.5891
Dew Point	^oC	-46^oC

Source: Typical constituents of SPDC gas at IMO River.

4.4.9 Fuel Supply and Consumption

The fuel for the plant will be natural gas. Fuel gas distribution will reach each GTG unit through a single pipeline system sized to handle the total gas flow.

Fuel Gas Consumption

Phase 1 & 2

The data presented for Phase 1 (Tables 4-4 and 4-5) is on the assumption that 4 GTGs are operational at full load capacity 23 hours a day and 7500 hours per year.

Table 4-4: Estimated Fuel Gas Consumption Rate by the Proposed Power Plant for GTG 1, 2, 3 & 4

Fuel Gas Consumption Rate for One Frame 9	Temperature		
	15^oC	26.8^oC	35^oC
Per hour (Sm^3/h)	40,130	37,158	35,303
Per day (Sm^3/d)	922,990	862,914	811,969
Per year (Sm^3/y)	300,975,000	281,385,000	264,772,500
Assumptions: 23hours full load operation per day and 7500 hours full load operation per year. Based on a Natural gas fuel LHV of 35.370kJ/Sm^3.			

Source: OMA Power Plant Preliminary Design Report Index (18-02-2011)

Table 4-5: Phase 1 Estimated Fuel Gas Consumption Rate per Hour (base load and based on ambient temperature of 30°C)

	Volumetric Flow Rate (Sm3/ h)	Mass Flow Rate (kg/h)
Frame 9E	34,667	28,613
Frame 9E	34,667	28,613
Frame 9E	34,667	28,613
Frame 9E	34,667	28,613
Total	138,667	114,452

Source: OMA Power Plant Preliminary Design Report Index (18-02-2011)

Phase 3

In Phase 3, two steam turbine units will be added to the six gas turbine units thus converting the plant under the Phase 3 works as a combined cycle facility.

Provisions will be made in the design to allow any items of equipment and associated piping to be disconnected for servicing/maintenance, purging and flushing without shutting down the turbines. It is also planned that for reliable operation of the gas turbines, the fuel gas shall be supplied at constant pressure and at an acceptable quality as required by the gas turbine original equipment manufacturer (OEM) specification. The fuel gas will be supplied at 28°C, above the gas dew point, to minimize any possible condensation of hydrocarbon in the station fuel gas system.

Furthermore, to ensure fail-safe protection of the proposed OMA power plant, emergency shut-off valves will be installed at each fuel gas treatment station inlet. Also, to measure and monitor the total gas consumption of the station, a computerized gas measurement system containing flow meters with meter-proving facilities, analyser, etc. will be provided to give information on volume, mass and energy as required. The flowmeter will be located in the utility control room and shall be used as a component of the gas control unit of each gas turbine.

Fuel Gas Receiving Skid

The fuel gas shall pass through a fuel gas-receiving skid consisting mainly of emergency stop valve (solenoid operated), pressure control valves, scrubbers, and common condensate drain tank before the fuel gas enters the GTG. The gas pressure control valve shall maintain proper pressure of the outgoing gas. The gas will first enter the scrubbers where all impurities (solid particles and liquid contaminants) to a large extent (above 99%) are removed. The condensate drain tanks will be responsible for collecting hydrocarbon drains from various points.

Fuel Gas Flow Meter

Fuel gas flow meter will be provided complete with continuous integration and automatic compensation for temperature and pressure fluctuations, as well as the summated fuel consumption totaliser. The flow meter is a metering system and will be used to measure the volume of the fuel gas flow used by the gas turbine.

Nitrogen Purging System

A nitrogen purging system will be employed to form part of the gas piping installation, the maintenance work; purging of air from the gas piping system prior to charging up with gas; and nitrogen blanketing.

Diesel Fuel System

Diesel fuel oil is used as the fuel of the black start and emergency diesel generator and the diesel fire pump according to 'Draft Report of the Environmental Impact Assessment of OMA Independent Power Plant'. The composition of distillate fuel is provided in Table 4-6.

All wastewater/waste oil drains from the fuel tank; fuel pump, oil filter, and fuel pipe will be channelled to the oil/water treatment facility. Treatment will be to comply with IFC EHS Guidelines or Nigerian effluent limits whichever is more stringent for each effluent.

Diesel Fuel Unloading Pumps

Two centrifugal fuel unloading pumps will be provided within the fuel pump room, such that while one is in use the other will be on standby in case of emergencies. Each pump design flow rate is estimated at about $90m^3/h$ and head $49mH_2O$. This will ensure that the entire diesel in the unloading tank can be drawn out within 20 minutes.

Diesel Fuel Storage Tank

The fuel storage tank will be of vertical, welded steel type. Floating suction will also be employed. The tank will be constructed in bunded areas capable of holding accidentally released fuel effectively until it can be detected and safely recovered. The bunds will be sized to 110% of the tank size in line with IFC EHS standards.

Table 4-6: Composition of the Diesel Fuel for IPP Project

Test	Method	Units	Result
Density @ 15.60 C	IP 365	g/cc	0.8658
API Gravity	IP 365	-	31.77
Water Content	IP 356	% m/m	0.02
BS&W	IP359	% vol	Nil
Pour Point	1P 15	0 C	_ 9
Wax	BP	%m/m	8.7
Wax Melting Point	IP 133	0 C	64.9
Sulphur	IP 336	%m/m	0.14
Cetane Index	D 975	-	45.31
Sodium	ICPAES	mg/kg	< 2
Potassium	ICPAES	mg/kg	<10
Calcium	ICPAES	mg/kg	<0.1
Lead	ICPAES	mg/kg	< 0.2

Nickel	ICPAES	mg/kg	< 0.1
Vanadium	ICPAES	mg/kg	< 0.1
Ash Content	IP 4	% m/m	<0.001
Copper Strip Corrosion (3hr @100 0 C	IP 154	_	1a
Cloud Point	IP 219	0 C	_ 5
Total Acid Number	IP 177	mg KOH/g	0.35
Strong Acid Number	IP 177	mg KOH/g	None
Viscosity @ 37.80 C	IP 71	cST	4.176
Viscosity @ 98.90 C	IP 71	cST	1.456
Flash Point	IP 34	0 C	89
Carbon Residue on 100% sample	IP 13	% Wt	0.01
Carbon Residue on 10% sample	IP 13	% Wt	0.2
Calorific Value	ASTM D240	MJ/kg	42.628
Particulate Matter	ASTM D2276	mg/l	0.4
Oxidation Stability	ASTM D5304	mg/100ml	<0.1
Compatibility	ASTM D4740	-	No.1

Source: GP 2013

Diesel Fuel Transfer Pumps

Two centrifugal fuel transfer pumps will also be provided within the fuel pump room so that while one is in use the other would standby in case of exigencies.

Diesel Purification Units

Two diesel purification units would be installed for conditioning the fuel; when one is in use, the other will be on standby.

Wastewater Drain Pump

In the lowest area of the fuel pump room, a wastewater pit will be constructed. This is to serve as the destination drain for all the diesel fuel equipment and pipe discharges including the ground flush water, during operation and maintenance activities. The wastewater drain pump will transfer the wastewater to oily wastewater treatment room automatically according to the water level.

Fuel Pump Room Maintenance Equipment

A 2-ton electrical motor driven hanging bridge crane will be provided at the project site to facilitate the haulage of equipment from the fuel pump room to maintenance area on site.

4.4.10 Plant Auxiliary Services

Maintenance Workshop and Laboratory Buildings

Due to the fact that some equipment will be maintained on site, and chemical analysis will be carried out there will be a maintenance workshop and a laboratory buildings on site. The maintenance workshop will occupy about 500m^2 area and shall house major equipment such as mechanical process machines and an overhead travelling crane. The laboratory shall cover an area of about 150m^2 and shall mainly house some test and analysis equipment.

Oxygen, Acetylene and Nitrogen Supply

Oxygen and acetylene shall be used for welding during maintenance while nitrogen will serve for pipe purging. These shall be sourced from the local market. Appropriate storage facilities will be provided for these gasses and used cylinders of these gasses.

Thermal Insulation Material

The aluminium silicate will be employed as the thermal insulation material. The protection layer will be made of stainless steel or textured aluminium of 0.5mm thickness.

Paint System and Galvanizing

An effective paint system shall be adopted to avoid rapid deterioration due to the weather. All paints shall have dry film thickness (DFT) of 300 microns. The paint system to be used shall be in accordance with the following order:

- shot blasting of the substrate;
- striping the coat of all welds (surface preparation) and other areas likely to cause incomplete application of primer;
- application of 125-micron base coat of inorganic zinc silicate primer;
- application of 125-micron intermediate coat of high-build epoxy; and
- Application of 50-micron colour coat.

Galvanizing shall be in accordance with the appropriate British standard, or equivalent, as appropriate. Pre-galvanized sheet and sections that are often bent into profiles shall not be acceptable because, the coating rapidly fails along the bend lines.

4.5 Process Design

4.5.1 Water Supply System

Water Demand and Groundwater Supply System

A test borehole has proven the presence of good quantities (60m^3/hr) of groundwater beneath the site. Additional production-scale groundwater boreholes will be sunk to provide the water supply for the various project requirements described above. The boreholes will be drilled to depths in the order of not less than 60 meters below ground level (m bgl) with a target capacity of 90m^3/hr per borehole, in order that each borehole can provide the full amount required for Phase 1 and operate alternatively, with a second borehole providing redundancy.

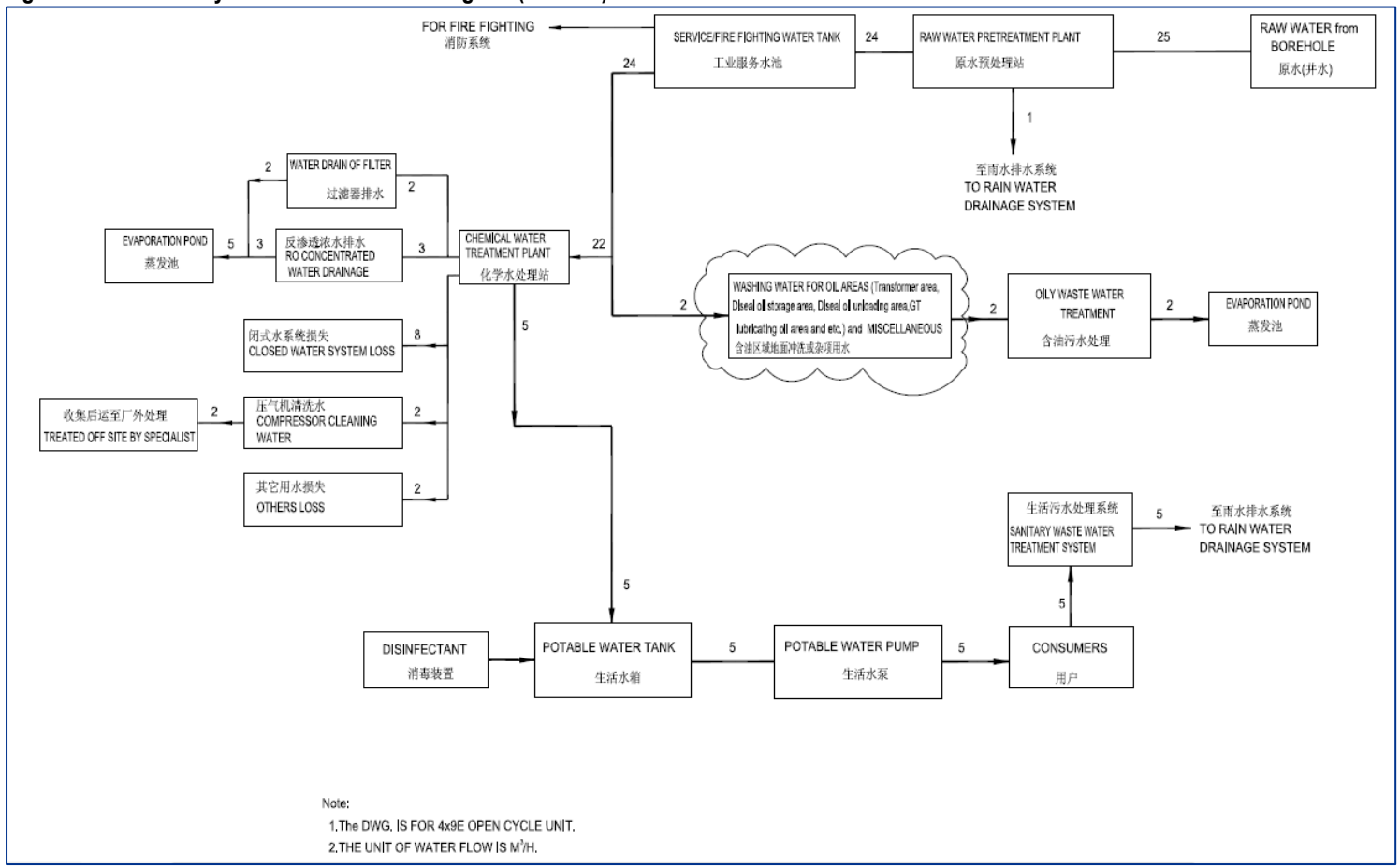
The water balance diagram for Phase 1 is presented in Figure 4-8. The estimated average water flow demand for Phase 1 is about 25-30m^3/h. Instantaneous flows could be greater than this average requirement, but these are unlikely to increase by greater than 1%.

Estimated water requirements for Phase 2 and Phase 3 are 12m^3/h and 120m^3/h, respectively, giving a cumulative total of 162m^3/h. Depending on the final installed capacity of the boreholes for phase 1, additional boreholes may be required for Phase 2, and will definitely be required for Phase 3. The locations of additional boreholes and any associated assessment will be confirmed at that stage.

The volume of water required to meet the maximum demand of the fire-fighting system is approximately 500m^3. This is discussed further in Section 4.6 below.

As detailed in Section 5.6.1, the aquifer from which water would be drawn is regionally extensive. Hydrogeological studies carried out on site indicate that it is very unlikely that there will be a significant impact on water availability at the community supply boreholes due to water abstraction at the plant during Phase 1.

Figure 4-8: Preliminary Plant water Balance Diagram (Phase 1)



Electric powered submersible borehole water pumps shall be installed with flow meters at the discharge points to measure the flow rate and regulate the flow capacity of the boreholes during the OMA power plant project. Also, by-pass pipes and valves will be installed to ensure that there is no disruption of the normal operation of the pumps should the flow meters be damaged.

There will be two 600m^3 surface tanks with pressed steel sectional structure for the storage of fire-fighting water and raw water. In order to ensure continuous water supply during inspection and maintenance activities, the raw water tank will be separated into two chambers so that when one chamber is being cleaned, the other can be routed to normal water flow ensuring that the power plant stays operational.

Also, to control microbial growth in the treated water and reduce sterilization time, a surface tank will be installed for storing sterilized drinking water at the project site. The tank will be a pressed steel sectional structure while the disinfectant will come (controlled and measured) from the circulating water treatment station.

The sterilized water tank is estimated to be 4m in length, 4m in width and 3m in height giving a total volume of 48m^3, and operational capacity of 45.6m^3. To ensure the safe and continuous delivery of the domestic water supply during inspection and maintenance, the sterilized water tank will also be separated into two chambers so that when one chamber is being cleaned the other can be routed to normal water flow.

All the pipes that will be used in the well water supply system shall be made of Glass Reinforced Epoxy (GRE), single main pipe types with nominal diameter of 150mm. The piping will also include valves, expansion joints, air vents, supports, flange and other accessories needed for the system.

Domestic Water Supply System

The domestic water will come from the Potable water tank and the supply system will convey water from the potable water tank to the consumers. This is to satisfy the demand for potable water, sanitation, and car wash water in the power plant area. The domestic water supply system shall be designed in accordance with World Health Organisation (WHO) standards.

The domestic water requirement of the power plant is estimated at about 5m^3/h. The water requirement for road wash will only occur in the dry season because in the wet season high rainfall density in the project area would account for these needs. Also, to ensure that daily water requirements are met, an automatic water supply device with pressure keeping and transformable water flow function will be installed. The domestic water supply system piping will be made of GRE pipes with nominal diameter of 50mm. The piping will also include valves, expansion joints, air vents, supports, flange and other accessories.

Any domestic water supply system piped to equipment areas shall be separated from the building supply by a “break tank”, which will prevent any possibility of backflow from the equipment into the domestic water supply system. Electrical water heaters will be installed at central points for sanitation purposes.

4.5.2 Air Cooling System Water Requirements

Phases 1 & 2

The circulating water system will be designed to meet the cooling water requirements of the frame 9 turbines and generators with a closed loop and will be equipped with Fin Fan coolers in the circuit.

Phase 3

With the absence of surface water around the plant vicinity and in order to conserve the use of ground water, an air cooled condenser (ACC) will provide the means of recycling the condensed water using exhaust from the steam turbine. The steam is passed in large ducts to the ACC and is condensed inside finned tubes. The tubes are cooled by an array of large forced draft fans.

The efficiency of the ACC system will be a function of the ambient temperature, with high efficiencies gained during low ambient temperatures, and lower efficiencies gained during high ambient temperatures. The dry ACC system will be designed to provide sufficient cooling capacity during times of high ambient temperature.

Circulating Water System Pumps, Pipes and Accessories

The gas turbine lubricating oil, hydrogen generator, boiler circulating pumps, sample coolers and other minor systems will be cooled by a closed circuit cooling system linked to external fin fan coolers.

According to the requirement of circulating water system, centrifugal circulating water pumps (one in operation and the other one on standby) will be utilized for each GTG. The pumps will be designed for continuous operation at any point on the head/quantity curve between rated minimum flow and maximum output.

Single main pipes will be used for the circulating water system. The pipes will be made of welded carbon steel, with nominal diameters of 250mm and 200mm, respectively. The piping will also include valves, expansion joints, air vents, supports, flanges and other accessories needed for the system.

In order to ensure the safe operation of the circulating water system and to remove suspended solids and floating material, a strainer will be installed. To ensure that damage to the strainer water flow meter does not influence normal operation of the circulating water system, a by-pass pipe and valve will be also installed.

4.5.3 Water Processes

Raw Water Treatment Process

In order to remove suspended solids and floaters from the borehole water, reduce the ion contents, and prevent rusting and corrosion (through oxidation and deposition of the iron and manganese ions) of the pipes and other water supply equipment, the groundwater shall be treated to ensure all regulatory requirements are met. The treatment will require chlorination of all potable water.

Oily Wastewater Treatment Process

Irregular oily wastewater consists mainly of oil-contaminated rainwater from fuel storage tank area and oily wastewater from emergency transformer oil tanks while regular oily wastewater consists mainly of oil from fuel oil storage tanks, GTG area, fuel oil pump house, maintenance shop, transformer, STG area etc.

Oily wastewater from various production areas shall be collected and treated together through oily wastewater treatment plant. The design capacity of the oily wastewater treatment plant is estimated to be 20m^3/h. When it rains, oil-contaminated rainwater shall be channelled into an oily wastewater storage tank before treatment. The wastewater storage tank will have a holding capacity of about 1000m3. This process will address wastewater associated with phase 1 and 2. At phase 3, the need to provide additional treatment facility will be detailed and provided at the same location.

Based on local regulatory requirements (FMEnv, 1991; DPR, 1999) the discharge limit (10mg/l) of oil concentration in treated wastewater in inshore waters shall be adopted. The required treatment equipment/facility shall be installed in the oily wastewater treatment room, which will be located next to the fuel storage tank.

Demineralization System

The requirement for demineralized water is estimated to be 36m3/h. Primary demineralization by reverse osmosis will be adopted for this system. The demineralization system shall consist of three trains of equipment: 1 train will be in operation while the other will be in backwash/cleaning, the third train will be in standby. The control system shall be automatic.

The quality of the demineralised water that will serve as direct injection water for the GTGs shall meet the following standards as a minimum:

- Sodium ions, Na^+ <50ppb (parts per billion)
- Silicon Dioxide / silica, SiO_2 <100ppb
- Conductivity <0.5µS/cm (25°C) microsiemens per centimetre

NO_X Control Process

The NOx control system is expected to be a dry low NOx (DLN) system. Wet NOx treatment will not be used.

4.6 Fire Protection

This section identifies the various fire protection techniques that are proposed for the OMA power plant project and provides information relating to anticipated types of fires, and the various protection/fighting techniques and equipment planned for installation.

A selection from the following facilities will be installed to provide an effective fire protection/fighting system in the proposed plant:

- A firewater distribution system.
- Foam systems.
- Sprinkler systems.
- Inert Gas installations.

- Carbon dioxide extinguishing systems.
- Portable fire-fighting equipment and fire/smoke suppression systems.
- Fire station for housing fire engines, ancillary equipment and supplies.

4.6.1 Firewater Distribution System

Fire water distribution system shall be provided and designed on a ring main basis, to cover the fire protection requirements for the plant and equipment.

The system will incorporate appropriate loops and section valves, so that sufficient water can be supplied to the required areas in the event of failure of a single path. The design will be in accordance with NFPA.

Firewater will be drawn from the service/fire water storage tanks. The volume of firewater required is approximately 500m^3, based on the maximum anticipated flow rate for the largest single fire risk associated with the power station plus the demand for two hydrant points, for a period of two hours. NFPA requires a flow of 150% of the rated capacity. This is in accordance with the requirements of the relevant international fire hazard control standard (NFPA 850).

4.6.2 Firewater Pumps

The firewater pumps will provide water for the entire power plant. One 100 per cent duty electric motor driven pump and one 100 per cent duty diesel engine driven pump shall be supplied, each pump capable of supplying water to all sprayers, sprinklers, hydrants or hose reels associated with the largest single fire risk and comply with the requirements of NFPA 20. Jockey pump(s) will be provided to maintain the fire main under pressure and to cater for minor usage/leakage.

The status of each pump will be indicated on the master fire alarm panel.

The fire pumps will be located within a building to give adequate protection from the environmental conditions.

4.6.3 Firewater Piping System

The firewater piping system shall be laid out in a loop system around each phase of the plant with sectional isolation valves provided at all crossovers and elsewhere, as necessary, to permit isolation of any sector of the firewater system without compromising the safety of the plant.

The firewater main supply lines shall not be smaller than 6 inch (150mm) in diameter. The lines shall favour the least hazardous side of the road to facilitate access to fire hydrants. Firewater lines around process equipment and large machinery shall generally be on the side of the road remote from them.

4.6.4 Hydrants

The arrangement of the site fire hydrant system will be in accordance with the requirements of NFPA 24, and the number of hydrants will be such that two hose streams can be directed to any single outbreak of fire.

4.6.5 Foam System

Foam injection lines will be provided for the application of aqueous film forming foam (AFF) to the liquid surface of the distillate fuel oil storage tanks via air foam chambers and top strake pourers. The installation will comprise all pipework, valves and fittings for the safe and efficient operation of the system. The foam system shall be designed in accordance with the requirements of NFPA 11, with the rate of foam application being not less than 4.1 litres/min to each square metre of liquid surface.

The system shall be arranged such that the control valves can be operated from the control panel located at the foam station. It is envisaged in the event of a fire, the foam system will be applied to the fire incident tank in conjunction with the automatic cooling water spray system, the activation of which will raise an alarm on the main fire alarm panel in the central control room.

In addition, the Contractor shall provide hose reel assemblies attached to the outside of the fuel oil tank bund walls, the hose reels shall be located at 30 metre spacing, and shall have the capability of injecting foam into the fuel oil tank bund area. Foam concentrate shall be held in containers located close to each hose reel. During a fire, the operator should remain as far as possible from the tank.

4.6.6 Water Sprinklers

These shall comprise specialized units:

- **Cooling of Storage Tanks and Pressure Vessels:** Water for cooling storage tanks and pressure vessels shall be applied at a rate of $0.5m^3/h/m^2$ of area calculated on the exposed area. In the case of vertical vessels (storage tanks) where cooling water is supplied by hose streams the required quantity shall normally be 25% of the total surface area.

- **Sprinkler Systems in Buildings:** Sprinkler systems shall be installed in all buildings where combustible material may be present. They shall not be installed in buildings housing electrical equipment. Installation of sprinkler systems in buildings shall be in accordance with NFPA codes.

4.6.7 Water Spray Systems

Water spray systems normally discharge a fine pattern of water and shall be used for fire extinguishing, control or prevention as well as for protection of structures and equipment from exposure to fire. For exposure protection of structures and equipment a fine spray of water is projected against the item to be protected from permanently installed spray heads.

Two types of water spray systems (manually and automatically controlled) will be installed in the proposed plant. Manually controlled systems are usually empty until water is admitted to the system, at which time water is discharged through all spray heads. Automatically controlled systems are of two types, the wet and the dry pipe systems.

The wet pipe system shall consist of spray heads attached to pipes containing water and permanently connected to a water supply. The water shall be discharged immediately through spray heads opened by fire. On the other hand, the dry pipe system shall consist of spray heads attached to pipes containing air under pressure, the release of which would permit water to enter the system through a deluge valve. The water shall be discharged through spray heads opened by fire.

4.6.8 Inert Gas / Argon Fire Protection System

Inert gas and Argon are relatively inexpensive and readily available fire extinguishing agents used to put out electrical fires in enclosed spaces. They shall be installed particularly for use in generator enclosures and all control cubicles where water cannot be used. Inert gas and Argon also offer the advantages of inert atmosphere with minimum risk to personnel, high efficiency, compact storage containers and pipework, no cold shocks to delicate apparatus, no residue left after discharge, indefinite storage life, and non-conductor of electricity and can be used safely on electrical and electronic apparatus. However, there could still be a threat of asphyxiation which shall be addressed in the Occupational Health and Safety Plans for the project detailed during the ESMP Phase.

4.6.9 Carbon Dioxide Extinguishing Systems

Carbon dioxide (CO_2) extinguishing systems shall be installed in the proposed OMA power plant site because when discharged into a closed room or into enclosed spaces it makes an effective extinguishing agent for fire involving liquid hydrocarbons and electrical equipment. Both high pressure and low-pressure systems shall be installed within the power plant. Specifically, it shall be used on electrical generating equipment for fire protection in the rotating electrical element as well as large electrical switchgears. However, it will not be used in the generator housings. However, there could still be a threat of asphyxiation which shall be addressed in the Occupational Health and Safety Plans for the project detailed during the ESMP Phase.

4.6.10 Hose Stations and Hose Reel Stations

Service water hose stations shall be provided at the diesel oil pump house, fuel gas arrival and metering facilities, diesel oil truck unloading bay, diesel tanks, slop oil handling and storage facilities, warehouses, the laboratory and workshops.

However, offices, the laboratory, workshops and warehouses shall be provided with fixed hose reel stations on each floor as required by the fire code.

4.6.11 First Response Fire Fighting Appliances

First response fire-fighting appliances are intended for controlling initial phases of all fires and for extinguishing small fires. Two types of extinguishers shall be used namely, dry chemical and CO_2 extinguishers. These are the most commonly found first aid fire extinguishing apparatus in use. The CO2 extinguishers are basically pressurized cylinders of CO_2 gas with suitable control valves and discharge nozzles. A dry chemical extinguisher consists of a container of dry powder, usually sodium bicarbonate with a flow fluidizing agent, a separate pressurizing gas cylinder, a suitable control valve and a discharge nozzle.

The carbon dioxide extinguishers to be used shall be fitted with discharge cones, flexible hose and trigger permitting one-person operation. The dry chemical extinguishers to be used shall also have discharge cone or nozzle, non-caking chemical charge, and carbon dioxide pressurizing cartridge. The cartridge shall be replaceable independently of powder charge.

4.6.12 Fire and Smoke Stopping System

A fire and smoke stopping system shall be provided for all the openings through which cables go. This shall include conduit ends, openings in walls, floors or ceilings, cable risers, under all electrical

enclosures and switchboards and any other areas which shall prevent the fire from spreading. The system shall be applied at 3m intervals to prevent the chimney from affecting the vertical cable systems (i.e. cable risers).

4.6.13 Miscellaneous Equipment

Miscellaneous equipment consisting of fire axes, shovels, heat resistant clothing, sand, buckets, etc. shall be identified and provided. A list shall be prepared identifying the quantity and their location.

4.6.14 Fire Station

A fire station will not be provided. However, space shall be reserved for a fire station, should it be decided to construct one in the future. The future fire station shall be of sufficient size to permit parking of all vehicles provided specifically for fire-fighting. In addition, space shall be provided in the station for storage of miscellaneous items such as hoses, axes, foam liquid, fittings for fire hydrants, etc.

4.6.15 Fire and Gas Detection, Control and Alarm Facilities

Fire and gas detection, control and alarm facilities shall be provided to cover the entire plant. Gas detection, control and alarm facilities shall cover areas where the gas pipelines, arrival facilities, scrubbers and generators are installed. The type of gas detectors to be used shall be suitable for the local conditions.

4.6.16 Emergency Shutdown

In the event of a plant fire or an emergency a controlled shutdown will be initiated. Such systems will be defined, engineered and implemented to safeguard the plant. An Emergency Response Plan (ERP) will be prepared as part of the project ESMP. The ERP will cover all potential emergency situations including fire and explosion and will incorporate the systems described here, according to the IFC's PSs and the WBG EHS guidelines.

4.7 Instrumentation and Control

The operations philosophy for the OMA power plant project is to:

- use minimum land resources for production facilities and activities;
- be self-sufficient in production operation and frontline maintenance capability;
- monitor the inflow of the sources of power generation (fuel gas and fuel oil) at the pipeline entry points and consequently control the product quality requirements to meet regulatory standards and project objectives; and
- Assure asset integrity.

All instrument control and protection panels with measuring equipment, relays, control switches, automatic controllers, etc. will be supplied and installed necessarily for proper operation and monitoring of the GTG units, HRSGs, Steam Turbine Generators (STG), switchyard equipment and their associated facilities. The control system will be micro-processor-based.

4.7.1 GTGs Control Requirements

The GTGs will be furnished with a control system (Mark VIe), including complete monitoring, control and protection requirements for GTG sets.

4.7.2 Control Mode – Plant Control System

The Plant Control System will be capable of providing control of the whole power plant, individual drives, of sequencing a functional group of drives to an optimized program of plant operation, and of sequencing functional groups to provide full automatic plant operation.

The Plant Control System will be interfaced with the substation SCADA system (SCADA system supplied by others).

The Plant Control System will incorporate functions for use by the operating, engineering and management staff including, but not limited to, data historian, event and alarm handling, engineering and diagnostic tools, software configuration tools, plant condition monitoring and performance monitoring.

Main items of plant such as the gas turbine, fuel systems, water treatment plant, compressed air system, black start facility etc. may be supplied with purpose-designed systems for control, monitoring and protection. Such systems will be designed to function independently of each other but shall be interfaced with the Plant Control System to allow integrated operation of the total plant. The Plant Control System will be fully integrated with the control, instrumentation and alarm equipment of the plant being provided, in order to maximise automation of the power plant and minimise operator manning levels.

4.8 Personnel Requirements

For Phase 3, there is likely to be a full time staff component of anywhere between 40 and 70 staff, depending upon the level of plant automation in the design for the latter project phases. Numbers will be confirmed at that time.

For Phase 1, it is anticipated to employ a total of 24 staff for the routine operations and maintenance (technical and administration) and 14 more at the major maintenance period of the proposed power plant; however, the figure is subject to review pending final design requirements. The staff distribution for the different activities of the power plant is listed below.

In addition there will be financial and management staff located in Abuja.

4.8.1 Operations

It is envisaged that five (5) shifts will be required to operate the power station. Three shifts will be on duty for eight (8) per day and seven (7) days per week. A shift will involve:

- GTGs/STG control room operators 10
- Administration and maintenance personnel 14

Thus, a total of 24 persons are envisaged for routine operations and maintenance of the power plant.

4.8.2 Maintenance Team

As above, however for major maintenance designated teams will be utilized at that time.

It is envisaged that these teams will consist of an additional 14 persons of varying disciplines utilized during the major maintenance shut down.

4.9 Maintenance and Inspection Philosophy

The maintenance and inspection philosophy for the proposed power plant facility shall be geared towards assessing and assuring the technical integrity of the GTGs/HRSG/STG and other installed devices with a view to achieving high availability at best value for money. This means achieving minimal power production deferment and reducing to as low as reasonably practicable the risk of GTG or other equipment failure.

4.10 Safety and Emergency Response Procedures

In case of an emergency during the life span of the project, the OMA Site Emergency Response Procedure further detailed in the Site HSE Plan would be triggered. Its objectives are among others to ensure:

- that the environment is protected;
- that manpower, equipment and funds are available to effectively contain and clean up oil/chemical spills;
- that good record keeping is maintained and accurate information concerning emergencies are disseminated to the workers, members of the public and government; and
- No loss of life.

The procedures cover the following issues:

- problem search;
- isolation of causes;
- notification of authorities;
- safety and environment issues;
- repair methods and procedures;
- emergency repair material;
- contractor arrangements; and
- Re-commissioning and start-up.

4.11 Abandonment and Decommissioning Activities

The design of the facilities shall take due recognition to decommissioning programme at the end of its operational life. When the facility reaches the end of its safe operating life or alternatively when the economic life is reached, it will be decommissioned. The abandonment plan shall take due note of the prevalent national and international legislative requirements as well as OMA HSE guidelines and standards for facility abandonment.

At the end of the Project's useful life, OPGCL will offer the facility for sale. If the facility is not purchased by someone else to operate, OPGCL will sell useful equipment for reuse elsewhere. OPGCL will sell useful buildings for reuse as appropriate under the terms of its land lease. All funds derived from these sales will be used to restore the site.

OPGCL will demonstrate with independent testing that it has not been responsible for contamination of the site with hazardous waste or spills during the expected 20 years (with 5 years optional extension) life-cycle of the proposed power plant, OPGCL shall develop a detailed decommissioning / abandonment plan for approval by FMEnv, before implementation.

Firstly, OPGCL shall consider the need for facilities decommissioning, then notify FMEnv. Secondly, a team shall be set up to study and plan the decommissioning / abandonment programme in a manner that meets standard requirements.

5. Physical Environmental Baseline[4]

5.1 General

The environmental baseline of the proposed project and its surroundings has been established for each environmental aspect under consideration. This has been achieved largely through consultations with relevant stakeholders, a desktop review of available data and site walkovers.

Section 5.2 describes the multi-disciplinary data acquisition method, followed by the detailed findings of each discipline in Sections 5.3 – 5.10 as follows:

- 5.3: Climate and Meteorology;
- 5.4: Air Quality;
- 5.5: Noise;
- 5.6: Geology, Hydrogeology and Hydrology;
- 5.7: Groundwater Chemistry;
- 5.8: Soils;
- 5.9: Ecology ; and
- 5.10: Wastes and hazardous materials.

5.2 Baseline Data Acquisition Method

A multi-disciplinary approach was employed in the acquisition of baseline data of the proposed project area. The environmental baseline data for the proposed OMA power plant project was obtained through desktop research from similar FMEnv approved projects such as GP's IPP scheme for Aba Industrial zone; two season field work/sampling and measurements as well as laboratory analyses of biological, chemical and physical characteristics of sampled environmental components.

5.2.1 Desktop Research

This method involved a detailed search of relevant textbooks, research publications, articles, and reports on previous environmental surveys of proximal environment. The demographic pattern and wildlife characteristics were also complemented from information acquired from literatures, questionnaires, focus group discussion and interviews. The data gathered included; maps, demographic, air/noise, meteorological and soil characteristic of the survey area among others.

[4] The language in this section contains original BGI text which has not been authored directly by Jacobs.

5.2.2 Field Observation, Sampling and Measurement

A soil, groundwater and vegetative sample collection and analysis program, including air quality and noise assessment survey, was conducted to document baseline conditions in and around the proposed Project site. The spatial boundary for the study area is shown in Figure 5-1. These activities occurred from 12th to 15th February (dry season sampling) and 3rd to 5th October (wet season sampling), 2013. Samples were collected, observed and documented in fieldwork notebooks with still photographs attached (where necessary). Numbers of samples collected from each environmental component are as follows:

- Soil Sampling 20
- Water Sampling 4
- Ground water 4
- Air Quality/Noise 10
- Vegetation 7 transects

In addition to the above surveys, a test water supply borehole was drilled and constructed at the site, and test pumping exercise was undertaken in November/December 2014.

An inter-disciplinary approach involving data acquisition on climate, air quality, noise, soil, ground water and vegetation was adopted for the field survey. The field sampling exercise was conducted in compliance with the FMEnv standard procedures and practices for environmental data acquisition. The collection and analysis of samples were in line with the applicable standards and procedures, namely the American Society for Testing and Material (ASTM). Details of the analytical procedures are presented in Appendix II. The analysis of samples was carried out in BGI laboratory.

Detailed methodologies for data acquisition for each environmental component listed above are presented in Appendix II.

5.2.3 Geo - Positioning

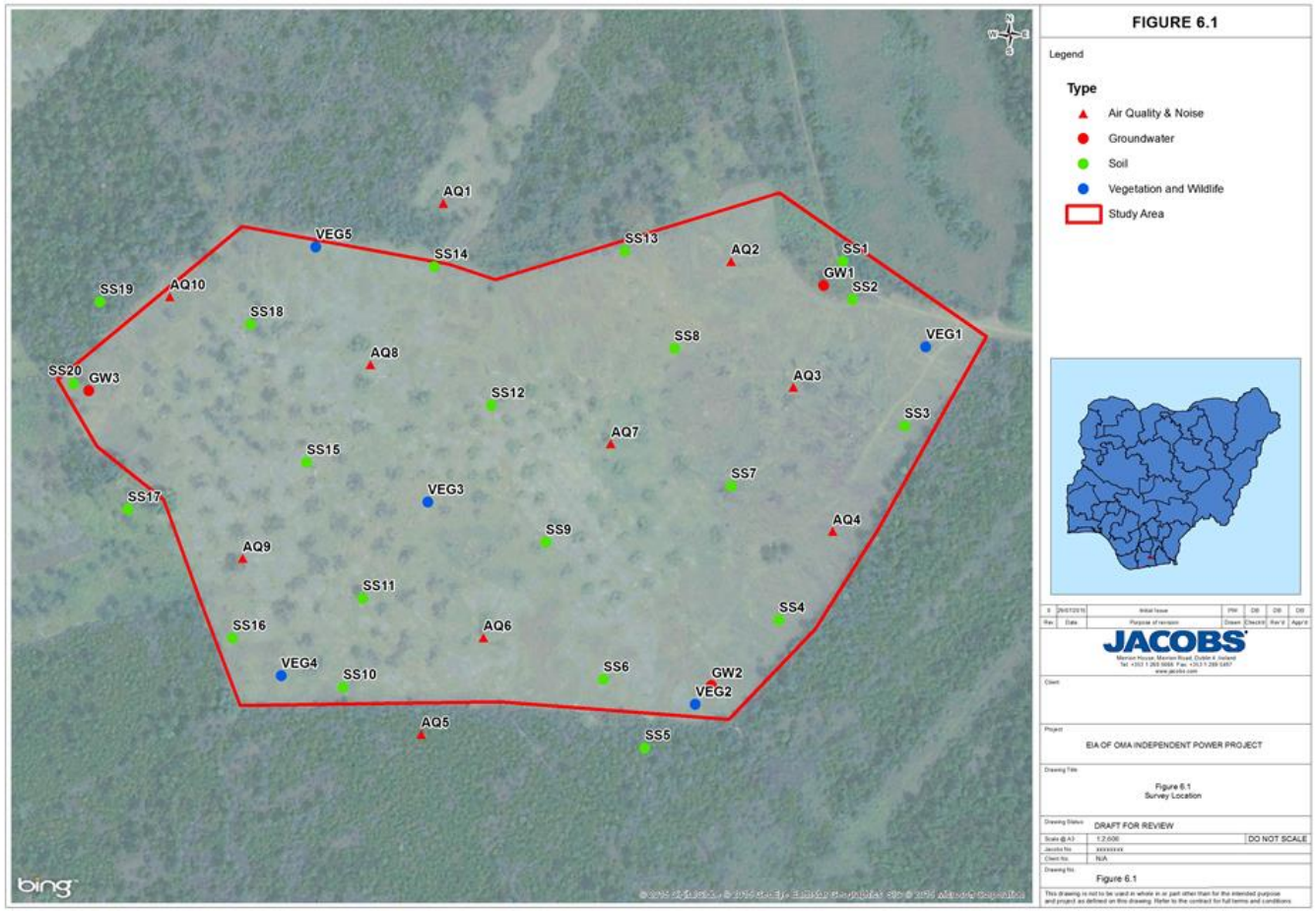
A hand-held Garmin Etrex Vista Global Positioning System (GPS) was used to collect coordinates of sampling locations during fieldwork activities. At each location, coordinates were collected and recorded into a field note book and was used to produce a sampling map showing the spatial boundary of the survey area. The coordinates are as presented in Table 5-1, and illustrated on Figure 5-1.

Table 5-1: Sampling Points and Geographical Coordinates

Locations	Sampling Type	Geographical Coordinates	
		Northing	Easting
SS1	Soil	4˚59′ 30".116	7˚17′03".958
SS 2	Soil	4˚59′ 29".056	7˚17′04".200
SS 3	Soil	4˚59′ 25".675	7˚17′05".534
SS 4	Soil	4˚59′ 20".613	7˚17′02".150
SS 5(control)	Soil	4˚59′ 17".329	7˚16′58".566
SS 6	Soil	4˚59′ 19".170	7˚16′57".514
SS 7	Soil	4˚59′ 24".220	7˚17′00".929

Locations	Sampling Type	Geographical Coordinates	
		Northing	Easting
SS 8	Soil	4˚59′ 27".905	7˚16′59".493
SS 9	Soil	4˚59′ 22".855	7˚16′56".078
SS 10	Soil	4˚59′ 19".169	7˚16′50".699
SS 11	Soil	4˚59′ 21".491	7˚16′51".227
SS 12	Soil	4˚59′ 26".541	7˚16′54".642
SS 13	Soil	4˚59′ 30".535	7˚16′58".222
SS 14	Soil	4˚59′ 30".227	7˚16′53".206
SS 15	Soil	4˚59′ 25".177	7˚16′49".791
SS 16	Soil	4˚59′ 20".561	7˚16′47".810
SS 17 (control)	Soil	4˚59′ 24".056	7˚16′45".104
SS 18	Soil	4˚59′ 28".862	7˚16′48".355
SS 19 (control)	Soil	4˚59′ 29".608	7˚16′44".432
SS 20	Soil	4˚59′ 27".412	7˚16′43".737
AQ 1(control)	Air Quality & Noise	4˚59′ 31".906	7˚16′53".430
AQ 2	Air Quality & Noise	4˚59′ 30".127	7˚17′01".031
AQ 3	Air Quality & Noise	4˚59′ 26".735	7˚17′02".649
AQ 4	Air Quality & Noise	4˚59′ 22".949	7˚17′03".610
AQ 5 (control)	Air Quality & Noise	4˚59′ 17".885	7˚16′52".818
AQ 6	Air Quality & Noise	4˚59′ 20".349	7˚16′54".387
AQ 7	Air Quality & Noise	4˚59′ 25".390	7˚16′57".823
AQ 8	Air Quality & Noise	4˚59′ 27".604	7˚16′51".504
AQ 9	Air Quality & Noise	4˚59′ 22".648	7˚16′48".103
AQ 10	Air Quality & Noise	4˚59′ 29".627	7˚16′46".282
VG 1	Vegetation & Wildlife	4˚59′ 27".762	7˚17′06".123
VG 2	Vegetation & Wildlife	4˚59′ 18".466	7˚16′59".940
VG 3	Vegetation & Wildlife	4˚59′ 24".016	7˚16′52".935
VG 4	Vegetation & Wildlife	4˚59′ 19".532	7˚16′49".055
VG 5	Vegetation & Wildlife	4˚59′ 30".908	7˚16′50".123
GW 1	Groundwater	4˚59′ 29".476	7˚17′03".457
GW 2	Groundwater	4˚59′ 18".932	7˚17′00".373
GW 3	Groundwater	4˚59′ 27".208	7˚16′44".113

Figure 5-1: Environmental Monitoring Locations.



5.3 Climate and Meteorology

Meteorological information from the Nigeria Meteorological Agency established synoptic station in Port Harcourt, which is the nearest meteorological station, approximately 45km southwest of the project area (there is presently no existing meteorological station in Aba, Abia State) and reported literature were used in describing the climatic condition of the project area. These were supported by data acquired from selected locations during the fieldwork.

The climate of the survey area like the entire Niger Delta area is closely tied to the general mesoscale trend in Nigeria. It follows that the weather experienced at any given location in Nigeria during the year is determined primarily by the geographical location and governed by the circumstances around the Inter-Tropical Convergence Zone (ITCZ). In this regard the prevalent weather condition in the survey area is warm and humid, typical of the humid tropical zone.

Two prevalent climatic regimes (dry and wet seasons) exist in the survey area, as illustrated in Figure 5-2. The two climatic regimes are dependent on the two prevailing air masses blowing over the country at different times of the year: the northeasterly air mass of Saharan origin that dominates the dry season, and the humid maritime air mass blowing from the Atlantic, dominating the rainy season.

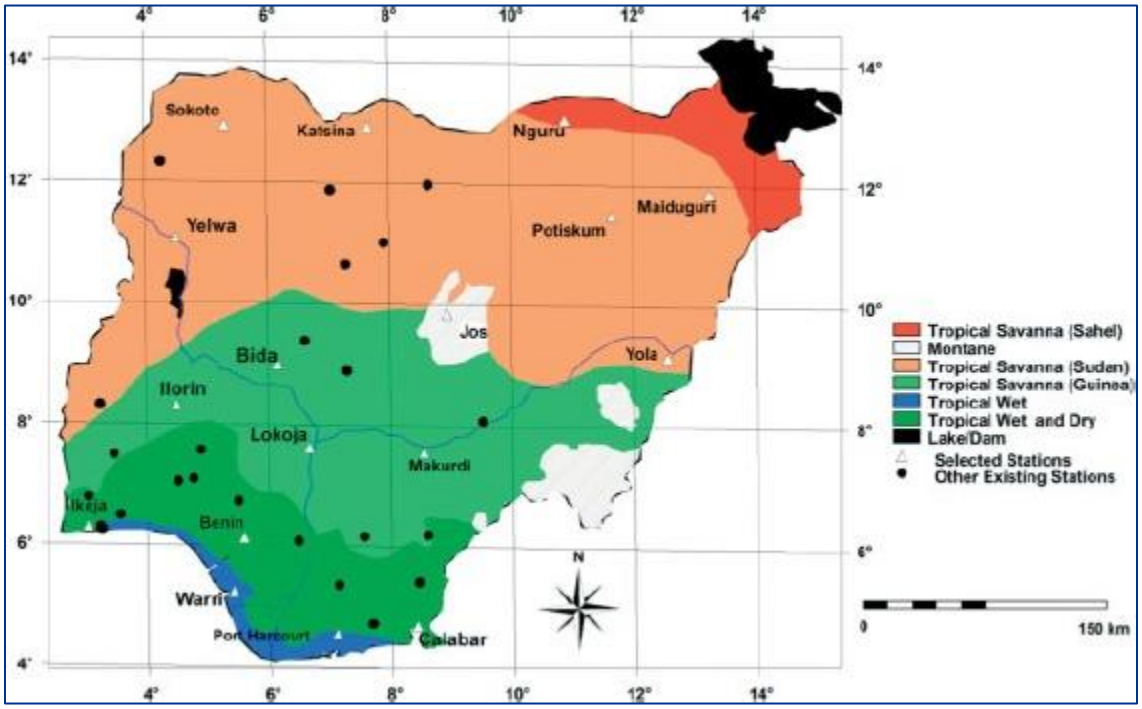
In the survey area, the dry season commences around November and extends to March, while the rainy season stretches through April to October. A short dry spell is experienced about the third or fourth week in August, commonly called August break in the area. September and October is the peak of flooding events in the area. The main characteristics of the climate and the meteorology of the survey area are presented in Table 5-2 and following figures, and are described below.

Table 5-2: Mean Monthly Weather Data for Port Harcourt (1998 - 2006 except rainfall data 1979 – 2009)

Months	Minimum Temp.(^{O}C)	Maximum Temp. (^{O}C)	Minimum Relative Humidity (%)	Maximum Relative Humidity (%)	Rainfall (mm)*	Wind Speed (m/sec)
January	21.9	32.3	43	94	26	0.83
February	23.0	33.4	46	94	53	1.02
March	23.8	32.9	55	95	109	1.06
April	23.7	32.3	60	95	157	1.00
May	23.4	31.4	61	94	256	1.00
June	22.9	30.1	65	95	300	0.93
July	22.7	28.8	70	95	374	0.98
August	22.7	28.6	71	95	306	1.10
September	22.2	28.2	68	93	362	0.97
October	22.8	30.2	64	94	246	0.88
November	23.1	30.9	59	94	88	0.76
December	22.2	32.2	51	94	22	0.77

Source: Nigeria Meteorological Agency (NIMET)

Figure 5-2: Basic Map of Nigerian Climates.



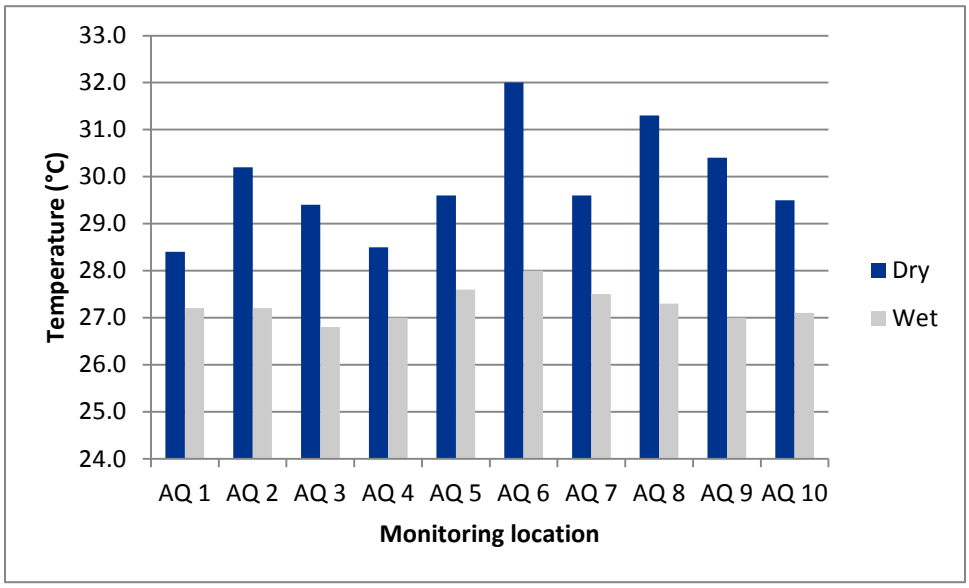
Source; "Air temperature, relative humidity, climate regionalization and thermal comfort of Nigeria" Int. J. Climatol.(2013)

5.3.1 Air Temperature

Temperature is an important weather variable because it determines the movement of water vapour, which brings precipitation. Temperature measurements are also used in calculations of plume rise during air quality analysis and can be used in determining atmospheric stability.

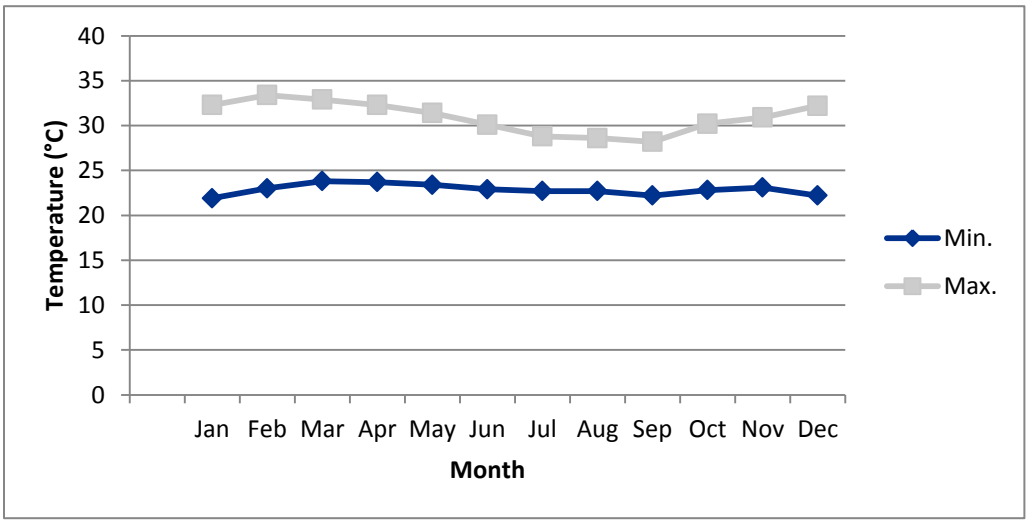
Mean daily temperature values were taken during the fieldwork at ten monitoring points across the project area. The mean daily temperature averaged across the sampled locations was 29.9°C during the dry season, and 27.3°C during the wet season (Tables 1a and 1b of Appendix III, Figure 5-3).

Figure 5-3 : Temperature during the wet and dry seasons at locations across the study area



Long-term mean air temperature data (1998 - 2006) show that the average monthly maximum temperature ranged from 28.2°C – 28.8°C (July/August/September) to 33.4°C (February) with a mean value of 30.9°C, while the average minimum temperature ranged from 21.9°C (January) to 23.7°C (April) with a mean value of 22.9°C for the period under review (Table 5-2 and Figure 5-4). The temperature of the region is indicative of a subtropical climate.

Figure 5-4: Average monthly maximum and minimum temperature at Port Harcourt (1998 - 2006)



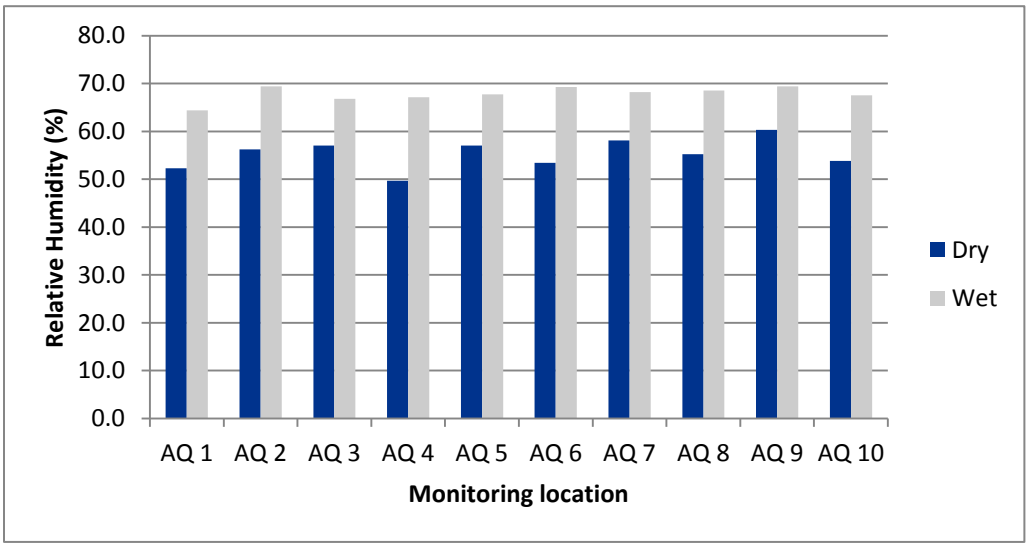
5.3.2 Relative Humidity

Relative humidity is a measure of how saturated the air is with water vapour at a given temperature, expressed as a percentage. It provides the moisture condition that may enhance the chemical reaction

and stability of airborne substance as well as the crystal growth of principal emissions, such as suspended particulate matter.

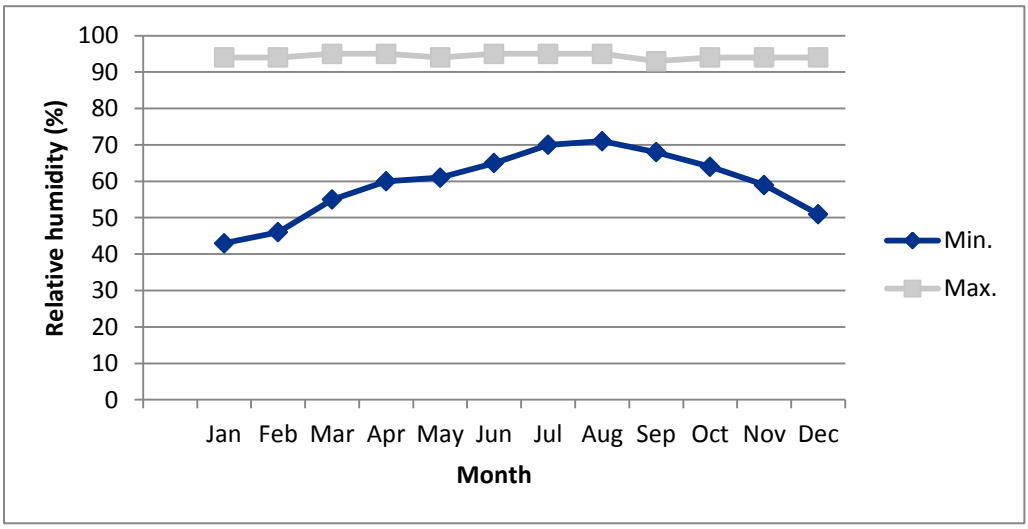
The relative humidity recorded lower values in dry season than in wet season, with values for the dry season being in the range of 49.7 to 60.3% with a mean of 55.3% while wet season values ranged from 64.4 to 69.4 % with a mean of 67.8%, as shown on Figure 5-5.

Figure 5-5 : Relative humidity during the wet and dry seasons at locations across the study area



Humidity values oscillate in tandem with air temperature, but as opposite fluxes. Analysing the long-term average monthly values for Port Harcourt within the periods under review (1998 – 2006) shows maximum values for relative humidity across the months ranging from 93% - 95% (Table 5-2 above), with minimum values highest during the months of rainy season and lowest during the months of dry season (Figure 5-6). When relative humidity rises above some critical point, suspended particles of soluble substances which were initially “dry” becomes “wet” i.e. the particles go into solution and this soluble particles comes down as wet deposition during rainy season.

Figure 5-6 : Average monthly maximum and minimum relative humidity at Port Harcourt (1998 - 2006)



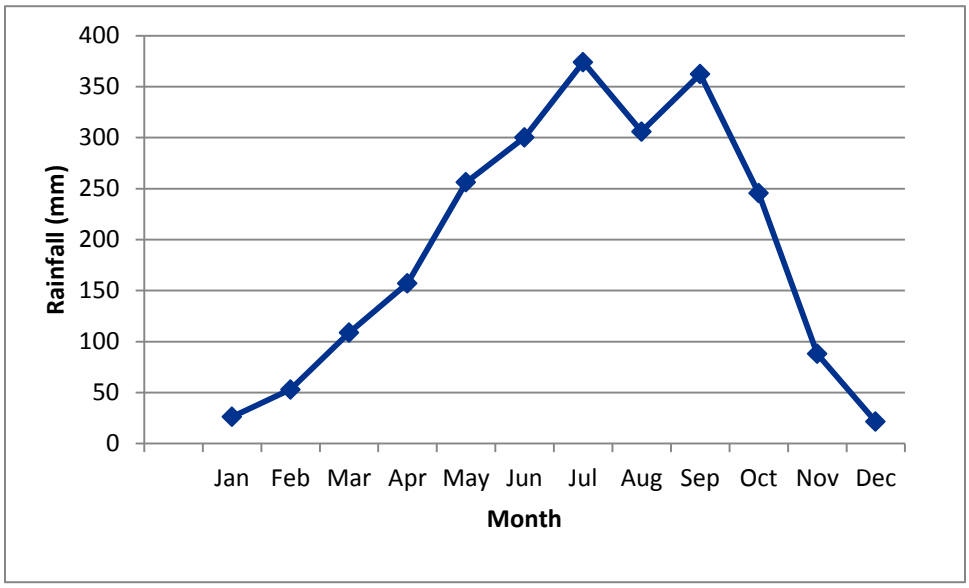
5.3.3 Rainfall

The hydrological cycle depends fundamentally on the inter-relationship between the circulation of the ocean and the atmosphere. Water is withdrawn from the oceans into the atmosphere by the process of evaporation which is dependent on factors such as air / sea temperatures, wind strength and humidity (Oguntoyinbo and Hayward, 1987).

Rainfall is very important in environmental and air pollution studies because of its ability to cause wet deposition (i.e. washing away pollutants from the atmosphere onto land and water). Rainfall can also dissolve acidic pollutants in the air forming acid rain, which could be harmful to humans, plants, animals and the environment in general.

The information gathered from Port Harcourt over a period of 30 years (1979–2009; Table 5-2 above and Figure 5-7, below) showed that rainfall in the area is highly seasonal, two distinct regimes – wet and dry seasons. The wet season exhibits heavy rains with the highest occurring in July (370mm) and much less between December and February (22mm). The mean annual rainfall in the area is approximately 2,300mm.

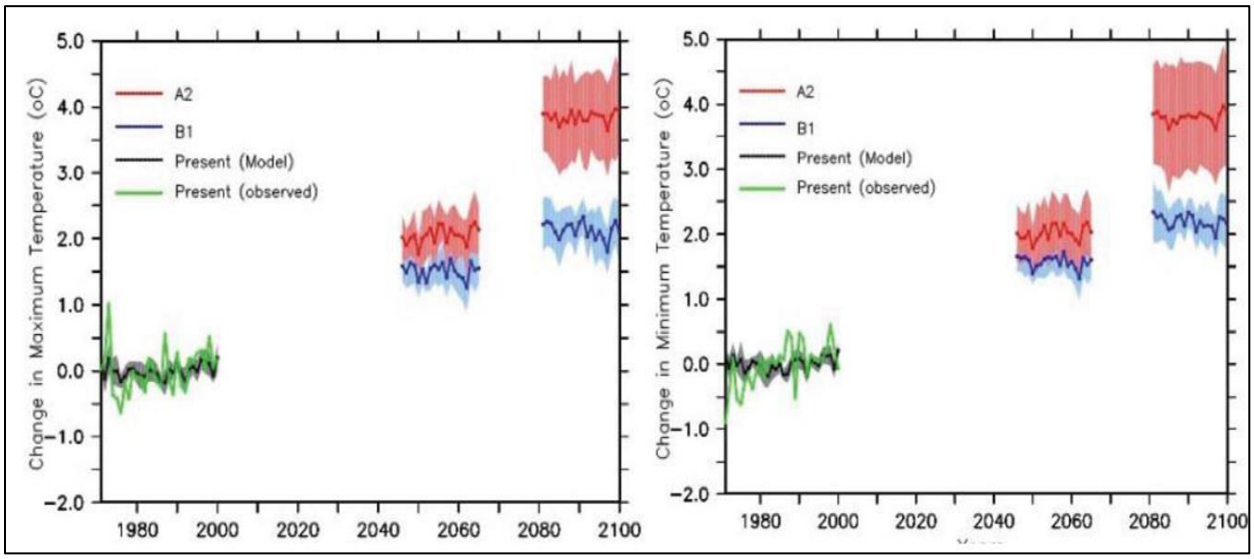
Figure 5-7 : Average monthly rainfall at Port Harcourt (1979 - 2009)



5.3.4 Climate Change Predictions

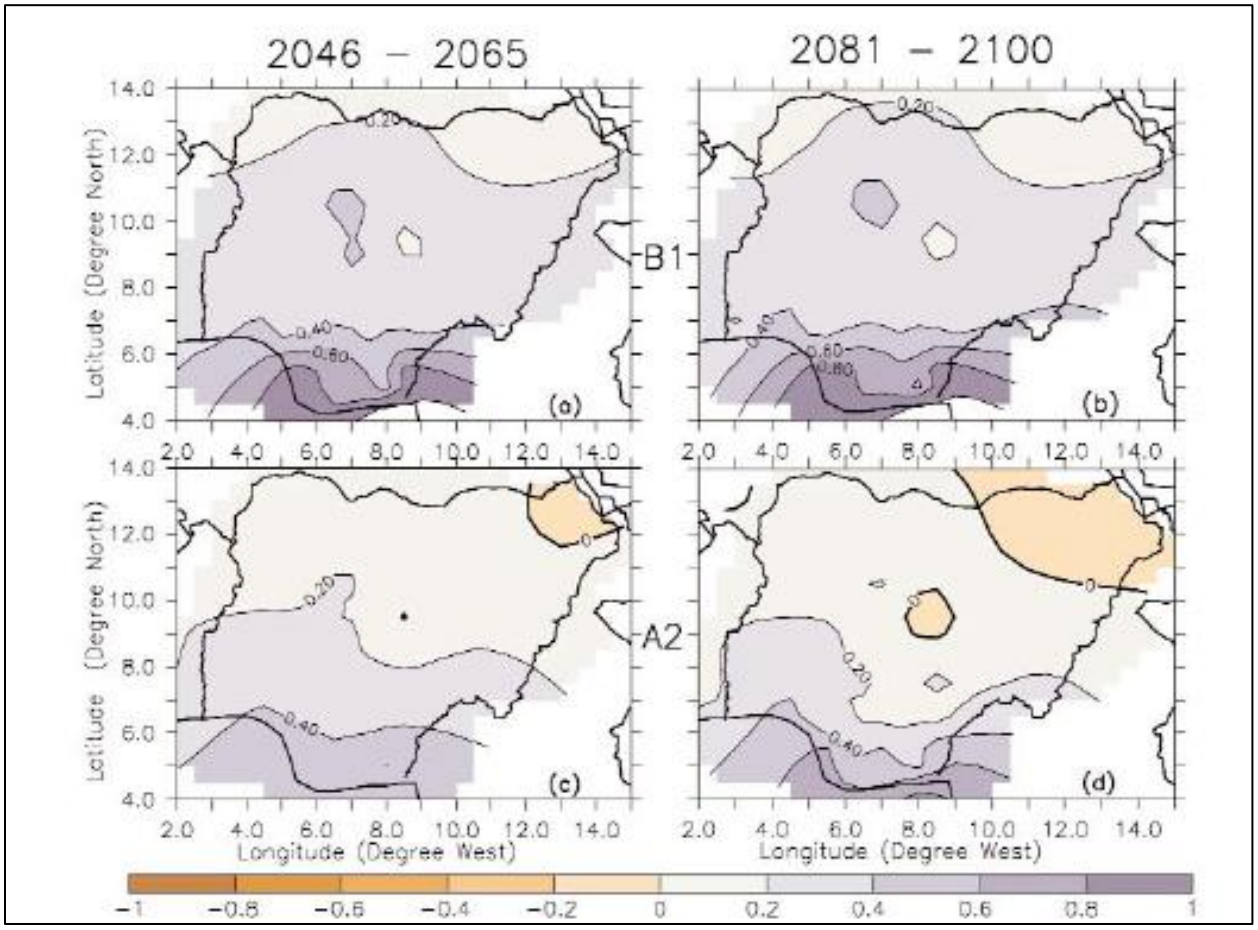
Information on climate change predictions for Nigeria was obtained from the UNFCCC 2nd National Communication submitted by Nigeria dated February 2014. The report indicates that temperatures in Nigeria have been on the increase in the last five decades particularly since the 1980s. After the last major drought in 1983, standardised temperature anomaly over Nigeria has been positive every year, with the exception of 1989 and 1992. The time series of projected minimum and maximum temperature changes during the periods of 2046-2065 and 2081-2100 show an increasing temperature and therefore a warmer climate under both the standard B1 and A2 scenarios (Figure 5-8).

Figure 5-8 : Time series of changes in maximum and minimum temperatures for present-day and future climate in Nigeria under B1 and A2 scenarios. The dashed lines show station observation; the full lines represent the model's mean, while the shaded regions are areas of a standard deviation away from the mean (UNFCCC 2014, from Abiodum et al., 2011)



Projected changes in rainfall patterns show a wetter climate over almost the entire country under both B1 and A2 scenarios, with the highest increase in the coastal region and the smallest increase in the northeast region (Figure 5-9). The A2 model, however, predicts a drier climate by the end of the century for the northeast of the country, and for the central Jos Plateau. The rainfall pattern shows no significant change between the middle and end of the century.

Figure 5-9 : Projected changes in rainfall over Nigeria in future (2046-2065 and 2081-2100) for B1 and A2 scenarios (UNFCCC 2014, from Abiodum et al., 2011)



Climate change must be considered in the project design, particularly in terms of the drainage system, in order that it will be able to cope with the potentially increasing duration and/or intensity of rainfall events. The project description acknowledges that the design capacity of the drainage system will include an additional factor to account for climate change-related increase in flows. Actions to address the potential impacts of a changing climate are included in the ESMP.

5.3.5 Winds

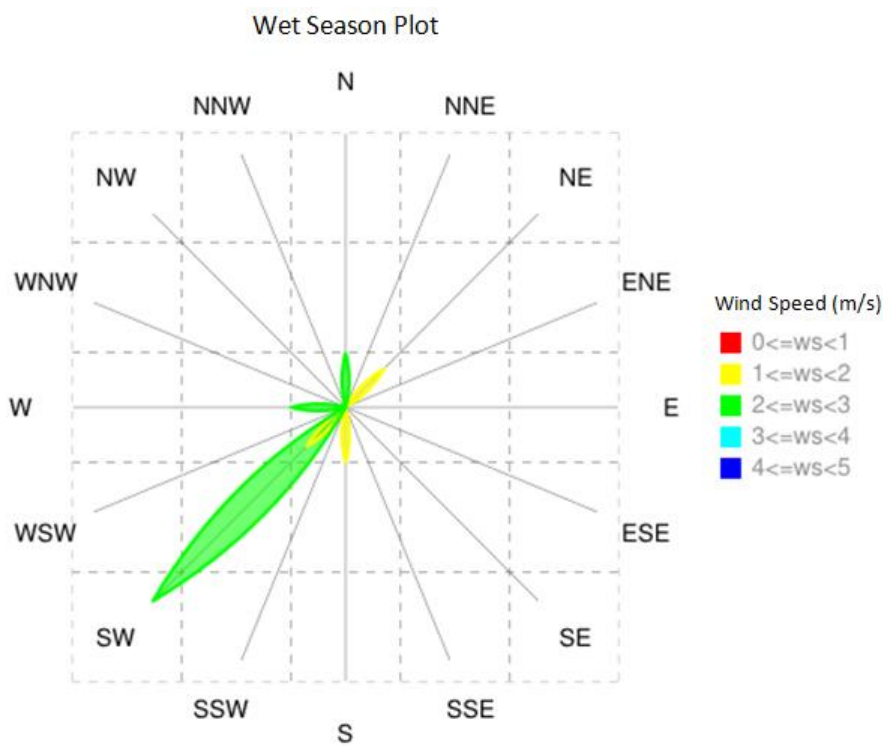
The climatic conditions of the area are characterised by two wind systems: the south-westerly monsoon (SW) and the north-easterly (NE). The former (SW) is due to the influence of the Atlantic Ocean air mass and is moist while the latter (NE) comes from the Sahara desert which is dry and cold (harmattan).

Results from field measurements showed that wind speed within the project area ranged from 2.4m/s to 3.5 m/s during the dry season and varied between 1.6 m/s and 2.4 m/s during the wet season (Figure 5-10 to Figure 5-13). Calm weather was observed within the study area during the period of field measurement. Calm conditions create a stable atmosphere and these periods are very important to air pollution studies because it is often associated with inversion.

Inversion refers to very stable atmosphere with vertical temperature gradient rising. This vertical temperature gradient traps pollutants at ground level with possible adverse effects on health. Wind direction was observed to be north-easterly during the dry season and south-westerly during the rainy season.

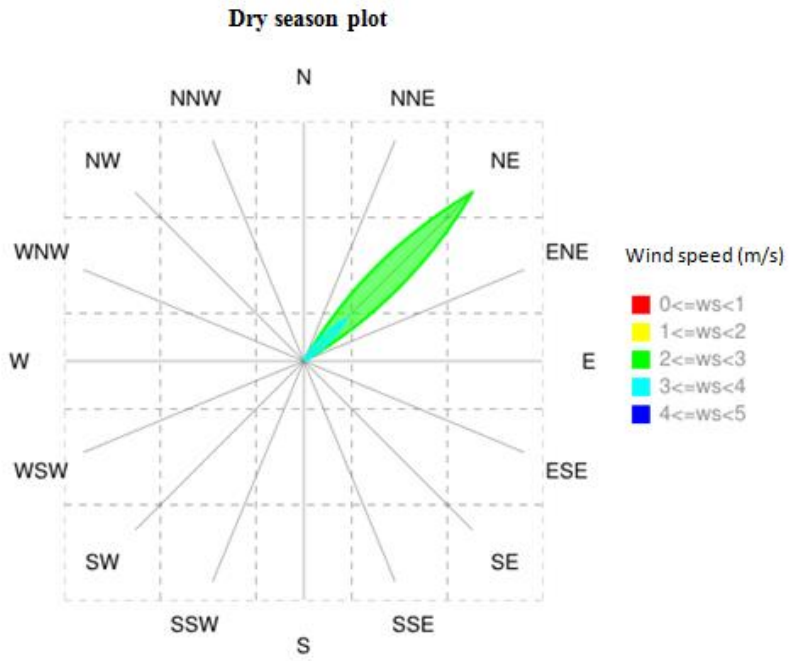
Wind speed/direction is very important in meteorological studies because it determines how far pollutants are being carried to and in what direction. The seasonal variations in the meteorological parameters are consistent with that reported in literature (Gobo, 1998).

Figure 5-10: Wind pattern of the area during the wet season fieldwork



Software: Environware (www.enviroware.com)

Figure 5-11: Wind pattern of the area during dry season fieldwork



Software: Environware (www.enviroware.com)

Figure 5-12: Diurnal wind class distribution at study area during the wet season

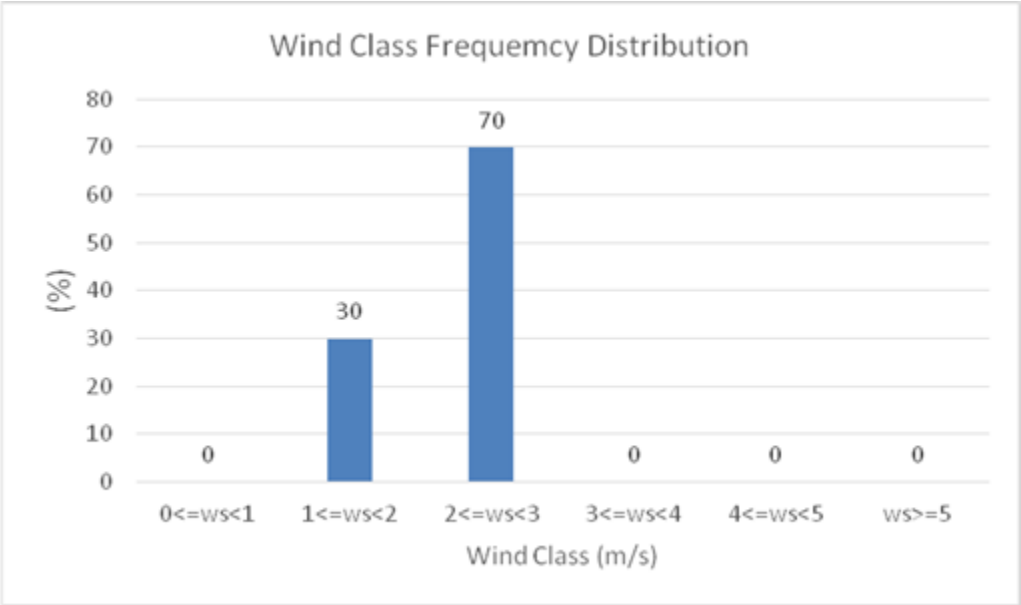
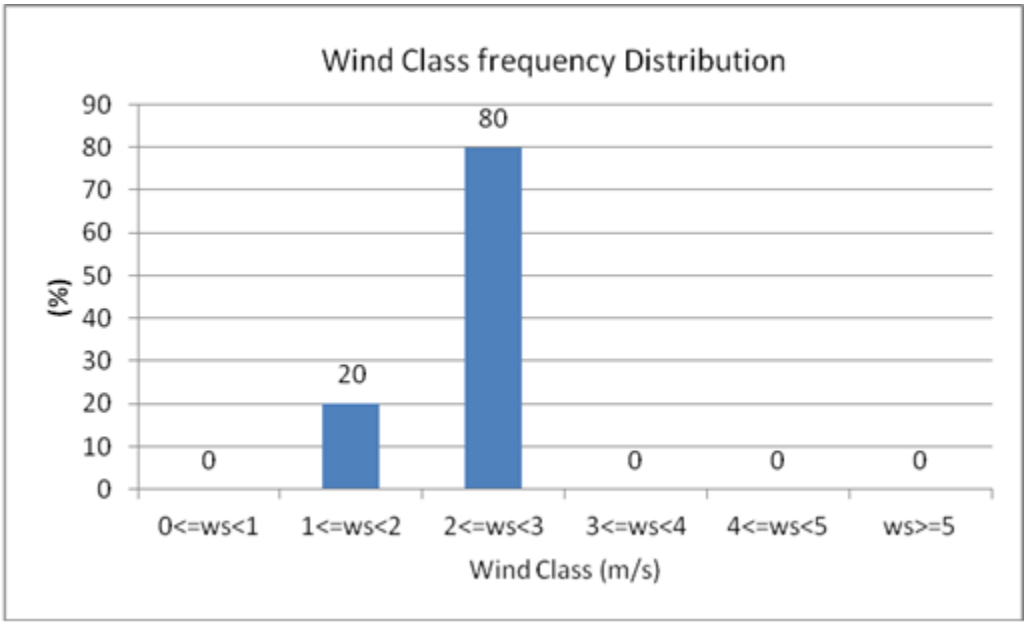


Figure 5-13: Diurnal wind class distribution at study area during the dry season



5.3.6 Atmospheric Pressure

An important characteristic of the atmosphere is its pressure as it often determines wind and weather pattern across an area. This is the force exerted on the earth surface by the weight of air molecules. The normal range of the earth's air pressure is from 970mbar to 1050mbar. These differences are the results of low and high air pressure systems which are caused by unequal heating across surfaces. Low pressure areas are usually associated with high winds, warm air and atmospheric lifting. Because of this, lows normally produces clouds, precipitation and other bad weather such as tropical storms and cyclones. Unlike areas of low pressure, the absence of clouds means that areas prone to high pressure experience extremes in diurnal and seasonal temperatures since there are no clouds to block incoming solar radiation or trap outgoing long wave radiation.

Atmospheric pressure at sea level measured during the dry season ranged from 1006 to 1013 mbar while ranging from 1007 to 1012 mbar during the wet season.

5.4 Air Quality

When atmospheric pollutants are released into the air due to the activities of man there is a potential risk to human health in areas of heavy pollution. There is therefore a need to comply with regulatory standards to safeguard people against associated health hazards. The concentrations of ambient Air Quality parameters determined within the survey area are presented in Appendix III. Sampling points were selected within and along the proposed boundary of the project site. Compliance with local limits is considered in the air quality assessment, the detailed assessment of which is included in Appendix VII.

5.4.1 Suspended Particulate Matter

Suspended Particulate Matter is a composite group of substances (liquid or solids) dispersed in the atmosphere, which range in diameter from a fraction of a micron to several hundreds of microns. The particles (dust, smoke and other aerosols) may be of anthropogenic and/or natural origin. The most significant of these are the particles of <10µm in diameter, usually referred to as PM_{10}.

High concentrations of suspended particulate matter (SPM) are known to irritate the mucous membranes and may initiate a variety of respiratory diseases. Fine particulates may cause cancer and aggravate morbidity and mortality from respiratory dysfunctions (Huang *et al*., 2009).

SPM can also cause damage to materials by soiling clothing and textiles, corroding metals (at relative humidity above 75%), eroding building surfaces, and discolouring/destroying painted surfaces (Peavy, et al., 1985).

Particulate monitoring is important not only in respect of health but in causing reduced visibility and entering into atmospheric reactions (WHO, 1976), influencing radiation budget of the atmosphere as a result of scattering and absorption and indirectly by serving as condensation nuclei and by modifying the albedo of clouds and the processes that lead to precipitation (Chineke and Chiemeka 2009).

The ambient SPM level in the survey area ranged from 59.0 to 162.0µg/m^3 during the dry season (Appendix III, Table 1a) and from 9.1µg/m^3 to 20.2µg/m^3 during the wet season (Appendix III, Table 1b). The values of SPM were within the FMEnv limit of 250µg/m^3.

5.4.2 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless and poisonous gas produced by the incomplete combustion of fossil fuels such as gas, oil and coal. At present ambient levels, it has little if any effect on property, vegetation, or materials. However, it impairs the oxygen carrying capacity of the blood at higher concentrations, owing to its high affinity for haemoglobin, the component of the blood that transports of oxygen.

The carbon monoxide levels in the ambient air across the locations ranged from 2.1 ppm to 3.2 ppm for the dry season and 1.3ppm to 2.4ppm for the wet season.

5.4.3 Oxides of Sulphur

Sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are the two oxides of sulphur of most interest in the survey of air pollution. The SO_2 is often measured during environmental assessment because it is relatively more stable in the atmosphere than SO_3.

SO_2 is a colourless gas that is produced from volcanic, oceans, biological decay and forest fire releases. It can also be produced from the combustion of fossil fuel.

Sulphur dioxide is an irritant gas which affects the mucous membranes when inhaled. Under certain conditions, some of the air-borne sulphur dioxide gas is oxidized to sulphur trioxide. Each of these two gases, in the presence of water vapour, forms sulphurous and sulphuric acid respectively resulting in acid rain, which destroys building materials and work of arts (Rao & Rao, 2005). Sulphur trioxide is a very strong irritant gas, much stronger than sulphur dioxide, causing bronchospasms at relatively low level of concentration. The adverse health effects of sulphur dioxide are breathing/respiratory illness, alterations

in pulmonary defences and aggravation of existing cardiovascular diseases. According to Rao & Rao (2005) Sulphur dioxide also causes necrosis and interveinal chlorotic bleaching of plant leaves.

The concentration of SO_2 measured ranged from 0.01ppm to 0.03ppm during the dry season (Appendix III, Table 1a), and 0.01ppm to 0.04ppm during the wet season (Appendix III, Table 1b). The FMEnv regulatory limit of SO_x is 0.10ppm. No increase in SO_x is anticipated as a result of emissions from the power plant.

5.4.4 Oxides of Nitrogen

Nitrogen oxides are formed by many human or anthropogenic activities and are classified as pollutants because of their environmental and health effects. Nitrogen dioxide (NO_2) is reddish brown in concentrated form and gives a brownish yellow tint at lower concentration. Nitrogen oxides are hazardous to human health and the environment. According to Davis and Masten (2004), exposure to NO_x concentrations above 5ppm for 15 minutes results in cough and irritation of the respiratory tract. Continued exposure to this gas may produce an abnormal accumulation of fluid in the lung (a condition described as pulmonary oedema). Excessive levels of nitrogen oxides can decrease the strength of textiles, discolour fabrics, and corrode metal surfaces. Oxides of nitrogen also suppress plant growth and cause leaf bleaching; however, NO_x are converted to nitrates through nitric acid formation and are important for soil fertility in tropical areas. The levels of nitrogen oxides for the dry season ranged from 0.01ppm to 0.02ppm (Appendix III, Table 1a), and <0.01 ppm to 0.02ppm during the wet season (Appendix III, Table 1b). The FMEnv regulatory limit for NO_x is 0.06ppm.

5.4.5 Hydrogen sulphide (H_2S)

H_2S is a foul smelling gas. The sources of its natural emission into the atmosphere include anaerobic biological decay process on land, in marshes and in the oceans. Exposure to H_2S for short periods can result in fatigue of the sense of smell. The concentrations of hydrogen sulphide in the ambient air of the proposed project area for the wet and dry seasons were below 0.01ppm at all locations (Appendix III, Tables 1a and 1b). These values were within the FMEnv regulatory limit of 0.08ppm.

5.4.6 Ammonia (NH_3)

Ammonia is a very soluble gas which may have health repercussion on human health. Exposure to NH_3 concentration higher than 0.5ppm (1 mg/m^3) can trigger changes in pulmonary function in healthy people. The levels of NH_3 in the ambient air at the sampled points were below the detection limit (less than 0.01ppm) for both the dry and wet seasons (Appendix III, Tables 1a and 1b), and were therefore within the FMEnv regulatory limit of 0.01ppm

5.4.7 Volatile Organic Substances (VOCs)

These include methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and other derivatives of aliphatic and aromatic organic compounds which are emitted from both man-made and natural sources. Hydrocarbon vapour in the atmosphere arise from fugitive emissions, vents and incomplete combustion of fuels, particularly where fuel to air ratios are too high. Most members of this group are significantly toxic and exposure to high concentrations in the atmosphere (about 1000ppm or more) could result in interference with oxygen intake and acute leukaemia (SIEP, 1996). The concentrations of VOCs in the survey area ranged from 3.5ppm to 6.2ppm during the dry season and from 2.5ppm to 7.3ppm during the wet season (Appendix III, Tables 1a and 1b).

5.4.8 Heavy metals

The concentrations of the heavy metals cadmium, iron, zinc, copper, magnesium, manganese, sodium and nickel were below the 0.01ppm detection limit for both the dry and wet seasons (Appendix III, Tables 1a and 1b). As illustrated in Tables 1a and 1b in Appendix III, the average heavy metal concentration values were compared with the Nigerian Air Quality Standards from the Federal Ministry of Environment and WHO standards and were shown to be within acceptable limits.

The low concentrations of gaseous pollutants obtained in the project area during this survey may be due to the absence of industrial activities in the area that would generate such materials as well as the influence of rains which dilute and dissolve pollutants in the atmosphere.

5.5 Noise

Noise is commonly defined as unwanted sound or an aspect of sound which is not pleasurable. It is an environmental phenomenon to which humans are exposed to throughout life. Noise can also be considered as environmental pollutant, waste product generated in conjunction with various anthropogenic activities (Davis & Masten, 2004). Noise produces undesired physiological and psychological effect in an individual and also interferes with the social ends (such as work, rest, communication, sleep etc.) of an individual or group. According to Davis & Masten, (2004), noise has both auditory effects and psychological-sociological effects on people. Auditory effects include both hearing loss speech interference, while psychological-sociological effects include annoyance, sleep interference, effect on performance, and acoustical privacy.

The noise levels measured at all points ranged from 38.6dBA to 47.2dBA for the dry season and 35.6 dBA to 48.1 dBA for the wet season. All noise level measurements were within the FMEnv regulatory permissible noise level of 90dBA. Noise monitoring data was collected at the same locations as air quality on the site and site boundary (see Figure 5-1). No significant local noise producing sources were identified during the surveys and therefore these locations were considered representative of the local ambient noise conditions for the nearest noise receptors.

5.6 Geology, Hydrogeology and Hydrology

Ugwunagbo and Ukwa West L.G.As are located within modified (farmed) areas of the rainforest belt. The state of Abia is generally flat lying with an overall gentle slope towards the coast some 60km to the south.

5.6.1 Geology and Hydrogeology

The site is located in the Eastern Niger Delta sedimentary basin which formed during cycles of subsidence and deposition. Two principal geological formations underlie the site; the Bende-Ameki Formation and the Coastal Plain Sands, also known as the Benin Formation. The Benin Formation overlies the Bende-Ameki strata. It is approximately 200m thick with a dip towards the south west. The lithology of the Benin Formation comprises unconsolidated fine-medium, coarse grained, cross bedded sands with occasional bands of clay and shale.

The two Formations are able to sustain regional borehole abstractions, however the Bende-Ameki Formation will sustain lower yields as it is comprised of lenticular sand bodies which are not considered to be extensive. Permeability of the Benin Formation is greater and is capable of sustaining higher groundwater yields.

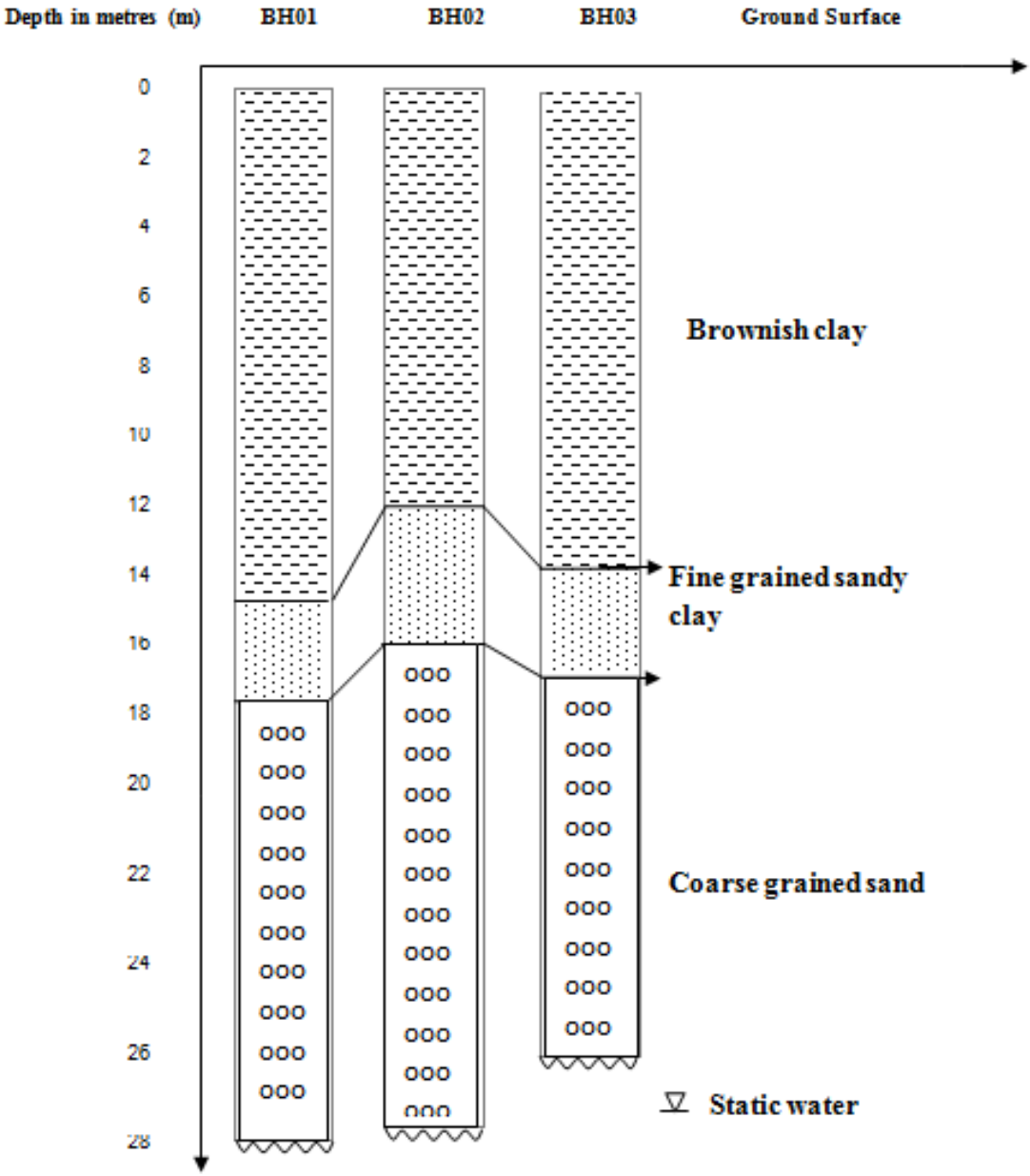
Within a regionally extensive, predominantly sand aquifer such as the Coastal Plains aquifer, with no significant local surface water features, regional groundwater flow is likely to be controlled by a combination of the prevailing topography and groundwater gradient to the nearest regional discharge sink (the rivers). Groundwater flow direction local to the site will also be influenced by localized variations in aquifer lithology, but is likely to broadly reflect the regional groundwater flow direction. It is anticipated that groundwater flow will contain a predominantly southerly component, and is likely to flow towards the southwest towards the closed regional surface water feature (the Imo River).

Two investigations have been undertaken to assess the geology and hydrogeology of the site. One investigation assessed the shallow soils and groundwater whereas the second predominantly targeted the deeper strata and the aquifer within the Benin Formation for the purposes of a test pumping exercise.

The stratigraphy of the shallow, subsurface soil in the study area was investigated using Percussion drilling technique to drill with a diameter size of 6 inches and a depth of 27m (90ft). These investigations confirmed the presence of the Benin (Coastal Plain Sands) aquifer beneath the site. The direction of flow for ground water was found to trend NE to SW.

The stratigraphy of the shallow boreholes and the units observed are displayed in a lithologic section to show stratigraphic features as shown in Figure 5-14. The lithologic units ranged from silty clay to coarse sand in a fining upward sequence. Three distinct lithologic units were observed in the three boreholes. In borehole 1, the clay unit had a thickness of about 15m, serving as a covering and reducing the vulnerability of the aquifer layer. The second lithologic unit consisted of fine to medium-grained sand with a thickness of about 1.0m while the third layer was observed to be composed of poorly graded medium-grained sandy clay with a thickness of about 10m, down to the aquifer layer. In borehole 2, the first layer consisted of silty clay with a thickness of about 12m. The second layer consisted of fine grained sand with a thickness of about 2m and the third layer had a thickness of 11m running through the aquifer layer.

Figure 5-14: Lithosections of Boreholes 1-3



In borehole 3, the first layer consisted of fine grained clay and a thickness of about 14m. The thickness of the second layer was found to be 2m and composed mainly of fine grained sandy clay. The third layer consists of poorly graded, coarse grained sand with a thickness of about 11m. The compositions of all the layers in the boreholes show broad a relationship in lithology sequence with shallow clays overlying fine sandy clay and coarse sand units. For the purpose of this ESIA it is considered that the aquifer within the Benin Formation is unconfined with recharge able to migrate directly to the water table. Travel times

within the unsaturated zone are likely to be relatively quick with low potential for attenuation of contaminants. The aquifer is therefore considered to be vulnerable to contamination from the surface.

The second investigation comprised geophysical surveys (both surface and downhole), construction of a deep (circa 60m) borehole and pumping tests. The geophysical surveys and borehole records provide a good correlation of the lithology present beneath the site; a summary of the strata identified is summarised in Table 5-3.

Table 5-3: Summary of Lithology observed in deep (60m) Boreholes

Depth to base of unit (m)	Lithology
12.0	Clay with sand
15.0 /16.0	Sand and clay
60.0	Sand, fine medium and coarse grained, brown to light brown becoming white in colour from 40.0 m

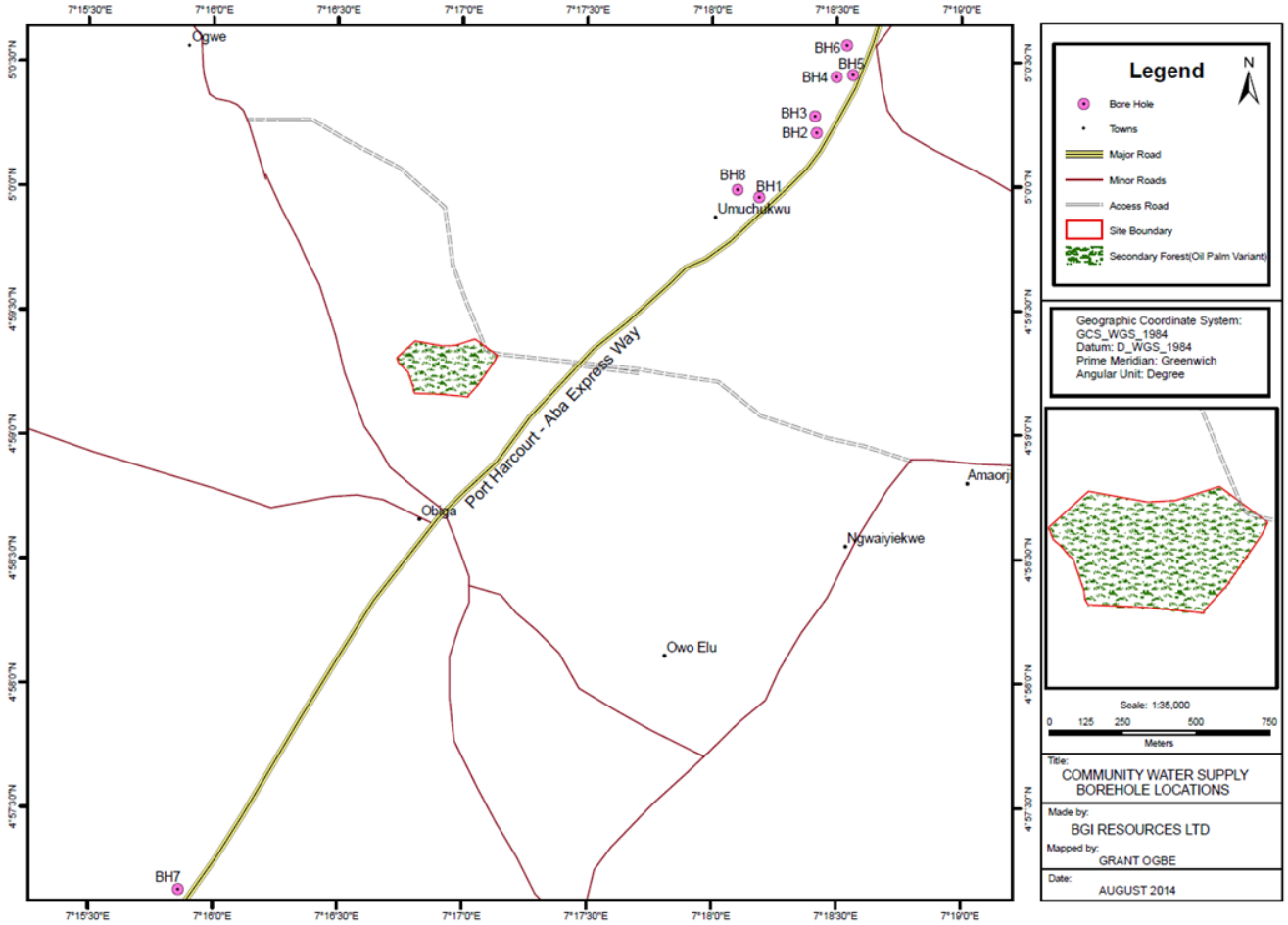
Groundwater was recorded at a depth of 17.95m below ground level indicating that the sand of varying grain size is saturated. Pumping tests undertaken as part the investigation determined a transmissivity of 439.09m^2/day and storativity of 0.00032. The maximum drawdown in the abstraction borehole was 2.24m and 0.47m and 0.22m in the observation boreholes located 17 m and 40 m from the abstraction point respectively.

A number of nearby community water supply boreholes are located in the vicinity of the site, as shown on Figure 5-15. Eight boreholes were identified by a borehole survey, seven of which are located northeast of the site around Umuchukwu, and one to the southwest. The closest of the northeast boreholes (BH8) is located approximately 1km from the site boundary. The borehole to the southwest (BH7) is located approximately 1.5km southwest of the site boundary.

Water level was also monitored before and immediately after the pumping tests in the community water supply boreholes. No variation in groundwater elevation was observed which indicates that the short duration of the test pumping did not impact upon the community supply boreholes.

A hydrogeological study was completed for the project which indicated that it is very unlikely that there will be a significant impact on water availability at the community supply boreholes due to water abstraction at the plant during Phase 1 (BH1). AECOM (the project Owner's Engineer, who is managing the technical review of the hydrogeological investigation) reported that the findings of the pumping test predict that any long-term effects on the village boreholes would be negligible. Furthermore, based on the findings from the testing of borehole BH1, it is considered likely that similar yields will be obtained from the additional two boreholes which may be required for Phases 2 and 3. Once drilling and testing of these has taken place this will be confirmed. There remains a small possibility that the two additional boreholes could produce a lower yield, although at the present time there is no evidence to suggest that this is likely. An action has been included in the ESMP to confirm the status of the additional boreholes' yields.

Figure 5-15: Community water supply borehole locations



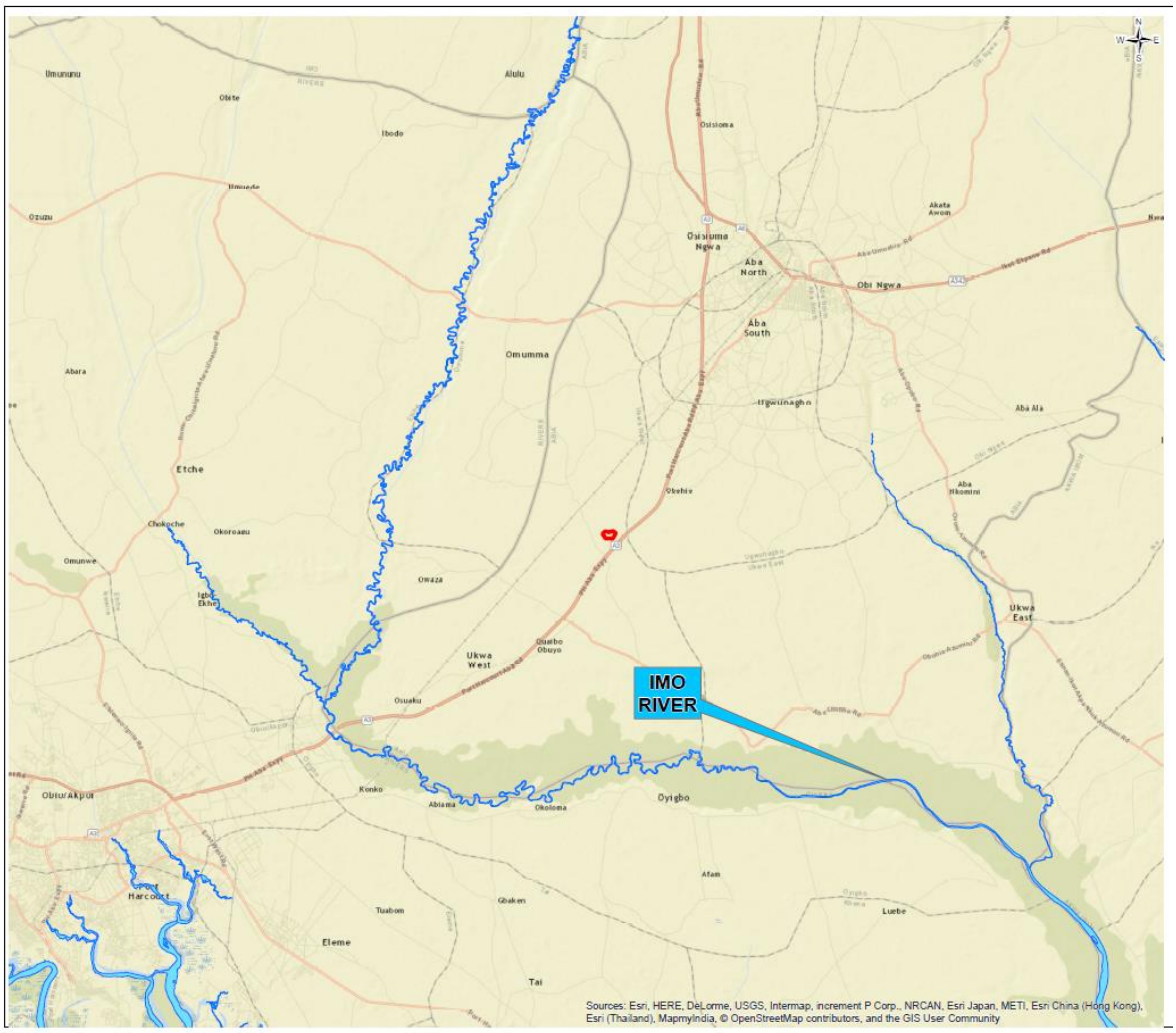
5.6.2 Hydrology

The most significant surface water feature in the region is the River Imo, located approximately 11.5km west of the site. The Imo flows in a southerly direction for approximately 20km to Obigbo, before turning east for approximately 40km to Ohambele, and ultimately turning south to the coast.

The other significant surface water feature is the River Aba, located approximately 20km to the east. The Aba flows to the southeast, to a confluence with the Imo, approximately 30km southeast of the site.

Site visits have confirmed mapping which indicates that there are no significant water courses located between the site and the River Imo, as illustrated in Figure 5-16.

Figure 5-16: River Network



5.7 Groundwater Chemistry

5.7.1 Physico-chemical Characteristics of Groundwater

The chemistry of groundwater varies from place to place depending on the nature of the subsoil and rocks that it passes through. In areas where volcanic rocks of sandstones are present, softer water is normal (Daly, 1994). However, groundwater is often 'hard', containing high concentrations of calcium, magnesium, and bicarbonate in areas where limestone bedrock and limestone-dominated subsoil are common. Therefore, in considering the impact of human activities, it is necessary to first consider the natural (or baseline) water quality. Groundwater is usually considered pure and safe to drink as it undergoes a filtering and cleansing process through a subsoil cover and rock medium that surface waters do not have. However, this does not guarantee groundwater purity. Problems can arise either due to the natural conditions in the ground or pollution by human activities.

The physicochemical characteristics of ground water in the survey area are presented in Tables 2a and 2b of Appendix III and described below:

- Temperature: The temperature of the groundwater of the survey area in the wet season, ranged from 26.30^{o}C to 26.8^{o}C while in the dry season, temperature values ranged from 27.30^{o}C to 33.20^{o}C. These temperature values compared well and corroborated the report of the NDES (1997) on groundwater temperatures of the Niger Delta.

- pH: The pH of the groundwater of the survey area in the wet season ranged from 6.50 to 6.65 and from 5.03 to 7.02 in the dry season. The regulatory limit of pH is 6.5 to 8.5 (DPR, 2002). The pH of ground water will vary depending on the composition of the rocks and sediments that surround the travel pathway of the recharge water infiltrating to the ground water. Ground water passing through carbonate-rich rocks (e.g. limestones and marbles) will usually have pH values greater than 7 as the acidic water is "neutralized." If the geology of the aquifer containing the ground water has few carbonate rocks (e.g., sandstones, metamorphic granitic schists and gneisses; volcanic rocks, etc.) the ground water will tend to remain acidic (The American Well Owner, 2003). Acidic pH may cause corrosion of the borehole casing and metals in the distribution system.

- Turbidity: Turbidity in water is a measure of the cloudiness. It is caused by the presence of suspended matter which scatters and absorbs light (Kiely, 1998). Although turbidity has no health effects, it can however interfere with disinfection and provide a medium for microbial growth. The values obtained for turbidity of the groundwater in the area ranged between 2.4 NTU and 5.3 NTU for the wet season and between 3.1 NTU and 11.0 NTU for the dry season.

- Electrical Conductivity: Electrical Conductivity is the ability of a solution to permit the flow of electrical current. It varies with the number and type of ions in the solution. The conductivity in water is proportional to the concentration of dissolved solids, mostly inorganic salts. The higher the salinity of water the higher the conductivity value (Kiely, 1998). The conductivity values ranged from 36.3µS/cm to 42.1µS/cm in the wet season and from 40µS/cm to 170µS/cm in the dry season.

- Salinity (as Chloride): This is a measure of solids of oxides and chlorides in water. It affects the taste of a groundwater quality. The salinity values ranged from 10.5 mg/l to 45.1mg/l in the dry season and ranged from 9.8 mg/l to 16.2 mg/l in the wet season.

- Dissolved Oxygen (DO): The concentration of DO in groundwater of the area during the dry season ranged from 3.90 mg/l to 6.72 mg/l. A range of 5.20mg/l to 6.10mg/l was obtained during the wet season in the survey area.

- Total Dissolved Solid (TDS): Total Dissolved Solid (TDS) of water is the differences between the total solid (TS) and the suspended solid (SS). The result of the total dissolved solid (TDS) showed relative high values with range of 22.0mg/l to 93.5mg/l and 15.3mg/l to 21.5mg/l for both the dry and wet seasons respectively. This result correlated with the obtained turbidity values and it could be said to be an indication of possible mineral salts intrusion into the groundwater.

- Total Suspended Solids (TSS): The TSS of the groundwater samples in the survey area during the dry season was between 7.43mg/l and 10.00mg/l. Values of TSS ranging from 2.0mg/l to 3.1mg/l were recorded within the area in the wet season.

- Chemical Oxygen Demand (COD): The COD of the groundwater samples in the survey area during the dry season was between 2.0mg/l and 10.0mg/l. COD values ranging from 12.4mg/l to 18.1mg/l were recorded within the area in the wet season.

- Biochemical Oxygen Demand (BOD): BOD level in the ground water samples within the survey area in the dry season was between 3.78mg/l and 6.60mg/l. Values ranging from 4.10mg/l to 4.61mg/l was recorded in wet season sampling.

- Total Hydrocarbon Content (THC): Groundwater chemistry indicates that the presence of hydrocarbon causes tastes and odour problems. The concentration of Total hydrocarbon (THC) were below the detection limit of <0.001 mg/l in the dry and wet seasons.

- Nutrients: Nutrients include the ionic forms (NO_3^-, PO_4^{3-} and SO_4^{2-}) and utilizable forms of nitrogen, phosphate and sulphur respectively. Nitrate (NO_3^-) is one of the most common contaminants identified in groundwater. It is highly mobile and under wet conditions is easily leached out of the rooting zone, through soil and permeable subsoil. NO_3^- is a good indicator of contamination by fertilizers and waste organic matter. The consumption of nitrate rich water by children may give rise to a condition known as methaemoglobinaemia, also called blue boy syndrome (Kiely, 1998). Sulphates (SO_4^{2-}) are also good indicator of contamination by fertilizers and waste organic matter.

  The concentration of nitrates (NO_3^-) was between 0.96 mg/l to 1.20 mg/l during the dry season and 0.15mg/l to 0.21mg/l in the wet season. Sulphates (SO_4^{2-}) recorded a concentration range of 1.41mg/l to 28.10mg/l and 2.21mg/l to 6.20mg/l during the dry and wet seasons respectively. Phosphate levels recorded across the boreholes during the dry season ranged from 0.11mg/l to 1.15mg/l. Phosphate range of 0.17 to 0.40 mg/l was obtained during the wet season.

  Cations: Sodium, potassium, ammonium and calcium ions (Na^+, K^+, $NH_4^+$and Ca^{2+}) are common cations that are essential macro nutrients present in a water environment.

  The values of potassium and calcium in the ground water were below the detection limits of 0.001mg/l during the dry and wet seasons. The levels of sodium ranged from 0.17mg/l to 1.10mg/l during the dry season and from 0.21mg/l to 2.20mg/l during the wet season. Ammonium ranged from 0.26mg/l to 0.33mg/l and from 0.07mg/l to 0.21mg/l during the dry and wet season respectively.

- Water Hardness (Carbonate and Bicarbonate): Groundwater passing through limestone dissolves the calcium and magnesium compounds, which cause hardness. Consequently, hard groundwater is common in limestone areas. Hard water is beneficial to health; it helps to build strong bones and teeth. In addition, it gives a pleasant taste. However, very high levels can be a nuisance, resulting in scale formation in kettles, pipes and boilers. The hardness of the groundwater was between 15.2mg/l and 26.0mg/l during the dry season while ranging from 35.0mg/l to 60.0mg/l in the wet season.

5.7.2 Heavy Metals in Groundwater

The assessment of heavy metal status is because of the concerns relating to their presence in water. Such concerns are toxicity, bioaccumulation and hazards to human health (GEMS 1992). The heavy metals concentration in boreholes water of the survey area is presented in Tables 2a and 2b of Appendix III. In both seasons of the survey, Cr, As, Cd, Hg, V and Pb were not detected in the borehole water samples. The concentrations of Fe ranged from <0.001mg/l to 0.012mg/l in the dry season and from 0.018 mg/l to 0.230 mg/l in the wet season while the concentrations of Zn, Cu and Ni were below the detection limit of 0.001 mg/l in the dry season and ranged from 0.006mg/l to 0.021mg/l, 0.020mg/l to 0.051mg/l and 0.17mg/l to 0.26mg/l respectively in the wet season.

The water quality of the groundwater boreholes in the survey area may stem from the fact that soil is a natural filter where processes such as filtration, adsorption, biodegradation, ion exchange and dispersion may reduce concentration of contaminants to a great extent (Adeyinka and Rim-Rukeh, 1999; Rim-Rukeh and Okokoyo, 2004).

5.7.3 Microbiology of Groundwater

The distribution of heterotrophic bacteria and fungi as well as the hydrocarbon utilizers in the ground water samples collected at different sampling locations is presented in Tables 2a and 2b of Appendix III. Total heterotrophic bacteria (THB) counts were observed to vary between zero and 1.0 x 10^1 cfu.ml^{-1} in the dry season, and between 2.0 x 10^1 cfu.ml^{-1} and 5.0 x 10^1 cfu.ml^{-1} in the wet season. Total heterotrophic fungi (THF) were not found during the dry season. The THF were however observed to range from 0 to 1.0 x 10^1cfu.ml^{-1} during the wet season.

Hydrocarbon utilizing bacteria (HUB) were not observed in the wet season, the mean HUB in the dry season was observed to be 5.0 x 10^0 cfu.ml^{-1}. Hydrocarbon utilizing fungi (HUF) were not found during the wet and dry seasons.

Coliform bacteria which were not detected during the wet season however ranged from zero to 2.0 x 10^1cfu/100ml during the dry season.

5.7.4 Groundwater Quality as Determined During Pumping Tests

Samples of groundwater were collected during the pumping test undertaken on the deep abstraction borehole. It is reported that the concentration of all of the elements analysed were within the acceptable limits set by WHO.

5.8 Soils

The soil provides nutrient for the healthy growth of plants and soil fauna. Soil as a natural resource is a complex body made up of interacting minerals, organic, water and air components with both biotic and

abiotic features. Thus its characterization is of prime importance in regard to conservation strategies and land use systems. Therefore to describe and understand soil material there is the need to characterize soil chemical, physical and biological properties (McKenzie et al., 2002).

5.8.1 Physical properties of Soil

Tables 3 a(i) and b(i) of Appendix III show some specific physical characteristics of soil. Seasonal variation had no effect on the textural class of the soil, the texture of the soils ranged from loamy sand to sandy soils. Available moisture content on the surface soil during the dry season ranged from 16.0% to 31.0% and from 42.0% to 52.0% during the wet season, while at the subsurface soil region, the available moisture content during the dry season ranged from 21.0% to 33.0% and from 39.0% to 51.0% during the wet season. Bulk density at the surface soils ranged from 1.36g/cm^3 to 1.66g/cm^3 during the dry season and from 1.36g/cm^3 to 1.54g/cm^3 during the wet season. At the subsurface soil region, bulk density ranged from 1.23g/cm^3 to 1.65g/cm^3 during the dry season and from 1.36g/cm^3 to 1.62g/cm^3 during the wet season. Porosity of the surface soil varied between 37.4% and 48.0% during the dry season while ranging from 42.0% to 49.0% during the wet season. At the subsurface soil region, porosity ranged from 38.0% to 49.0% and from 37.7% to 53.7% during the wet and dry seasons respectively. Based on these indexes of structural stability, the physical properties of this soil are considered structurally stable for any land use system. The second lithologic unit consisted of fine to medium-grained sand with a thickness of about 1.0m while the third layer was observed to be composed of poorly graded medium-grained sandy clay with a thickness of about 10m, down to the aquifer layer. In borehole 2, the first layer consisted of silty clay with a thickness of about 12m. The second layer consisted of fine grained sand with a thickness of about 2m and the third layer had a thickness of 11m running through the aquifer layer.

5.8.2 Chemical Properties

Soil pH and Redox reactions: Soil reaction which is given in terms of pH value is a measure of the free hydrogen ion (H^+) concentration of soil solution. It is one of the most common and important measurements in standard soil analyses. Many soil chemical and biological reactions are controlled by the pH of soil solution in equilibrium with the soil particle surfaces (Taylor, 1955). The value of the free H+ concentration in a soil influences the availability of nutrient elements and biochemical reactions in the soil. In strongly acidic soils for instance, basic cation uptake by plant roots is inhibited. Beneficial soil microorganisms are affected by soil reaction and the yields of many crops are highly reduced when the pH values are low (strongly acidic < 5.0) (NSPS, 2005). The results of soil reaction revealed only slight differences in pH between the surface and subsurface layers during the wet and dry seasons (Tables 3a(ii) and 3b(ii) of Appendix III). On the surface soil, pH ranged from 4.11 to 5.63 and 4.12 to 5.83 during the wet and dry seasons respectively. The pH of the subsurface soil ranged from 4.11 to 5.28 and 4.00 to 5.55 during the wet and dry seasons respectively. Soil pH is often considered in terms of the soil capability and suitability to support plant growth. The pH of 4.8 is set as the lower limit for optimum growth of plants, and conversely the pH of 9.5 is regarded as the extreme upper limit of alkalinity at which plants can still grow. Thus, the soil under this pH condition can support the optimum performance of most arable crops.

Electrical Conductivity: The electrical conductivity of a soil indicates the total ionic strength (anions and cations) of a soil. Low total ionic strength in a soil indicates low dissolved salt contents and vice versa. Consequently Electrical conductivity increases with higher amount of soluble salts. During the dry season, the spatial variation in conductivity ranged from 23.0µS/cm to 82.0µS/cm with a mean value of 48.45µS/cm at the surface level, and from 20.0 µS/cm to 90.0 µS/cm at the subsurface level. But during the wet season, electrical conductivity value of the surface soil increased by 48.7% (40.0µS/cm - 105.0µS/cm) and 50% in the subsurface (45.0µS/cm -90.0µS/cm) with a mean value of 72.05µS/cm and

71.1µS/cm in the respective layers. Though these values are within the tolerance levels for plant growth, there is however, the likelihood of soil nutrients immobility owing to very low conductivity especially during dry spell. Electrical conductivity tolerance levels for plants growing on soils have been set at 4000 µS/cm in the saturated soil extract.

Exchangeable cations (Magnesium, Mg and Sodium, Na): The exchangeable cations concentrations of the soil was not in consonance with the decreasing cation magnitude of Oputa and Udo (1980), that is, $Ca^{2++} > Mg^{2++} > K^{+} > Na^{+}$. The Magnesium level in the soil during the wet and dry seasons varied with soil depth, higher concentration was observed at the surface layer, with 78.9% reduction during the wet season. The concentration ranged from 1.60mg/kg to 32.0mg/kg; 1.12mg/kg to 29.2mg/kg (dry season) and from 1.11mg/kg to 6.62mg/kg; 1.02mg/kg to 5.18mg/kg (wet season) in the respective depth (surface and subsurface soils). The same trend was observed for Sodium (Na) content (Tables 3a(ii) and 3b(ii) of Appendix III) with 38.9% reduction during the wet season. During dry season Na ranged from 3.98 to 21.3 meq/100g and from 0.89meq/100g to 17.2meq/100g at the surface and subsurface layers while varying between 1.18meq/100g to 16.3meq/100g and 0.5meq/100g to 46.2meq/100g at the surface and subsurface layers during the wet season.

Leaching of magnesium (Mg) and sodium (Na) is largely responsible for the development of acidity in the soils. The low level of Na and Mg which may favour the solubility of aluminium (Al) and manganese (Mn), thus reducing plant yield is indicated by this soils' pH, which varied from slight to moderate acidity. Although Na deficiency has not been identified as a limitation to most of the arable crops such as maize production, magnesium deficiency is common. This indirect effect of Na and magnesium results in the rise of exchangeable Al level which usually occurs at low pH and affect crop yield (Enwezor and Sabulo, 1984).

Sodium Absorption Ratio (SAR): Sodium absorption ratio measure the level of monovalent cation that attach to soil micelle in place of basic cations. The state of soil aggregation at any time results from the balance between the forces or processes promoting aggregation and those tending to cause its breakdown. SAR controls the stability of soil aggregation. As the ratio of SAR increases in the soil, the amount of basic cations attached to the soil sorption site decreases. SAR was more on the subsurface soil during both seasons with 53% and 54% reductions during the wet season (2.4 to 9.3 and 2.0 to 8.7 in the surface and subsurface layers respectively). A serious destructive condition may occur during the dry season (2.0 to 8.7) because thoroughly desiccated aggregates are dispersed by air during dry spell. Also during wet season, the water drawn into each aggregate over its entire periphery may trap and compress the air originally present in the dry aggregate. Because the cohesive strength of the outer part of the clod is reduced by swelling and the pressure of the entrapped air builds up in proportion to its compression, sooner or later the latter exceeds the former and the clod may actually explode. It is assumed that during the rainy season, drainage occurs under steady-state conditions, that is, that temporal perturbations at the soil surface resulting from intermittent periods of rainfall and evapotranspiration are damped out in the upper layer of the soil.

Cations Exchange Capacity (CEC): CEC measures the strength of essential nutrient elements storage in the soil which could be released for crop use in large amount for sustainable growth and development. Most of the cations in tropical soils that are available for plant uptake are induced by microbial activities in the soil (NPSPS, 2005). Thus CEC availability is also affected by soil environmental factors that affect microbial activities. The critical level of 20.0meq/100g was provided for tropical soils (Edem, 2002). The CEC contents of the soils in dry season ranged from 1.30meq/100g to 21.3meq/100g (surface) and from 1.35meq/100g to 17.3meq/100g (subsurface). In wet season, CEC content on the surface soil ranged from 6.15meq/100g to 23.5meq/100g with a mean of 13.48meq/100g, while the subsurface soil layer varied from 2.15meq/100g to 17.0meq/100g with a mean of 9.13meq/100g.

5.8.3 Salinity and Organic Compounds

Salinity: Salinity determined as chloride is a monovalent stable oxidation state of halogen in soils. It is essential for plant growth in trace amounts. As shown in Tables 3a(iv) and 3b(iv) of Appendix III, the concentration of chloride in these soils ranged from 4.44mg/kg to 62.1mg/kg at the surface soil level with a mean of 39.99mg/kg, and from 8.88mg/kg to 53.3mg/kg at the subsurface soil level of dry season. Salinity determined as chloride is a monovalent stable oxidation state of halogen in soils. It is essential for plant growth in trace amounts. Excessive amount of chloride in soils increase the osmotic pressure of the soil water thereby reducing the availability of water to plants. The wet season influenced the reduction of the chloride concentration on the surface soils by 43.5% (8.44mg/kg to 45.5mg/kg) and 31.54% (10mg/kg to 33.4mg/kg) on the subsurface soil. As chloride moves through the soil, its carries water solute load in its convective stream, leaving some of it behind to the extent that the component salts are adsorbed, taken up by plants, or precipitated whenever their concentration exceeds (> 30 their solubility (mainly at the soil surface during evaporation). These could be attributed to overland flow and leaching processes that took place during intensive down pour.

Nitrate-N and Ammonium-N (Total N): Total Nitrogen content of a soil gives an indication of the organic nitrogen present in the soil. Most of the Nitrogen in soils is in the organic form as only relatively small quantities occur in NH_4^+ and NH_3^+; the more available forms. The amount of available nitrogen in the soil is an indication of how suitable conditions in the soils are. A value below 0.1% total Nitrogen is considered low for soils The concentration of Nitrate-N of the surface soil ranged from 0.33 to 1.82 mg/kg and from 0.23mg/kg to 1.26mg/kg during the wet and dry seasons respectively while at the subsurface soil layer, concentrations ranged from 0.21mg/kg to 0.99mg/kg and 0.17 to 1.26 mg/kg during the wet and dry seasons. Ammonium-N concentrations ranged from 0.10 to 0.59 mg/kg and from 0.09 to 0.43 mg/kg at the surface and subsurface soils respectively during the wet season while ranging from 0.15mg/kg to 0.98mg/kg at the surface soil and from 0.12mg/kg to 0.89mg/kg at the subsurface soil during the dry season. Nitrogen values of 0.15%, 0.15% - 0.20%, and >2.0% are classified as low, medium, and high respectively (Enwezor et al, 1988).

Oil and Grease: Although oil and grease are alien to the soil, oil by itself on polluting the soil is not toxic to plants but it exerts its adverse effects on plant indirectly by creating certain conditions which make nutrients essential for plant growth unavailable, while the adverse conditions created in the soil makes some nutrient like Zn and Fe more available and toxic to plant (Odu, 2000). The concentration of oil and grease of the surface soil of the proposed site ranged from 0.32mg/kg to 2.13mg/kg and 0.27mg/kg to 1.20mg/kg during the wet and dry seasons respectively. Concentration ranges of 0.22mg/kg to 1.12mg/kg and 0.22mg/kg to 1.23mg/kg where obtained at the subsurface soil during the wet and dry season respectively.

Total Organic Carbon (TOC): Organic carbons are complex and valuable mixture of compounds which is alien to soil and their presence affects exchange of oxygen and stain surface soil. Soil organic carbon usually mixes up with fine clay particles to form soil colloids. It is an important soil fraction due to its binding properties which enhances most physical and chemical activities in the soil thus, increasing contact with other colloids and with soil solution resulting in the strong friction and cohesion bonds between particles and soil water. Thus, clay soil holds together better than sandy soil when wet. The concentration of TOC varied from 0.27mg/kg to 1.23mg/kg with a mean of 0.83mg/kg (surface soil), and 0.29mg/kg to 1.32mg/kg with a mean value of 0.80mg/kg (subsurface soil) in the dry season. But generally during wet season, TOC values increased in a range of 0.87mg/kg to 21mg/kg, averaging 5.32 mg/kg on the surface and 0.52mg/kg to 15.8mg/kg, averaging 3.92mg/kg in the subsurface. TOC increased by 536% on the surface and 338% in the subsurface layers during the wet season. This result

could be attributed to favourable environmental condition during this season where soil fauna thrives in large number and subsequently break down compounds to simple form that is released into the soil.

The important physical advantage of this soil is its non-vulnerability to soil erosion particularly under aggressive rainfall condition. The TOC increased significantly during the wet season as a result of rainfall. The TOC is accounted for mainly from biogenic sources of wax and suberins from decay of plants and animals. No special management tool is required for this soil.

Analyses of soil samples showed that concentrations of the phenols, polycyclic aromatic hydrocarbon (PAH), Aliphatic Hydrocarbon, and BTEX were below detectable limits.

5.8.4 Heavy metals (Trace elements)

The mineral elements originate from soil and dissolve in water for plant roots' absorption. Those required in small quantity for optimum performance are regarded as trace elements. The concentration of these metals can however be increased to become potential pollutants if heavy metals – containing waste products from industrial or domestic activities are introduced into the environment (Bohn et al, 1984). Concern over the presence of heavy metals in an environment arises from the fact that they cannot be broken down into non-toxic forms. Thus once aquatic ecosystems are contaminated by heavy metals, they remain a potential threat for many years

Tables 3a(iii) and 3b(iii) of Appendix III show the characteristics of heavy metals in both surface and subsurface soils in the proposed project area during the wet and dry seasons.

Copper (Cu): Copper is important for the reproductive growth and root metabolism. A major property affecting the availability is soil pH, a measure of soil acidity or alkalinity. Cu tends to be less available in soils with high pH (Akinrinde, 2006). Copper concentrations during the wet season, ranged from 3.04mg/kg to 9.10mg/kg and 0.82mg/kg to 8.23mg/kg at the surface and subsurface soil layers respectively while ranging from 3.31mg/kg to 8.00mg/kg at the surface soil and from 0.82mg/kg to 8.12mg/kg at the subsurface layer during the dry season. The concentration of Cu showed 16.47% increase during the wet season on the surface layer and only 4% reduction in the subsurface.

Nickel (Ni): The total Ni concentrations in dry season ranged from 1.01mg/kg to 2.99mg/kg (1.67mg/kg) on the surface soil layer, and from 1.15mg/kg to 2.29mg/kg (1.58 mg/kg) at the subsurface level. Soil study during the wet season revealed value range from 0.52mg/kg to 2.52mg/kg (1.37mg/kg) and 2.10mg/kg to 14.3mg/kg (5.16mg/kg) in the surface and subsurface layers respectively. Ni concentration reduced by 17.64% and 25.12% in the surface and subsurface soils respectively during the wet season as a result of rainfall.

Lead (Pb): Lead concentrations ranged from <0.01mg/kg to 0.42mg/kg at the surface soil and from <0.01mg/kg to 0.60mg/kg at the subsurface soil during the wet season. Concentration ranges of 0.09mg/kg to 0.35mg/kg at the surface soil and 0.05mg/kg to 0.70mg/kg at the subsurface soil were obtained during the dry season. Rainy season generally reduced the concentration of Pb by 40.46% and 59.68% on the surface and subsurface layers respectively.

Iron: Iron concentration in dry season ranged from 18mg/kg to 29mg/kg at the surface soil level, and from 18mg/kg to 28mg/kg at the subsurface soil level. Lower concentrations of iron were observed in the wet season with values ranging from 2.25mg/kg to 15.50mg/kg (6.36mg/kg) on the surface soil layer and 2.10 to 14.3mg/kg (5.16mg/kg) at the subsurface layer.

Zinc: Zn concentrations during the dry season ranged from 1.98mg/kg to 8.01mg/kg at the surface soil level, and from 0.82mg/kg to 54.0mg/kg in the subsurface level. Zn on the surface soil during the wet season showed concentration range of 1.01mg/kg to 8.04mg/kg and 0.89mg/kg to 5.33mg/kg in the subsurface layer with concentrations average of 5.28mg/kg and 3.70mg/kg at the surface and subsurface soil layers respectively.

The elements Mercury, Vanadium, Cadmium, Barium and Chromium were below the equipment detectable limits of <0.001mg/kg (Vanadium and Barium) and <0.01mg/kg (Cadmium, Mercury and Chromium). This is indicative of the absence of significant pollution or toxicity in the proposed project area.

5.8.5 Microbiological Characteristics of Soil

The soil environment which is one of the most abundant and diverse ecosystem on the earth (Brady, 2002) is teeming with biological life. The microbial community in soil is important because of its relationship to soil fertility and the biochemical cycling of elements. The soil microbes consisting mainly of fungi and bacteria are substantial to the recycling of nutrients within the system. Microorganisms are the first component of biota in an ecosystem which could be employed in predicting and demonstrating the effect of environmental pollution resulting from any contamination. As shown in Tables 3a (v) and 3b(v) of Appendix III, total heterotrophic bacterial counts (THBC) in the surface soil varied from zero to 6.0 x 104 cfu/g soil with a mean value of 2.35 x 104 cfu/g and from zero to 8.0 x 104 cfu/g of soil averaging 2.85 x 104 cfu/g in the subsurface layer during the dry season. THB counts of 1.0 to 8.0 x 104cfu/g with mean of 2.85 X 104 cfu/g and 1.0 to 5.0 x 104cfu/g with a mean of 2.45 X 104 cfu/g were obtained in the surface and subsurface soils during the wet season. THFC during the wet season ranged from zero to 4.0 x 104 cfu/g and zero to 3.0 x 104cfu/g in the surface and subsurface soils respectively. Similarly, the heterotrophic fungi count in the soil during the dry season did not change significantly. It varied between zero and 3.0 x 104 cfu/g soil with mean values of 0.90 X 104 cfu/g and 0.30 X 104 cfu/g in both the surface and subsurface soil layers. During the seasons under investigation, the Counts for the Hydrocarbon utilizing bacteria (HUB) and fungi (HUF) were equally low at both soil depths. HUB and HUF varied between zero and 1.0 x 102cfu/g of soil at the surface and subsurface layers during the dry season, while HUB ranged from zero to 2.0 x 102cfu/g and zero to 3.0 x 102 cfu/g at the surface and subsurface layers respectively during the wet season. HUF ranged from 1.0 to 2.0 x 102cfu/g and zero to 3.0 x 102cfu/g of soil at the surface and subsurface layers respectively during the wet season. The results show HUB/THBC ratios of both seasons to be less than 1%, an indication of the absence of crude oil pollution in the environment.

The results of bacteria and fungi population in the area are indicative of a rich/thriving environment and do not indicate the presence of any significant pollution in the soil.

5.9 Ecology

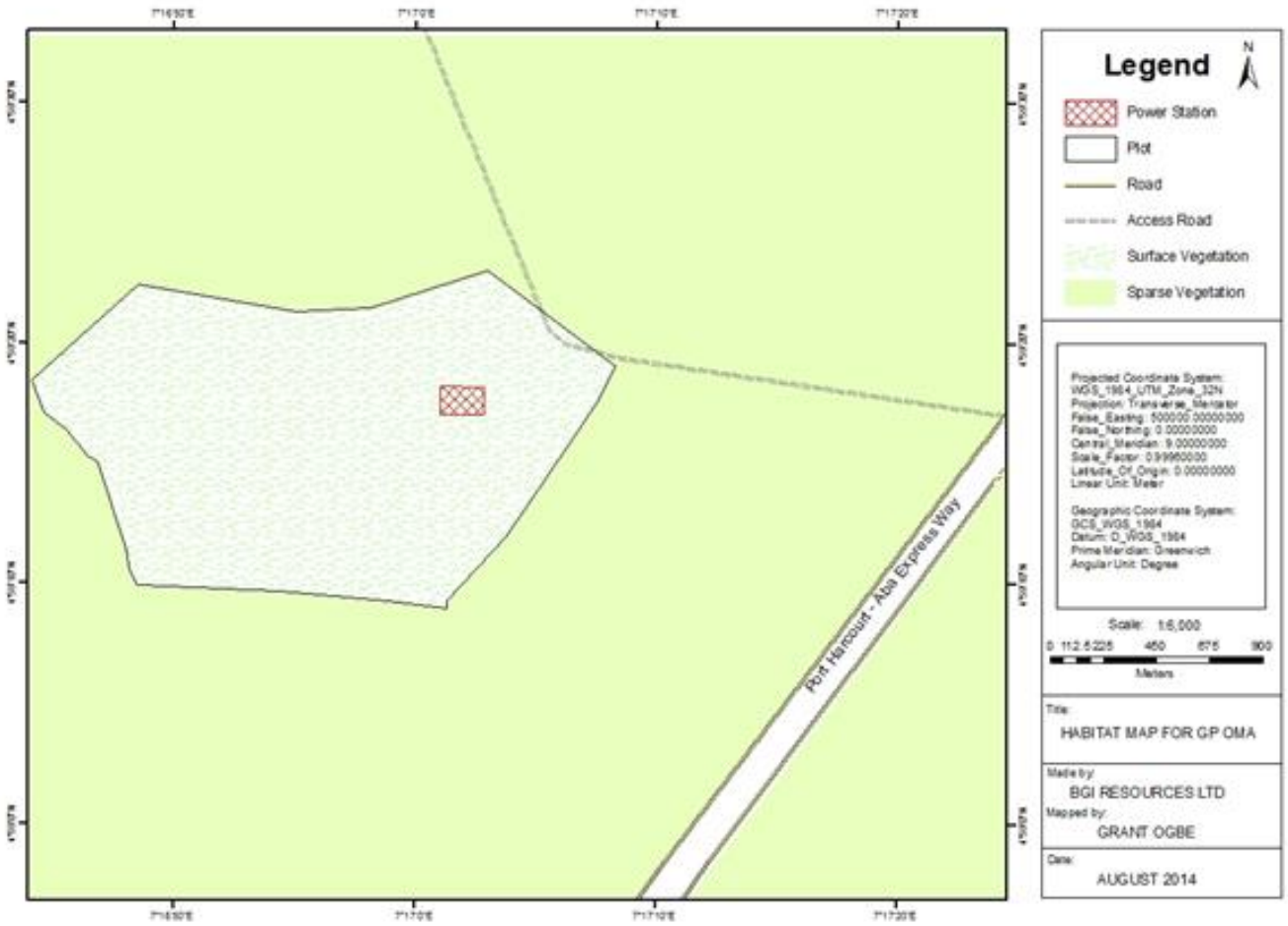
No known areas of natural or critical habitat (endemic species, wildlife breeding sites) or archaeological significance were found within 10km of the proposed development area.

5.9.1 Environmental Status of Vegetation /Forestry

Vegetation in most of the sampling locations in the proposed project area (Veg. 1-5 on Figure 5-1) consisted of a mosaic of farmlands (mostly cassava) and fallow lands at various stages of regeneration. Vegetation in the area has been greatly disturbed by farming and other anthropogenic activities. A checklist of plant species in the proposed project area is shown in Table 4 of Appendix III. Figure 5-17

shows the site location and surrounding vegetation types. No natural watercourses were found within 1km of the site boundary and no water courses or aquatic habitats were noted within the site boundary.

Figure 5-17: Vegetation types within and adjacent to the survey area



The vegetation in the area can be described as the oil palm variant. This is indicative of lowland rain forest that is undergoing active regeneration. These areas have been long under cultivation. Oil palms were the dominant emergent canopy species with heights of up to 25m (Figure 5-18). Tree species diversity (Shannon-Wiener index) was generally low (1.36 – 2.06). Only 5 - 9 species (belonging to 4 - 6 families) of the dimension of trees were identified in these areas.

Figure 5-18: Oil palm (*Elaeis guineensis*), dominant emergent canopy species

The trees were of low stature, poorly stratified and with average height of the 5 tallest trees (exclusive of palms) not exceeding 6.2m as outlined in Table 5-4. These values indicated that trees of timber size were grossly lacking. The secondary nature of the vegetation was further indicated by the occurrence of species of the tropical rainforest biome such as *Pycnanthus angolensis*, *Albizia zygia* and *Anthonotha macrophylla*. The low stature and tree species diversity indices suggested that the community is of recent origin or affected by recent changes. Such communities are unstable and likely to change rapidly. The ground flora (low-lying vegetation) was dominated by graminaceous and herbaceous genera including members of the Poaceae (*Panicum maximum*, *Axonopus compressus*), Asteraceae (*Chromolaena odorata*), Malvaceae (*Sida acuta*, *Urena lobata*), Fabaceae (*Desmodium ascendens*) and cover crops (*Ipomoea involucrata*).

5.9.2 Plant Tissue Analysis

The levels of essential elements in representative plant species from the proposed OMA Power Plant Project area were within the usual concentrations found in higher plant tissues (Table 5-5). The observed values are adequate to sustain maximum plant growth. The results indicate that plants in the survey area were essentially free of heavy metals contamination.

Table 5-4: Forest Data Summary in the Project area

Vegetation Transect	No. species	No. families	Av. Height*	Diversity Index**
VEG 1	5	4	5.0	1.36
VEG 2	8	5	5.0	1.79
VEG 3	8	5	5.4	1.57
VEG 4	8	5	5.0	1.92
VEG 5	9	6	6.2	2.06

***** Average height, 5 tallest trees (exclusive of palms)
****** Trees species diversity Index (Shannon-Wiener).
Source: GP fieldwork, 2013

Table 5-5: Mean Concentrations of Heavy Metals in Foliage of Representative Plant Species from the Project area.

Sample code	Parameter (mg/Kg dry weight)							
	Fe	Zn	Cr	Mn	Mg	Cd	Ni	Pb
Alchornia cordifolia	91.3	nd	<0.10	25.0	595.0	0.06	0.05	0.01
Panicum maximum	148.5	25.0	4.0	67.5	270.0	0.05	0.05	0.02
Harungana madagascariensis	185.5	44.0	5.0	36.0	710.0	0.10	0.05	0.02
Manihot esculenta	170.5	25.0	<0.10	nd	700.0	0.06	0.03	0.02
Elaeis guineensis	180.0	nd	<0.10	nd	690.0	0.07	0.06	0.01
*Minimum values for maximum plant growth (mg/Kg)	100.0	20.0	**	20.0	200.0	**	**	**

nd Not determined
* Based on Marschner, 1995
** Toxic even in low concentrations
Source: GP fieldwork, 2013

5.9.3 Plant Pathological Studies

Vegetation was generally healthy with no obvious signs of stress due to any disease condition or heavy metal toxicity. The pathogens from diseased plants in the area are shown in Table 5-6. Leaf spots were the dominant disease symptoms on the foliage of unhealthy plants. *Fusarium*, *Aspergillus* and *Penicillium spp* were the pathogens with the highest relative incidence.

Table 5-6: Plant Pathological Conditions (Disease Symptoms and Isolated Pathogens) of Some Plants in the Project Area

Plant species	Pathological condition	Pathogens isolated
Elaeis guineensis	Leaf spots	*Cercospora sp.*
Mannihot esculenta	Leaf spots, sooty mold, root rot	*Thielaviopsis brasicola, conidial stage of Ceratocystis sp.)*
Harungana madagascariensis	Necrotic spots on leaves	*Plerothecium sp.*
Alchornia cordifolia	Leaf spots, rot and mold	*Fusarium oxysporium, Penicillium vermiculatum*

Source: GP fieldwork, 2013

5.9.4 Economic Crops

The major farm crop found in the project was *Manihot esculenta* (cassava). Trees which offer non-timber forest products (barks, fruits, roots etc.) that play roles in traditional medicine and nutrition included *Elaeis guineensis* (oil palm), *Microdesmis puberula*, *Alchornia cordifolia* and *Harungana madagascariensis* (blood tree). Selected plant species with uses to the communities in the Project area are provided in Table 5-7.

Table 5-7: Selected Plant Species with Potential Utilitarian Benefits to the Communities in the Project Area

Species	Uses
Harungana madagascariensis	Bark decoction used as blood tonic.
Alchornia cordifolia	Treatment of foot rot (*Taenia paedis*)
Elaies guineensis	Soap making, cooking oil and alcohol production
Microdesmis puberula	Bark decoction used as anti-helminthic (treatment of parasitic worms (helminths), applied to snakebites or to scarifications and other numerous medicinal uses.
Rauvolfia vomitoria	Root-bark decoction used as emetic and for malaria, jaundice or allied ailments.

Source: GP fieldwork, 2013

5.9.5 Wildlife

The wildlife resources have been grouped under the following major headings: mammals (small mammals), avifauna and reptiles (and amphibians). The mammalian species were predominantly rodents (small mammals) like *Thryonomys swinderianus* (grasscutter, illustrated in Figure 5-19), *Xerus sp* (ground

squirrel) and *Cricetonys gambianus* (giant rat). The avifauna were the most conspicuous form of vertebrate wildlife and included weaver birds (*Plesiositagra cucullatus*), hawks (*Polyboroides radiates*, as illustrated in Figure 5-19) and kites (*Milvus migrans*). Herpetofaunal species included lizards and snakes. A checklist of the wildlife is shown in Table 5-8. Hunting activities (including the setting of traps) in the area was very limited.

Figure 5-19: *Polyboroides radiates* and *Thryonomys swinderianus*

There is a dearth of information on the wildlife of the survey area, resulting in an unclear picture of wildlife diversity, abundance and distribution. Most of the wildlife taxa would, therefore, be classified as “not evaluated” or “data deficient” based on IUCN (2012) guidelines.

This implies that data is insufficient to assign conservation status to these organisms. Under these circumstances, the IUCN (2012) recommends that such organisms should be given the same degree of protection as threatened taxa, at least until their status can be evaluated, which is likely more protection than they would be accorded under national law .

As stated in Appendix II Field Methodology, Section 1.3, invertebrate surveys were not undertaken due to the assessment that the habitats present would be unlikely to support species of conservation concern or interest. Therefore invertebrate species have not been evaluated in this section.

Table 5-8: Wildlife of the Proposed Project Area

Class	Family	Species	English Name	Detection Method	Habitat	NARESCON (1992)	IUCN (2012)
Amphibia	Bufonidae	*Bufo regularis*	Toads	DS	Forest/ garden	Satisfactory	Not Evaluated
	Ranidae	*Dicroglosus occipitalis*	Frogs	DS	Forest/ garden	Satisfactory	Not Evaluated
	Ranidae	*Rana temporalis*	Frogs	DS	Forest/ garden	Satisfactory	Not Evaluated
Reptilia	Agamidae	*Agamma agamma*	Common lizard	DS	House/ garden	Satisfactory	Not Evaluated
	Boidae	*Naja melanoleuca*	Black cobra	SH	Forest/ swamp	Satisfactory	Not Evaluated
	Viperidae	*Bitis gabonica*		SH	Forest	Rare	Not Evaluated
		Veranus niloticus	Nile monitor lizard	SH	Sandbank	Common	Not Evaluated
Aves	Accipitridae	*Necrosyrtes monarchus*	Common vulture	DS	Garden/ roadsides	Satisfactory	Not Evaluated
	Accipitridae	*Milvus nigrans*	Black kite	SH	Riverbank/ pond-sides	Satisfactory	Not Evaluated
		Crinifer piscator	Plantain eater	DS	Forest	Satisfactory	Not Evaluated
	Corvidae	*Corvus albus*	Pied crow	DS	Forest/roadsides	Satisfactory	Not Evaluated
	Ardeidae	*Ardeola ibis*	Cattle egret	DS	Garden/ roadsides	Satisfactory	Not Evaluated
		Pycnomonus barbatus	Common garden bulbul	SH	Garden/ roadsides	Satisfactory	Not Evaluated
	Ploceidae	*Plesiositagra cucullatus*	Weaver birds	DS	Garden/ roadsides	Satisfactory	Not Evaluated
	Bucerotidae	*Polyboroides radiates*	Carrier hawk	DS	Garden/ roadsides	Satisfactory	Not Evaluated

Class	Family	Species	English Name	Detection Method	Habitat	NARESCON (1992)	IUCN (2012)
		Strix wordfordii	African hood owl	SH	Garden/ roadsides	Satisfactory	Not Evaluated
		Hirundo nigrita	Swallow	DS	Forest/ roadsides	Satisfactory	Not Evaluated
	Gutteridae	*Guttera edourdi*	Crested guinea fowl	XX; feathers seen	Forest	Satisfactory	Not Evaluated
	Ardeidae	*Bubulcus ibis*	Cattle egret	DS	Forest	Common	Not Evaluated
Mammalia	Muridae	*Cricetonys gambianus*	Giant rat	BU	Forest	Satisfactory	
	Muridae	*Rattus rattus*	Common rat	DS	House/ garden	Satisfactory	
	Bovidae	*Tragelaphus scriptus*	Bush buck	FP	Forest	Satisfactory	
	Bovidae	*Philantomba maxwelli*	Maxwell duiker	SH	Forest	Satisfactory	
	Sciuridae	*Sciurus sp*	Palm squirrel	DS	Forest	Satisfactory	
	Sciuridae	*Xerus* sp	Ground squirrel	DS	Forest	Satisfactory	
	Thryonomidae	*Thryonomys swinderianus*	Cane rat	SH	Forest	Satisfactory	
	Chiroptera	*Pteropus sp*	Fruit bat	DS	Forest	Satisfactory	

Note: DS-Direct Sighting, FP- Foot Prints, XX- Information from literature, BU-Burrows, SH- Information from hunters

5.10 Wastes and Hazardous Materials

An understanding of the local waste management conditions is necessary in order to inform decisions around waste disposal for the project and to reduce the potential for adverse effects on the environment either from waste handling and storage or from waste disposal.

During the ESIA, baseline conditions were examined in order to understand current waste management practices and the implications of these for the project.

Wastes Generated Within or Adjacent to Project Area

Wastes are mainly generated from the household activities in the villages. Households commonly dump their refuse in the bush behind their houses. These dumps sometimes generate compost which the household uses as manure on farms or over which crops are planted. The usual crops planted over these former dumps include vegetables, banana and plantain. Hitherto, much of the waste generated in these communities had been easily biodegradable, but increasingly household refuse is consisting of plastic and metal materials from bottled and canned drinks and foods. These are equally dumped in the back yard and they are beginning to constitute a nuisance to farming around the homestead. Comparatively, a very negligible proportion of households burn their refuse. These households claim that they mostly burn waste paper, plastics and clothing. A former borrow pit in the outskirts of Ihie-Iyi used to serve as a landfill for Aba town. This has been closed. However, some refuse is seen scattered along portions of the Port Harcourt Enugu Express Road in the community. Local sources attribute this to some residents of Aba who illegally drop off their refuse by the side of the express road while driving through the community. An illegal dump site on the outskirts of Ilhie is illustrated in Figure 5-20.

Figure 5-20: Illegal dump site on the outskirts of the community

The use of water closet type of toilet is not common among households. Most households use pit toilets. Many of these are covered pit toilets. A few households across the study area indicated their members defecated in the bushes. This was not for lack of a toilet at home but apparently, some farmers were in the habit of mostly defecating when they were at work in their farms and doing so in the bushes around their farms.

The most commonly used household refuse and sewage disposal methods could be considered generally safe for now. The methods are not modern but they are generally effective in consigning household waste. It is noteworthy, however, that with increasing population and urbanization these methods will become obsolete and unhygienic.

Solid Waste Management

The wastes generated in the communities were mainly garbage and other domestic wastes. In Ihie Ukwu, wastes were dumped in farm, while tenants dump on any available space in the community. Ogwe community seems to have a more defined way of disposing domestic refuse, which is mandatorily down in the farmland. Ihie Ukwu and Ogwe communities do not enjoy municipal solid waste disposal services, such that wastes were often dumped indiscriminately especially in Ihie Ukwu. Leaching from the wastes can be a source of contamination of the groundwater, especially as electronics are sometimes part of the wastes. Electronics have been shown to be capable of contributing as much 50% – 80% of the heavy metals leaches from a dump site. (Chiodo *et al* 2002).

It was obvious during the field survey that members of the community made some effort to ensure the safe management of wastes, but the widespread complaints of vector and rat infestations in the community seem to suggest that these efforts are not sufficiently effective.

6. Socio - Economic Baseline

6.1 Introduction

This section describes the social and economic characteristics of the communities surrounding the project in order to measure the influence of the project on these factors. The socio-economic baseline presented originated from a combination of a desktop study of published sources, a household survey, targeted interviews with community leaders, and focus group discussions. Secondary data was obtained from public agencies such as the National Population Commission (NPC) and the National Bureau of Statistics (NBS). The scope of the socio-economic studies is provided in Appendix IV.

6.1.1 Socio-economic Structure of Nigeria and the Abia State

The Federal Republic of Nigeria covers an area of 923,768 km^2 with a population of over 140 million. Primary traditional agriculture remains the dominant economic activity of the nation, accounting for about 40.0% of GDP and more than 60.0% of total employment[5]. The proposed project is located in the Abia State, which is one of five states in the south eastern geopolitical zone of Nigeria. The southern section of the State lies within the riverine part of Nigeria. It is generally low-lying, characterized by heavy rainfall. Abia State is mainly an agricultural state, but is also engaged in crude oil and gas production.

There are seventeen local government areas (LGAs) in the state. Each local government is headed by a democratically-elected Chairman working with an elected council. The closest major urban area to the project site is one of the biggest in the state known as Aba, a major commercial centre. Presently, the project area is largely inhabited by Igbo people, one of the three largest ethnic groups in Niger and they speak Igbo, with some dialectical variation[6].

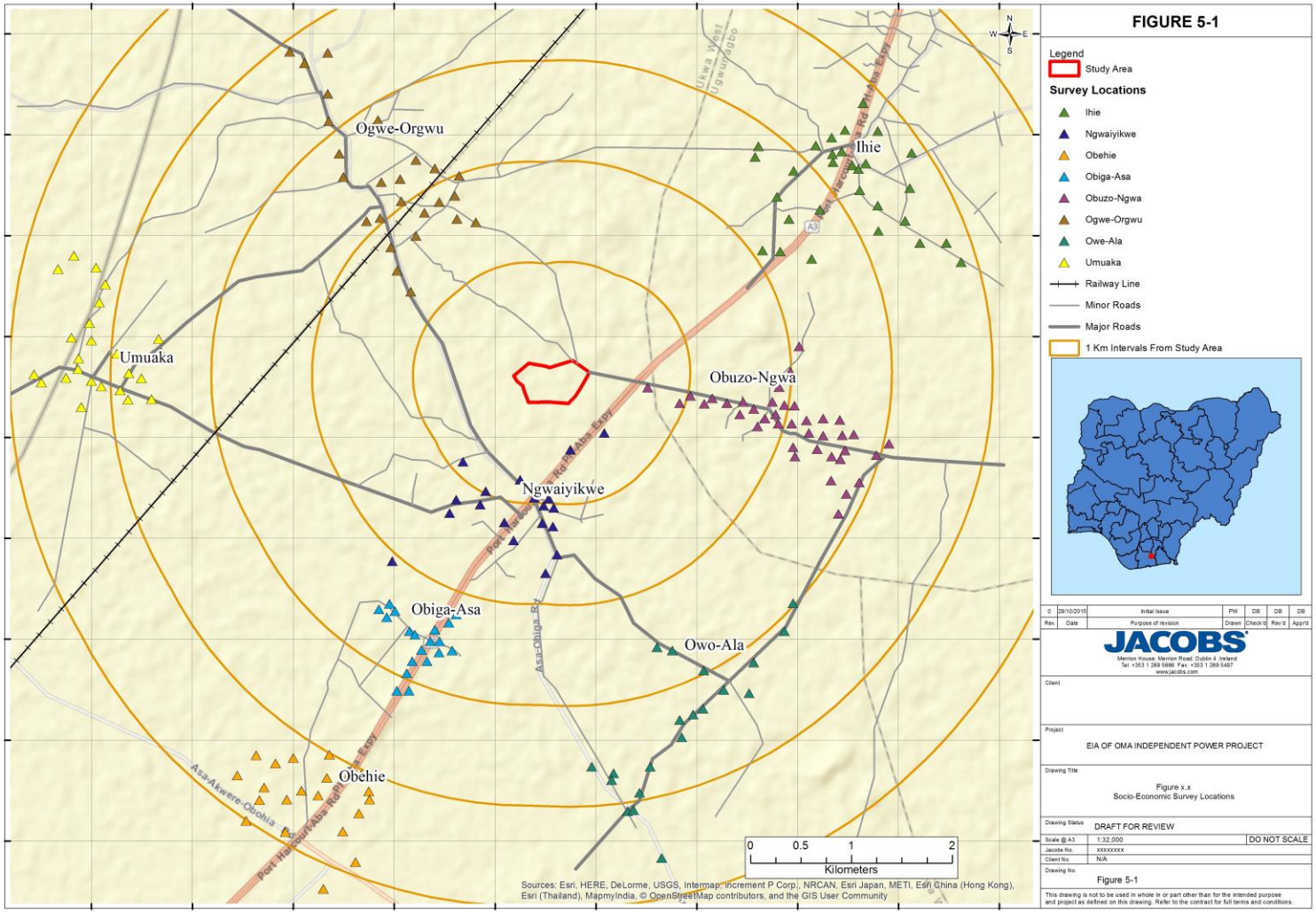
The affected communities fall within two local government areas (LGA) jurisdiction, namely Ukwa West and Ugwunagbo. Ukwa West has its government headquarters at Oke Ikpe and has an area of 271km^2 and a population of 88,555 at the 2006 census with a total land mass of 105sq miles. The local government (Ukwa West) is the only major crude oil producing area in Abia State, but some of its communities and wards are lacking in some basic amenities, such as good roads, and electricity. Ugwunagbo as a local government has its headquarters in the town of Ugwunagbo. It has an area of 108km^2 and a population of 97,710 according to the 2006 estimated census. Ugwunagbo is primarily a farming community.

6.1.2 Project Area of Influence

Settlements/communities of primary interest were selected for the socio-economic study based on a 5km radius around the proposed project site. Obehie, Orgwu (Ogwe), Ihie-Iyi, Obiga, Ngwaiyiekwe, Obuzongwa, Owo-ala, and Umuaka by their local names are the identified communities within the 5km radius to the proposed OMA power plant project and each of these communities was surveyed using a targeted questionnaire. Figure 6-1 illustrates the local geography and settlement areas within the Project Area of Influence. The sample population size that was targeted in each community generally correlated to the size of the community, i.e. more surveys and focus groups were conducted in the more populous areas.

[5] Nigeria Millennium Development Goals Report, UNDP 2013.
[6] Ijezie, Innocent, et al., Socioeconomic status and obesity in Abia State, South East Nigeria, Dovepress Journal, 15 October 2013.

Figure 6-1 : Socio-economic survey locations



Household Survey

In order to better understand current socio-economic conditions in the project vicinity a survey was conducted based on a random sampling of respondents in the project area of influence. Because of local privacy customs, surveys were not conducted door to door. Instead, surveys were administered in public places to a cross section of each of the community with the aid of the community's leadership and/or an interviewer. The survey questionnaire was designed to collect some census level data along with the inclusion of some open-ended questions to understand local development challenges and strengths and get local input on the project. Out of 200 questionnaires administered, 178 responses were received targeting a cross section of each community (Table 6-1). An overview of the survey area is shown in Figure 6-1.

Table 6-1 : Oma Household Surveys

Community Number	Community	Questionnaire administered	Questionnaire retrieved
1	Obehie	20	20
2	Ngwaiyiekwe	20	20
3	Obuzongwa	40	35
4	Obiga	20	19
5	Orgwu (Ogwe)	25	20
6	Owo-ala	20	15
7	Umuaka	25	24
8	Ihie-iyi	30	25
Total		**200**	**178 (89%)**

Interviews and Focus Groups

A focus group was conducted in each community covering all eight communities. Focus groups were designed for groups of 10-15 people that were willing to participate in a brief discussion of the project, but were sometimes larger. They all included representation from youth, women and leaders in the community. A breakdown of the venue for each is described in Table 6-2.

Table 6-2 : Focus Group Discussion (FGD) Venue and GPS Coordinates

S/no	Community	Focus Group Discussion (FGD) Venue	GPS Coordinates
1	Obehie	Eze Palace	N04^{0}57.03.5' E007^{0}15.41.7'
2	Ngwaiyiekwe	Eze Palace	N04^{0}58.17.1' E007^{0}16.59.5'
3	Obuzongwa	Eze Palace	N04^{0}59.09.9' E007^{0}17.39.0'

4	Obiga	Civic Town Hall	N04^{0}57.49.4' E007^{0}16.19.9'
5	Orgwu (Ogwe)	Elder Council Chief Place	N05^{0}00.03.3' E007^{0}16.11.9'
6	Owo-ala	Civic Town Hall	N04^{0}56.58.8' E007^{0}17.21.9'
7	Umuaka	Civic Town Hall	N04^{0}59.16.2' E007^{0}14.29.8'
8	Ihie-iyi	Eze Palace	N05^{0}00.13.6' E007^{0}18.39.2'

A member of the Social Impact Assessment (SIA) Team conducted the focus group assisted others taking notes and photographs where possible. Focus group leaders employed rapid appraisal methods including targeted questions and a discussion guide to understand community views and capture their concerns and perspectives. Interviews were also held with traditional community leaders and influential members of the community to get a sense of the type of the community make up and structure and how the community identified itself.

6.1.3 Population Demographics in the Study Area

The National Population Commission (NPC) published provisional population estimates by sex and age for Ugwunagbo and Ukwa West LGAs following the national census conducted in 2006. The population of Ugwunagbo LGA was given as 85,371 and Ukwa West as 87,367. The NPC estimates an annual growth rate of 3.2% for the entire population of Nigeria (NDHS, 2008). Applying this rate in the Ugwunagbo and Ukwa West LGAs would result in population projections of 106,458 and 112,441, respectively, by 2013. Table 6-3 presents the projected population of the LGAs up to 2017. Additionally, the National Bureau of Statistics (NBS) in 2006 estimated the population density of the Abia State at 578.4 persons per square kilometre. This makes Abia State the fourth most densely populated state in Nigeria, after Lagos, Anambra and Imo States.

Table 6-3 : Projected Population of Ugwunagbo and Ukwa West LGAs, 2013-2017

Year	Projected Population	
	Ugwunagbo	Ukwa West
2006	85,371	87,367
2013	106,458	112,441
2014	109,872	116,023
2015	113,373	119,693
2016	116,958	123,537
2017	120,715	127,468

Source: NPC Priority Table Vol. IV, 2010 and BGI Projections, 2013.

Based on interviews with community leaders, estimated population in the Project Area of Influence consists of approximately: Obehie 5,000; Ngwaiyiekwe 4,500; Obuzongwa 2,000; Obiga 3000; Ogwe (Orgwu) 2,000; Owo-ala 1,500; Umuaka 3,500; and Ihie-Iyi 6,000. It is difficult to verify the accuracy of these figures as individual community population figures are not yet publicly available. However, it gives an indication of community size relative to each other.

Photographs of communities are provided where available, Figure 6-2 to Figure 6-5.

Obehie Community

Obehie is located between 4-5 km southwest of the project site more developed communities surrounding the site including medium density housing and development. The population of Obehie largely migrated from Ngwa to the north moving to the area in search of a favourable place to settle. Asannetu (Nzu) founded Obehie community upon discovering a pond in the area and the original inhabitants were from his family. Obehie is made up of three (3) villages, namely Umuokomiri, Umuoyeke, and Umuala and is largely rural. The community is divided by the expressway.

Figure 6-2: Representative Housing in Obehie Community


Ngwaiyiekwe Community

This community consists of migrants from Okpu-alangwa in Isialangwa. There are seven (7) villages that make-up Ngwaiyiekwe – Umuokimo, Amozu, Amapu, Umuogwu, Ogbu, Umuogwu, and Umuchenna. In terms of governance, village heads are appointed to run the affairs of the distinct villages and report to the Eze who is the overall leader. This area is located directly south of the site, would be considered semi-rural and includes medium density housing, some sparse string development which increases in density as it straddles the expressway. There are also multiple religious centres/churches in the area.

Obuzo-ngwa Community

Members of the Obuzongwa community migrated from Okpualangwa in Isialangwa. They left Okpualangwa in search of fertile land where they could farm. The community is made-up of ten (10) villages – Nwoko, Atah, Anere-Okpo, Adindu, Ukwu, Anyanwu, Egbu, Nwosu, Oru and Aguo located directly east of the project site and is generally rural with low density housing and string development. There is also a religious centre/church in the area.

Figure 6-3: Obuzo-ngwa Community (Left: isolated residence of the Community Head, Right: a dilapidated major road in the community)

Obiga Community

The households of Obiga migrated from Umumgbede in Asa-Amata, northwest of the area, due to the prolific hunting and availability of water. Obiga is made up of four (4) villages – Umuokoagu, Umuokeye, Umuoji and Umuchigbu and is located three kilometres southwest of the project site and is divided by the expressway. The area is generally rural and characterised by low density string development. There is also a large market centre in this area.

Figure 6-4: Representative Housing Obiga Community

Ogwe-Orgwu

Ogwe-Orgwu is located approximately 3 kilometres to the northwest of the project site and consists of a single village in the Ogwe community, made up of five (5) families – Umuogwa, Umuopara, Umunwakwonta, Umuayara and Umunwa-ulu. This area is generally more dense than most of the other communities within the

project area of influence and would be characterised as semi-rural with dense clustering of houses. This area also contains a religious centre/church and a train line

Umuaka community

Umuaka community located 4-5 km directly west of the project site and is made-up of twelve (12) villages – Umuebo-Okolia, Umuebo, Umukwuru, Umuochukwu, Umuada, Umuabali, Abali Ukwu na Okoro, Umuachankwu, Umuobike, Umuodeke, Umudubo and Umuelekwa. It is fairly populated and could be considered more urban than the other surrounding areas.

Ihie-iyi community

Inhabitants of the Ihie-Iyi community migrated from Ngwuikwu in Isialangwa North Local Government Area (LGA). They settled in the community (Ihie-iyi) as of abundant land for farming. Ihie-iyi is made up of ten (10) villages, namely Ihie-ukwu, Amapu-umuba, Amo-orji, Ihie-etiti, Amuozu, Umu-nneato, Umuamuka, Umuakara, Umu-okpa, and Umu-umuogu-umuba. Village heads (Onyeisi-ala) are picked from these ten villages as a representative in the Ihie-iyi community leadership structure. This community is located to the northeast and is located along the expressway. It is, therefore, more commercialised than the other communities in the project area of influence. Housing is low to medium density in this area and there are at least 5 churches/religious centres in this community. Development generally increases north of this area, towards the urban area and regional capital area of Aba.

Figure 6-5: Ihie-iyi Community

Owo-Ala community

Owo-Ala is made up of five (5) villages namely Umunta, Obumbu, Umumkpeke, Umuagu and Umuogbuji. Each of the five (5) villages is equitably represented in the community leadership. Farming activities serve as their primary occupation while trading among others as their secondary occupation. This area is located 4-5 km to the southeast of the site and is more sparsely populated than some of the other surrounding communities and would be characterised as rural.

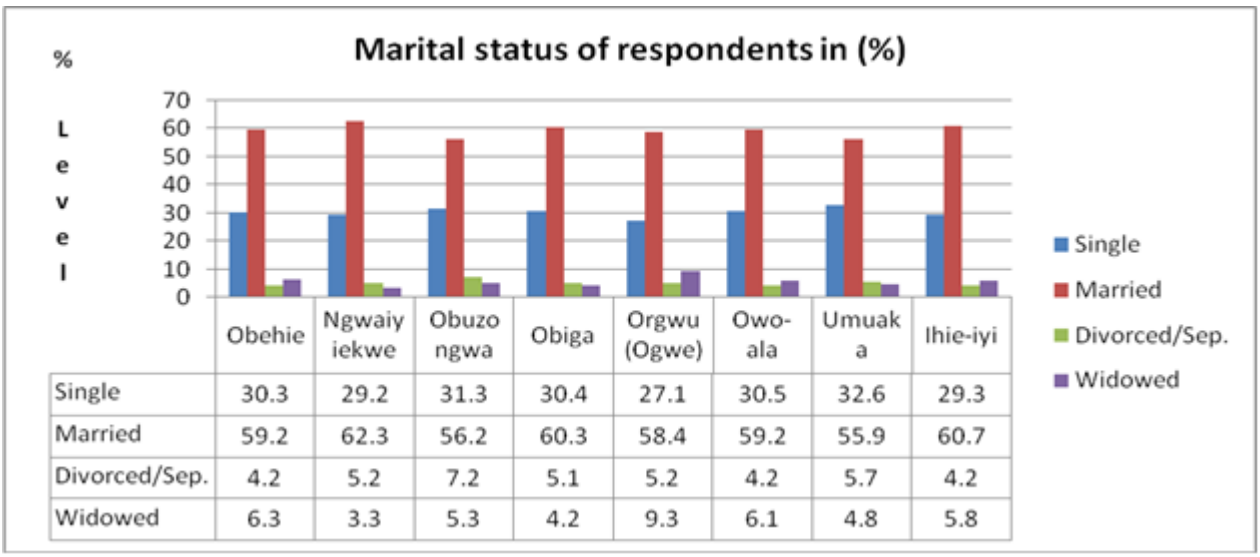
Household Composition, Structure and Size

According to the household survey and field observations, the communities within the Project Area of Influence are permanent communities. They are all considered rural settlements with varying degrees of commercial development. The housing pattern, type and structure of the settlements are consistent with a typical rural setting. The major influence on the pattern of settlements is the kinship/lineage ties and land ownership rights. In other words, family play a major role in the proximity of houses to each other and who people's neighbours are. While in the urban in larger urban centres in Nigeria, housing patterns and physical settings are characteristically nucleated clusters, with transportation routes and accessibility playing much of a role in settlement expansion. In Abia State which is more rural, housing settlements are generally scattered.

Sizes of households vary from community to community within the study area, influenced by the cultural economy, educational status/awareness of the resident population, and cultural practices. According to a 2006 Niger Delta Regional Master Plan Development survey, large households are more prevalent in rural areas (NDDC 2006). The household survey of the studied communities revealed that households in the project area consist of approximately 7.6 per family. In terms of household make up, women have an average of 5 children in the house and households typically also include a minimum of 2 and a maximum of 5 non-dependant members, making the average household size approximately 10.

According to respondents, the large household sizes were attributed to several cultural and socio-economic influences in the area. In the Niger Delta, marriage at a young age is considered a socio-cultural norm. Also polygamy has some prevalence in the community as well as the taking of mistresses and other informal arrangements. On average, about 59.1% of the sampled respondents are married while about 30.1% are single (Figure 6-6). Those divorced/separated and those living as a widow account to about 5.2% and 5.6% respectively.

Figure 6-6 : Marital Status within Project Area of Influence



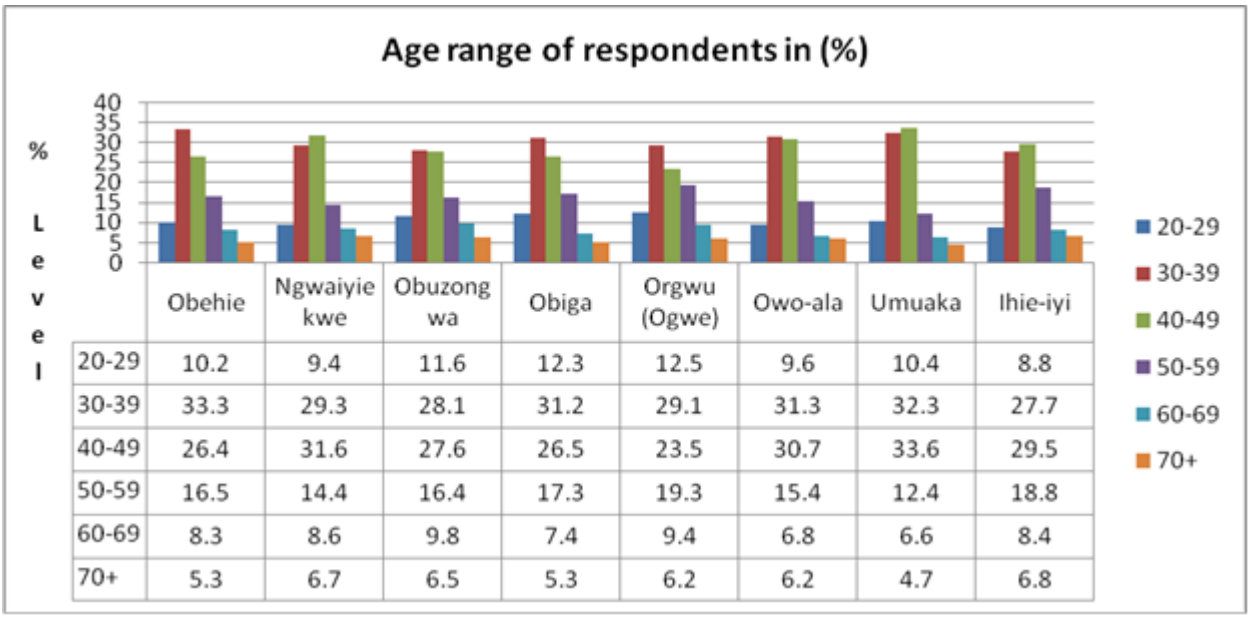
	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
Single	30.3	29.2	31.3	30.4	27.1	30.5	32.6	29.3
Married	59.2	62.3	56.2	60.3	58.4	59.2	55.9	60.7
Divorced/Sep.	4.2	5.2	7.2	5.1	5.2	4.2	5.7	4.2
Widowed	6.3	3.3	5.3	4.2	9.3	6.1	4.8	5.8

The household structure of in the communities within the Project Area of Influence parallel the patriarchal leadership structure of Nigerian society. Men are typically the head of Nigerian households and there are overwhelmingly more male (93%) heads of households than females (7%) in the Niger Delta. The three different

types of male-headed household structures are traditional (one husband and one spouse), polygamous, and single male (male with no spouse, including widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

The socio-economic survey response indicates that most of those surveyed were adults of at least 20 years old (Figure 6-7). On the average, about 24.6% and 30.3% of the communities' respondents were respectively in the 20-29 and 30-49 years age brackets, while about 16.3% were aged 50-59 years and those aged 60 and above is about 14.1%. Sex distribution of the population in the community shows a disproportionate sex structure. The field survey also included more male than female respondents, approximately 60.8% males and 39.2% females, which roughly matches the communities' population structures in the Region. According to the 1991 census, females out-numbered the males in the Nigeria. However, surveys carried out in the course of the Niger Delta Master Plan development process show that there are actually more males (54%) than females (46%) in the Region.

Figure 6-7 : Age of Survey Respondents



	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
20-29	10.2	9.4	11.6	12.3	12.5	9.6	10.4	8.8
30-39	33.3	29.3	28.1	31.2	29.1	31.3	32.3	27.7
40-49	26.4	31.6	27.6	26.5	23.5	30.7	33.6	29.5
50-59	16.5	14.4	16.4	17.3	19.3	15.4	12.4	18.8
60-69	8.3	8.6	9.8	7.4	9.4	6.8	6.6	8.4
70+	5.3	6.7	6.5	5.3	6.2	6.2	4.7	6.8

Ethnic Characteristics in the Project Area of Influence

The area predominantly consists of members of the Igbo ethnic group that have, over the years, traded and inter-married with other groups like the Ikwere, Etche, Opobo, Ogoni, Ibibio, and Bony. These ethnic groups share common cultural and social affinities with respect to marriage ceremonies, dressing patterns and festivals.

Religion and Cultural Heritage

Each of the affected communities described in the project area of influence contains sacred site(s), including shrines to Amadi-oha (the god of Thunder and Lightning), although this deity has declined in local popularity as a result of Christian influences. In December, many communities celebrate Ekpe (a masquerade event). At Umuaka community, there is an idol (Ohuogu and Ihuali) that is consulted for matrimonial problems. This shrine is also believed to provide protection during war. The project area of influence also contain churches including the Anglican Church, Catholic Churches, Assemblies of God Church, Redeemed Christian Church of God and Living Faith Church (Winners Chapel), Evangelical Christian Church, Christ Apostolic Church etc., in the communities.

The communities are now predominantly Christian and public primary schools in the area originated via the Christian Missionary Service (CMS) or Anglican Communion. In addition to these denominations, several Pentecostal sects like the Christ Embassy, Faith Apostolic Church, Church of God Mission, Christ Chosen Church and God's Grace Ministry have emerged as having a strong influence dominant in the communities.

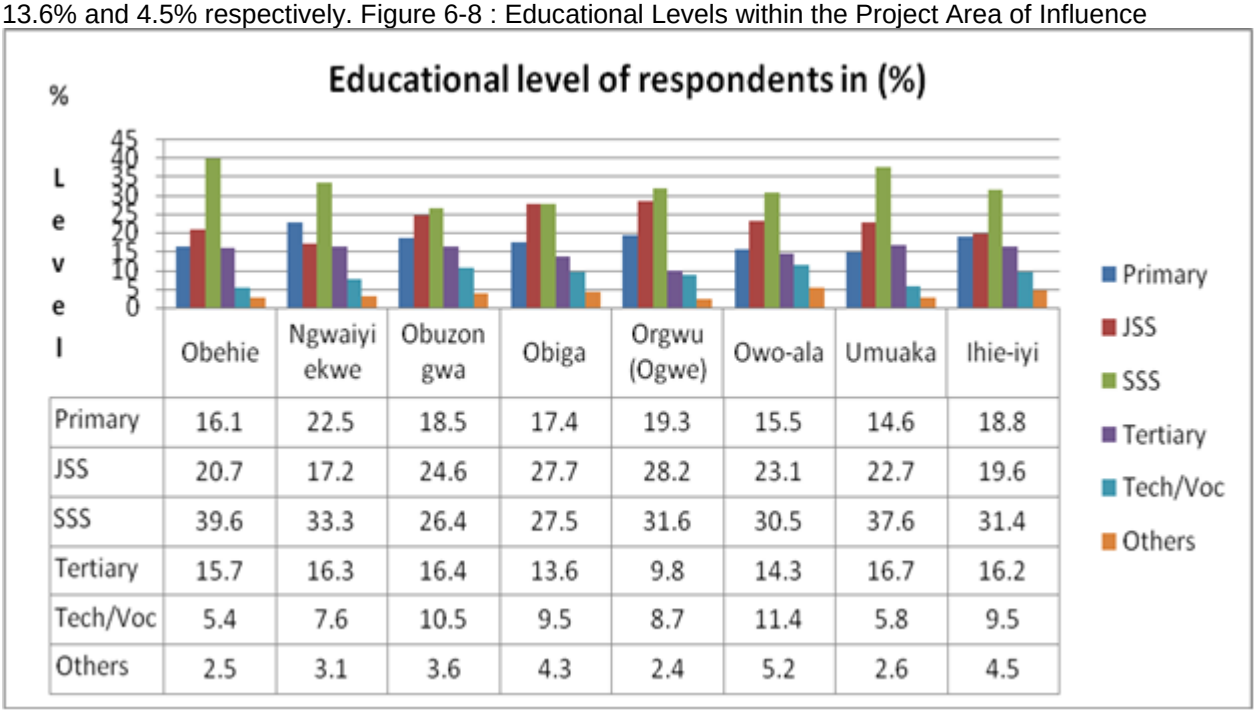
Even though the communities are largely Christian, traditional worship is still prevalent in the communities and numerous family shrines exist in the studied communities.

Sacred groves/shrines exist either within the community's centre or are located on the outskirts of a village in the forests or close to streams/rivers/water-courses. These traditional places of worship are considered important cultural heritage centres for the locals. In general, trespassing in these areas without required permission can cause outrage and mean fines for the trespassers. Seasonal cultural festivals and dances also include revered shrines, for which infringements also attract serious punishments in the communities.

Education

The schooling structure across Nigeria consists of six years of primary education, six years of secondary education (3 years of junior and 3 years of senior secondary) and four years of university of polytechnic education. The adult illiteracy level of the population in the Niger Delta Region is 78.7%. About 65 percent of the total sampled population in the communities surveyed showed having some form of education, with people having primary accounting for about 17.8%, post-primary (junior secondary school (JSS) and senior secondary school (SSS)) educational attainment 29.8% and 32.2% respectively (Figure 6-8). Also about 13.5% of the sampled respondents possessed vocational/technical training while 14.4% also possessed tertiary education. About 11.9% of the respondents do not have any formal educational training. The actual proportion of the population without any formal education in the study area may actually be higher as respondents tended to be younger and lack of education is more common among older generations.

Survey results showed that currently approximately 55.3% of the boys and 44.7% of the girls are presently attending various schools within and outside the communities. About 36.8% and 30.3% of the school age children in the households are currently attending primary and secondary schools respectively. However, the levels of vocational training and skill acquisition of respondents' children in the studied community are about 14.8%. Children in the process of attaining some tertiary education and other forms of education amounted to 13.6% and 4.5% respectively. Figure 6-8 : Educational Levels within the Project Area of Influence



Level	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
Primary	16.1	22.5	18.5	17.4	19.3	15.5	14.6	18.8
JSS	20.7	17.2	24.6	27.7	28.2	23.1	22.7	19.6
SSS	39.6	33.3	26.4	27.5	31.6	30.5	37.6	31.4
Tertiary	15.7	16.3	16.4	13.6	9.8	14.3	16.7	16.2
Tech/Voc	5.4	7.6	10.5	9.5	8.7	11.4	5.8	9.5
Others	2.5	3.1	3.6	4.3	2.4	5.2	2.6	4.5

For the 18.2% of those surveyed that do not have all their children in school, this was attributed it to lack of resources resulting on the inability to sponsor their school education. In most of the communities studied such as Obehie, Ihie-iyi, Orgwu (Ogwe), and Ngwaiyiekwe, there are private schools. Approximately 55.5% of the respondents send their children to public school, while 44.5% are in private school.

Migration

According to regional data, the majority, approximately 65-70% of the population, in the study area LGAs are considered non-migrants. According to the household survey conducted, the majority in the study area have spent a greater part of their life in the communities. Results showed that approximately 75.4% of the respondents in the surveyed community on the average have lived in the communities their whole lives since birth without migrating. Approximately 5.7% have spent over 20 years in the communities and migrated there. Approximately 9.5% migrated into the community within the last 11-20 years, and 9.4 migrated into the communities within the last 10 years.

Most of the respondents are considered mainly 'natives' of the communities and out migration is very uncommon with the exception of for temporary periods for work.

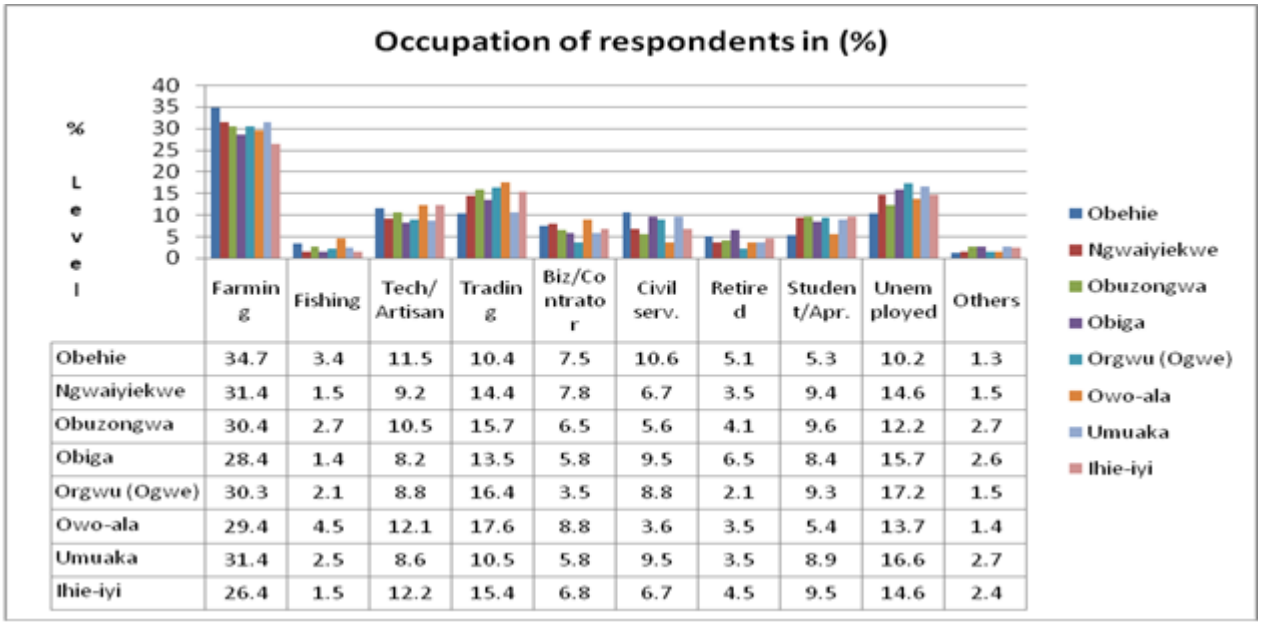
6.1.4 Local Ethnic and Vulnerable Groups

There are a wide variety of ethnicities in Nigeria however, based on the findings of the socio-economic survey completed for the Project, there are no local ethnic or vulnerable groups living within or directly adjacent to the Project site. There are other vulnerable groups that were identified within the LGAs and larger project region by the survey respondents and focus groups such as disabled people and marginalised, but according to the findings these groups were not detected within the study area of influence. Therefore, issues associated with impacts to Indigenous Peoples from the project are not considered further in this assessment.

6.1.5 Economic Profile

According to survey responses and focus group discussions, the inhabitants of the surveyed communities are predominantly farmers. The principal crops planted are yam, plantain, cassava, oil palm plantation, cocoyam, banana, maize, melon, pepper and vegetables. As illustrated in Figure 6-9, survey results showed that farming, fishing and trading account for about 49.8% of the primary occupation of the people, with fishing being a very small contribution of 2.4% of the population. Approximately 9.8% of the population engages in technical/artisan jobs.

Figure 6-9 : Occupations within the Project Area of Influence



	Farming	Fishing	Tech/ Artisan	Trading	Biz/Contrator	Civil serv.	Retired	Student/Apr.	Unemployed	Others
Obehie	34.7	3.4	11.5	10.4	7.5	10.6	5.1	5.3	10.2	1.3
Ngwaiyiekwe	31.4	1.5	9.2	14.4	7.8	6.7	3.5	9.4	14.6	1.5
Obuzongwa	30.4	2.7	10.5	15.7	6.5	5.6	4.1	9.6	12.2	2.7
Obiga	28.4	1.4	8.2	13.5	5.8	9.5	6.5	8.4	15.7	2.6
Orgwu (Ogwe)	30.3	2.1	8.8	16.4	3.5	8.8	2.1	9.3	17.2	1.5
Owo-ala	29.4	4.5	12.1	17.6	8.8	3.6	3.5	5.4	13.7	1.4
Umuaka	31.4	2.5	8.6	10.5	5.8	9.5	3.5	8.9	16.6	2.7
Ihie-iyi	26.4	1.5	12.2	15.4	6.8	6.7	4.5	9.5	14.6	2.4

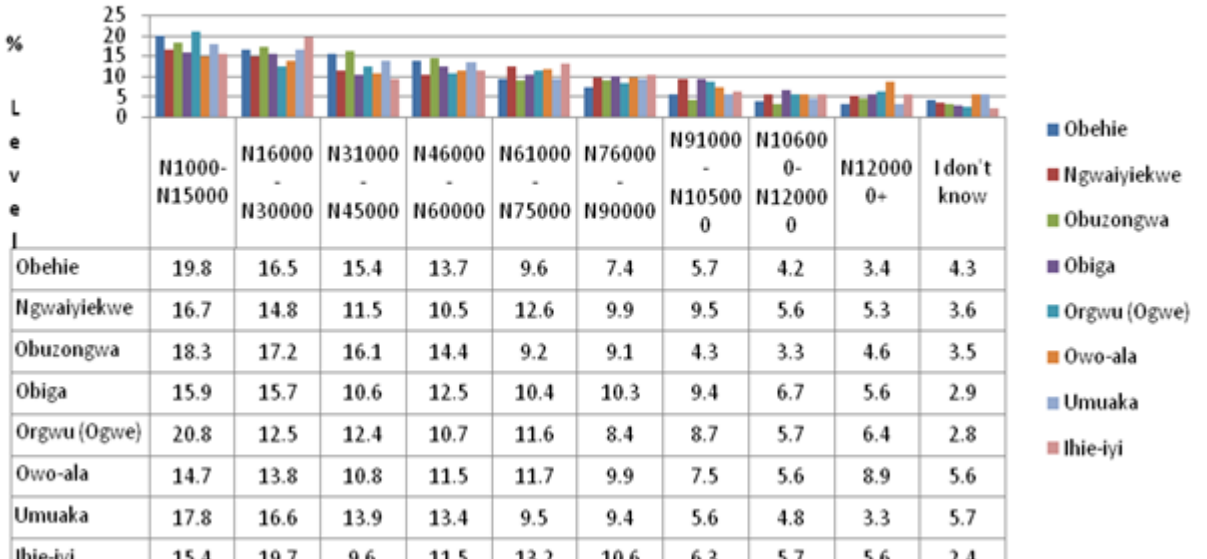
Other economic activities include business/contracting consisting of 6.8% and unemployment which constitute 12.6%. About 21% of the sampled population are civil servants, students/apprentice or retired.

6.1.6 Income

In Nigeria personal income levels of self-employed rural households are always difficult to determine because most people do not keep records and as such, are uncertain of their actual income. Many household members also engage in several income-generating activities and the respective contributions and find it difficult to keep track of the total. Therefore, reported income levels can be considered somewhat unreliable.

In any event, the results of the socio-economic survey suggest that the majority of respondents (17.4%) earning NGN1, 000–15,000 (approximately $5-75 US per month), which is considered a low income (Figure 6-10). Approximately 15.8% of the population had income in the higher bracket of NGN 16,000-30,000 ($75-150 US), and about 12.5% earn between 31,000-45,000 ($150-225 US). Also, about 12.3% and 10.9% earn between NGN 46,000-NGN60,000 ($230-300 US) and NGN61,000-NGN75,000 ($300-375 US) respectively. While 9.4% of the population earn between NGN 76,000-NGN 90,000 ($375-450 US) and a significant proportion of the population (17.7%) earn above NGN 90,000 ($450 US) in a month. Approximately 4% do not know their estimated earnings per month.

Figure 6-10 : Estimated Income within the Project Area of Influence



% Level	N1000-N15000	N16000-N30000	N31000-N45000	N46000-N60000	N61000-N75000	N76000-N90000	N91000-N105000	N106000-N120000	N120000+	I don't know
Obehie	19.8	16.5	15.4	13.7	9.6	7.4	5.7	4.2	3.4	4.3
Ngwaiyiekwe	16.7	14.8	11.5	10.5	12.6	9.9	9.5	5.6	5.3	3.6
Obuzongwa	18.3	17.2	16.1	14.4	9.2	9.1	4.3	3.3	4.6	3.5
Obiga	15.9	15.7	10.6	12.5	10.4	10.3	9.4	6.7	5.6	2.9
Orgwu (Ogwe)	20.8	12.5	12.4	10.7	11.6	8.4	8.7	5.7	6.4	2.8
Owo-ala	14.7	13.8	10.8	11.5	11.7	9.9	7.5	5.6	8.9	5.6
Umuaka	17.8	16.6	13.9	13.4	9.5	9.4	5.6	4.8	3.3	5.7
Ihie-iyi	15.4	19.7	9.6	11.5	13.2	10.6	6.3	5.7	5.6	2.4

6.1.7 Community Infrastructure

The survey showed that the communities in the Project Area of Influence generally have access to some basic social amenities, like borehole water which are provided by the state government, NDDC, and EU. A breakdown of current community facilities is provided in Table 6-4. It is also worthy of note, that some other basic amenities are lacking in the communities. For example, there are no health centres in some of the communities, and most of the communities where health centres exist, are either not functional or have no health workers.

Examples of this include the Obuzongwa health centre, Ihie-iyi health centre and Obehie health centre. People generally rely on private rather than public health centres. In case of serious health conditions, the patient is usually taking to the hospital in Aba for treatment. There is a power supply in all the affected communities, while some complained of having frequent outages such as the Owo-ala community. Public water boreholes are also lacking in some of the communities, and even when present, it is often not functional as in the Obehie, Ngwaiyiekwe, Obuzongwa, Obiga, Orgwu (Ogwe) and Owo-ala communities.

A safe and reliable water supply is currently available to only a small percentage of the population in the Niger Delta Region. In the supply systems surveyed and reported in the NDRDMP Report (NDDC 2006), about 8% of the population actually enjoys water supply in urban and rural centres, while only 3% of the population in rural villages.

Table 6-4 : Social infrastructural facilities in the Project Area of Influence

Community	Type of infrastructure	Provider/Donor	Functional
Obehie	Borehole water by defunct Oil Mineral Producing Areas Development Commission (OMPADEC)	Defunct OMPADEC	No
	Health centre	By State government	Yes, functional
	Power supply by defunct PHCN	Defunct PHCN	Yes, but there is need for electrification expansion to areas in the community that had not been wired.
	Market with open shops by Nkwa West LGA	By Nkwa West LGA	Yes, functional
	Primary School (Obehie Central School)	By State Government	Yes, functional
	Secondary (Community Secondary School)	By State Government	Yes, functional
	Other Primary and Secondary Schools	By Private individual	Yes, functional
Ngwaiyiekwe	Public Borehole water	By community self-effort in collaboration with the Presidential Task Force PTF	Not functional
	Market	By community self-effort	Yes, functional but in dilapidated state
	Hospital	Private	Functioning
	Health centre	By Nkwa West LGA	Yes, existing but not functioning
	Primary School (Community Primary School)	By State Government	Yes, functioning
	Secondary School	Nil	Nil, attend secondary education in the neighbouring communities.
Obuzongwa	Borehole water	By Niger Delta Development Commission (NDDC)	Not functional. The Sound proof generator and sumo (pump) was also

			vandalized.
	Kindred civic hall	By community self help	Not yet completed (abandoned)
	Power supply transformer	By NDDC	Yes, functional and relatively stable
	Telecommunication mast	By MTN (a multinational mobile telecommunications company), Nigeria	
	Market (Open market shops)	By NDDC/ International Fund for Agricultural Development (IFAD)	Ongoing project – 90% completion
	Primary School (Isimanu Community School)	By State Government	Yes, functional
	Secondary School	Nil	Nil, attend secondary education in the neighbouring communities.
	OMA IPP site junction	OMA IPP	Ongoing
	Health centre	By State Government	Yes, functional with only a nurse in charge and no visiting doctor
Obiga	Mono-pump	By State Government	Yes, functional
	Borehole water	By NDDC	Not functional. The generating set had been vandalized.
	Primary School (Migrant Farmers Primary School)	By State Government	Yes, functional
	Transformer	By NDDC	Yes, functional
	Civic Hall	By community Self help	Yes, in use but dilapidated
	Health centre	By MDG	Yes, functioning but in a dilapidated state. Does not have visiting doctor but has a nurse.
Orgwu (Ogwe)	Borehole water	By community self help	Not functional
	Power supply	By defunct PNCH	Yes, functional but erratic in supply.
	Primary and Secondary School (none)		Nil, although there exist primary and secondary school in Ogwe where Orgwu village is part of.

Owo-ala	Health centre	By NDDC	Not functional
	Mono-pump	By State Government	Yes, functional
	Primary School (Migrant Farmers Primary School)	By State Government	Yes, functional
	Secondary School	Nil	Nil, attend secondary education in the neighbouring communities.
	Power supply	By defunct PHCN	Yes, functional but sporadic in supply.
Ihie-iyi	Six (6) borehole water supply	By State Government and other Developmental agencies	Yes, four (4) functional while two (2) are not functional.
	Transformer	By defunct PHCN	Yes, functional but sporadic in supply.
	Market	By community self help	Yes, functional but not fully in use.
	Health centre	By Ugwunagbo LGA	Yes, functional
	Borehole water	By British American Tobacco Foundation	Not functional
	Two (2) Primary School (Ihie-iyi Community and Amapu Migrant Primary School)	By State Government	Yes, functional
	Secondary School (Community Comprehensive Secondary School)	By State Government	Yes, functional
Umuaka	Mono-pump	By State Government	Yes, fully functional
	Town Hall	By community self help	Yes, in use but dilapidated
	Health centre	By Ukwa West LGA	Yes, exist but not fully functional
	Primary School (Community primary School)	By State government	Yes, functional
	Secondary School (Community Secondary School)	By State government	Yes, functional

The local population utilises a mix of transportation modes including cars, trucks, buses, as well as travelling on foot and motor bicycles known as Okada (Figure 6-11), and tricycles (keke) within the local community. However, outside the communities the main form of transport is bicycles, motor-cycles and buses. Common destinations for most residents, outside their communities, include Aba town, Ekeakpara market and the LGA headquarters. During the rainy season various ponds developed along the roads which make sections of the roads difficult to pass with vehicles.

Figure 6-11 : Transportation in Project Area of Influence

Access to public communication facilities like mobile telecommunications are available in most of the communities, although network connectivity tends to fluctuate.

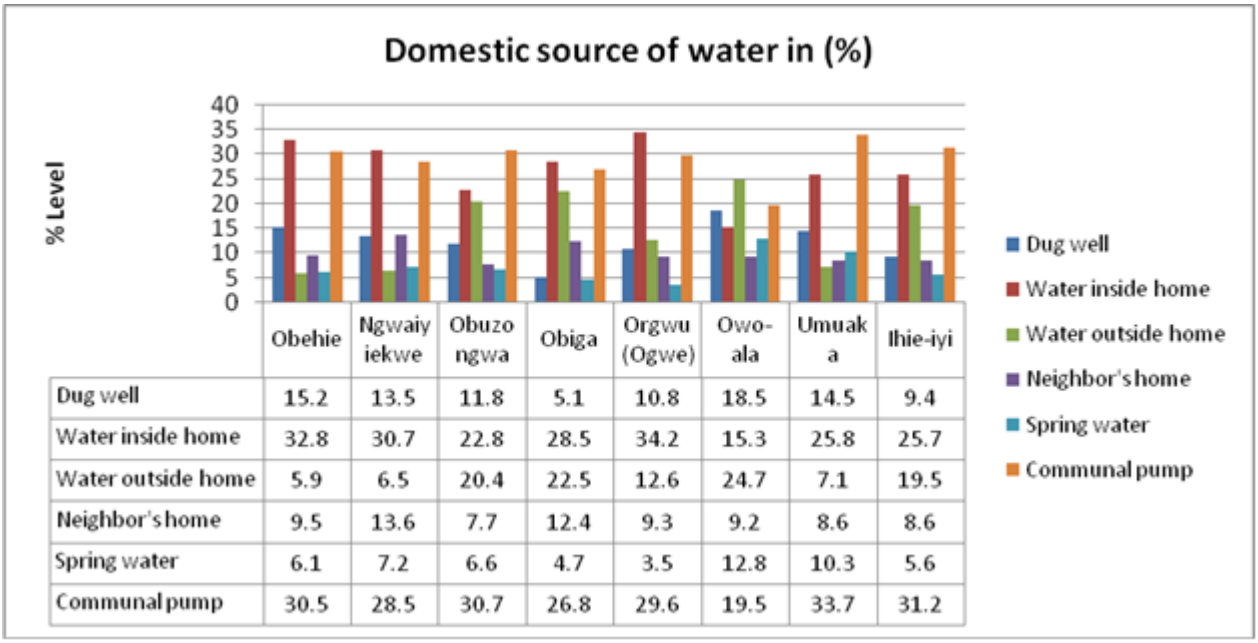
Major challenges identified by the community during the focus groups in terms of existing infrastructure include:

- Unreliable power supply, and neglect of stand-by generators that incur high costs of fuelling and maintenance;
- Very poor maintenance, leading to deterioration of facilities, leaking water pipes which interrupt supply;
- Poor management systems including planning, supervision, regulatory enforcement and billing, rendering the system not viable.

6.1.8 Water Supply and Sanitation

According to the survey responses in terms of water supply 12.3% rely on dug well as a source of domestic water, 26.9% had the water source inside their home, 14.9% get water outside their home, and 9.8% depend on their neighbours for water (Figure 6-12). Responses showed that 7.1% depend on spring water and 28.8% of the population depend on communal water. Those households with a source of domestic water supply outside their home reported that it is within 100-500 meters of their home. When asked if they have had problems in the course of getting water, 54.5% responded ‘yes’ while 45.5% said ‘no’. Of the 54.5% who had problems, 15.5% attributed it to pipe leakage, 30.7% sanitation issues, 7.6% felt that water was too expensive, 30.7% had access difficulties, and 15.5% complained of low quality of the water. According to the survey 70% of the population depend on these water sources for drinking, while the other 30% use it for washing of clothes, cooking and domestic uses only.

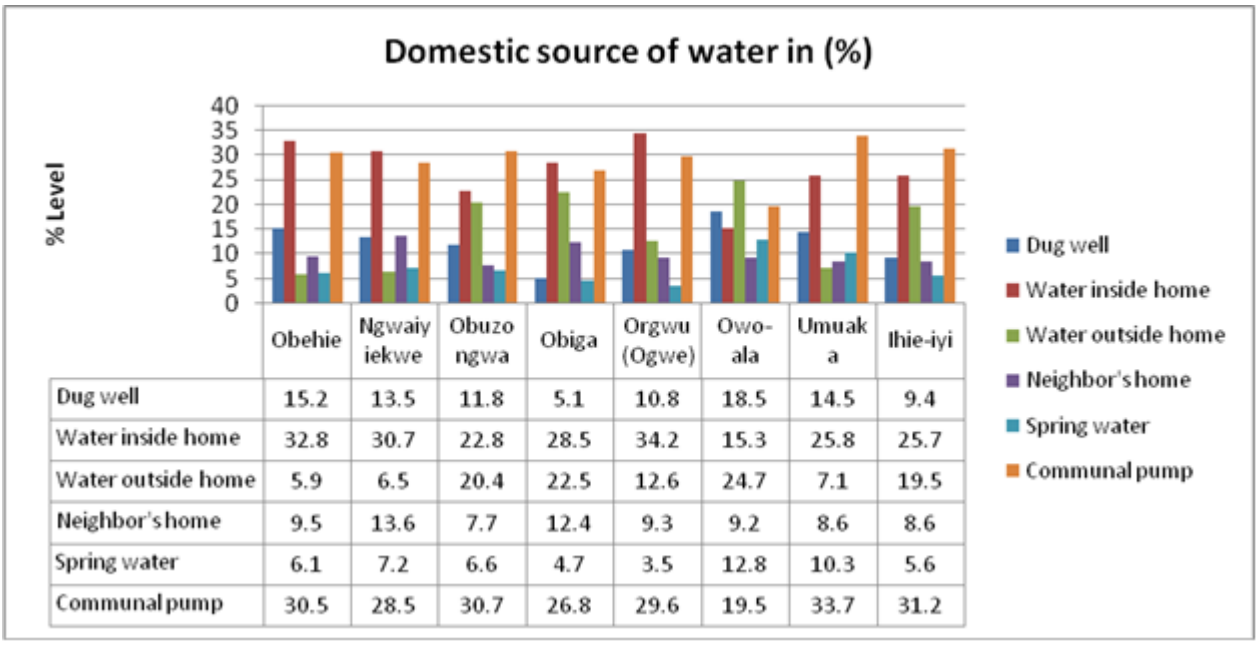
Figure 6-12 : Domestic source of water in the surveyed communities



	Obehie	Ngwaiy iekwe	Obuzo ngwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuak a	Ihie-iyi
Dug well	15.2	13.5	11.8	5.1	10.8	18.5	14.5	9.4
Water inside home	32.8	30.7	22.8	28.5	34.2	15.3	25.8	25.7
Water outside home	5.9	6.5	20.4	22.5	12.6	24.7	7.1	19.5
Neighbor's home	9.5	13.6	7.7	12.4	9.3	9.2	8.6	8.6
Spring water	6.1	7.2	6.6	4.7	3.5	12.8	10.3	5.6
Communal pump	30.5	28.5	30.7	26.8	29.6	19.5	33.7	31.2

Apart from water supply, the survey also reported the types of sanitation facilities used in these communities. On average, 24.1% use interior toilet with flush tank, 11.7% exterior toilet with flush tank, 55.1% pit latrine, and 9.1% use ventilated improved pit toilets. Therefore more than half of the communities reported using pit latrines, which raises safety concerns associated with the local water supply.

Figure 6-13 : Type of sanitation used in the communities



	Obehie	Ngwaiy iekwe	Obuzo ngwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuak a	Ihie-iyi
Dug well	15.2	13.5	11.8	5.1	10.8	18.5	14.5	9.4
Water inside home	32.8	30.7	22.8	28.5	34.2	15.3	25.8	25.7
Water outside home	5.9	6.5	20.4	22.5	12.6	24.7	7.1	19.5
Neighbor's home	9.5	13.6	7.7	12.4	9.3	9.2	8.6	8.6
Spring water	6.1	7.2	6.6	4.7	3.5	12.8	10.3	5.6
Communal pump	30.5	28.5	30.7	26.8	29.6	19.5	33.7	31.2

Survey data indicate that waste management in the communities is by the following methods: 6.6% of respondents have solid waste collected by waste provider, 26.7% is disposed by the children of the household and dumped in the communal dump site, 40% is burned, while 26% of respondents bury waste (Figure 6-13). Overall, observation in the community revealed that solid waste management in the communities is generally poor. Wastes were seen dumped indiscriminately in backyards and frequently along the roadway.

6.1.9 Community Health Profile

Survey results show that on the average, 36.4% of the respondents household have permanent/chronic disease/health problem while 63.6% do not. The 36.4% reported to having cholera, typhoid fever, persistent waist pain, malaria, arthritis, and eye problems (short and long sightedness). Most residents have visited at least one hospital or more for a check-up and/or treatment. On the average, 45.4% said to have visited a hospital in the past year. Meanwhile, 9.1% of the respondents suffered water-borne diseases in the last year.

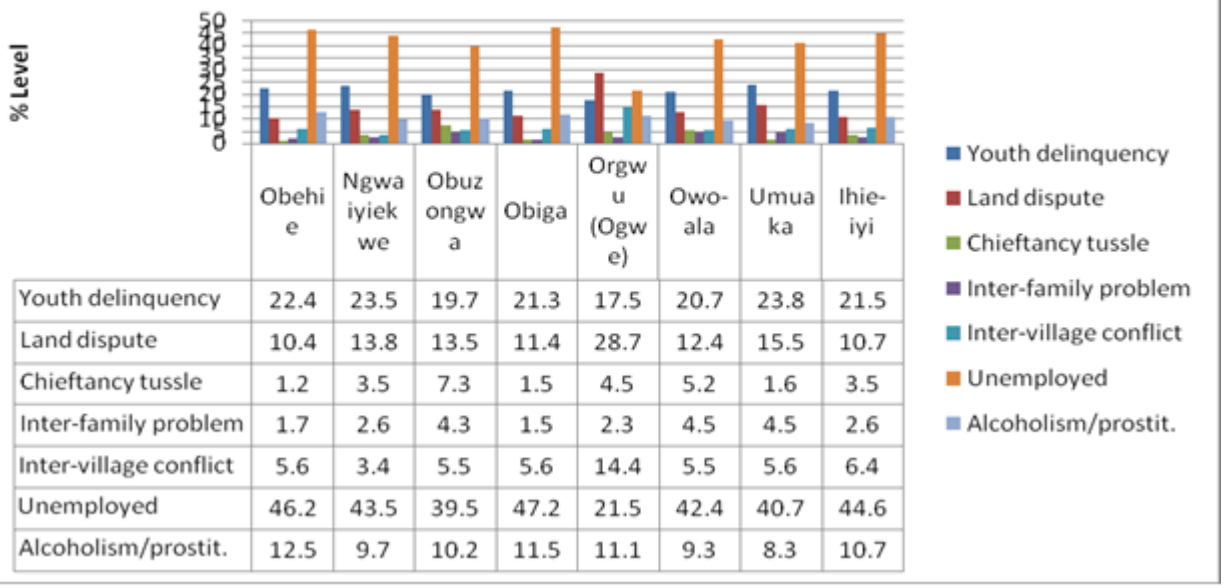
The nearest hospital is in Aba, which is about 20-30 minutes' drive. As stated above, many of the local public health care centres are not functional. Staff levels are also limited. For example, at Obehie, there is no doctor and only two nurses on the ground. At Ihie-iyi there is only one nurse and in Obuzongwa the only nurse also works elsewhere and is frequently not available. At Obiga, Umuaka, and Owo-ala, there are currently no medical staff available. Approximately 95% of the existing health centres have no electricity. In fact, the health centres are generally un-equipped. No ambulances are available in case of emergency.

There is still relatively little information available at the community level on HIV/AIDS in Nigeria. It is considered taboo to report HIV/AIDs, so statistics are difficult to obtain. On whether the population is aware of HIV/AIDS, survey respondents reported that they are aware of the virus. Awareness campaign has been carried out in Nigeria in even very rural communities through the National Agency for the Control of AIDS (NACA), health workers, and ultimately through the word of mouth. Despite this, 5% of respondents still reported that they believe that HIV/AIDS does not exist. Survey respondents reported that their household members have gone for an HIV/AIDS test, but many reported being afraid of the test results and opted not to follow-up. Respondents reported to believing that knowledge that you have the virus is enough to kill you, therefore it is better not to know. Respondents did report taking precautionary measures to prevent HIV spread such as abstinence, same partner, and use of condoms.

6.1.10 Social Structures

As shown in Figure 6-14, existing community challenges reported during the focus groups included youth delinquency, land disputes, chieftaincy conflicts, inter-family problem, inter-village conflict, unemployment and alcoholism/prostitution. Youth delinquency and unemployment were identified as the most prevalent social problems in the area at 21.3% and 40.7% respectively. The next highest categories include land disputes at 14.5%, 10.4% alcoholism/prostitution, 6.5% inter-village conflict, 3.5% chieftaincy disputes, and 3% inter-family problems.

Figure 6-14 : Types of social problem affecting communities



	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
Youth delinquency	22.4	23.5	19.7	21.3	17.5	20.7	23.8	21.5
Land dispute	10.4	13.8	13.5	11.4	28.7	12.4	15.5	10.7
Chieftancy tussle	1.2	3.5	7.3	1.5	4.5	5.2	1.6	3.5
Inter-family problem	1.7	2.6	4.3	1.5	2.3	4.5	4.5	2.6
Inter-village conflict	5.6	3.4	5.5	5.6	14.4	5.5	5.6	6.4
Unemployed	46.2	43.5	39.5	47.2	21.5	42.4	40.7	44.6
Alcoholism/prostit.	12.5	9.7	10.2	11.5	11.1	9.3	8.3	10.7

6.1.11 Housing Types

The housing type in the surveyed communities is typical of a rural area, consisting predominantly of block cement houses as well as mud houses with zinc roofs. According to the survey, 6.2% of the housing types are mud with thatch roof, 11.7% mud houses with zinc roof, 6.1% wood/plank with zinc roof, 6.2 % zinc with zinc roof, while concrete houses with zinc roof represent 65.2%, and those identified as other housing types (likely shanty housing) account for about 4.6% (Figure 6-16). Typical housing is depicted in Figure 6-16 below.

Figure 6-15 : Typical housing types

(a) 

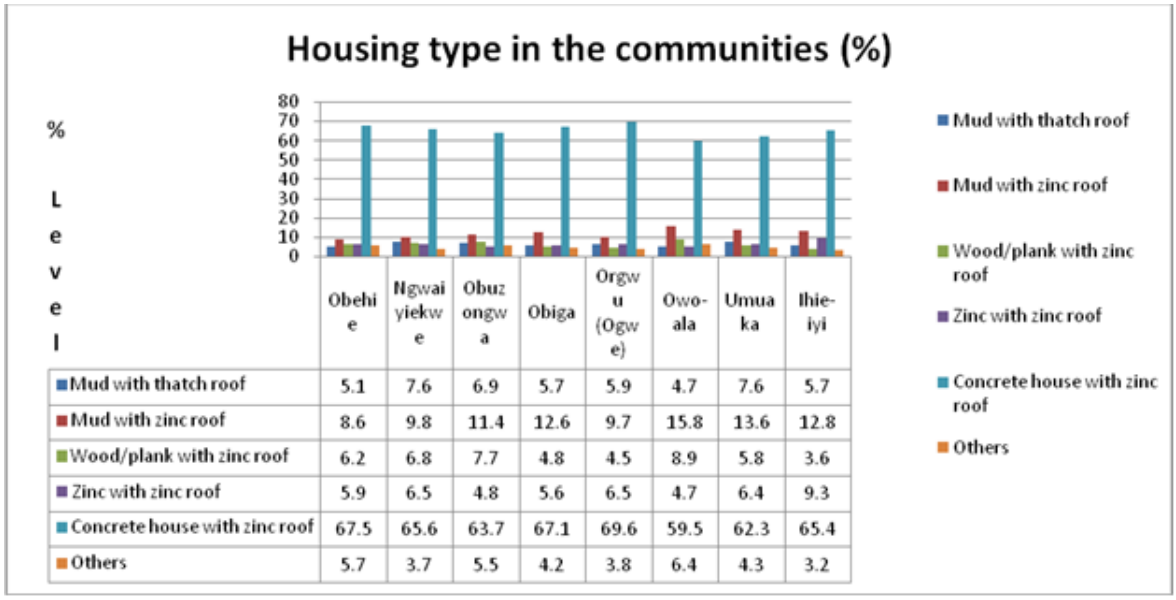
(b) 

(c) 

(d) 

(a) and (b) Block houses with zinc roofs
(c) Block house with aluminium roof
(d) Mud house with zinc roof

Figure 6-16 : Housing type in the communities



	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
Mud with thatch roof	5.1	7.6	6.9	5.7	5.9	4.7	7.6	5.7
Mud with zinc roof	8.6	9.8	11.4	12.6	9.7	15.8	13.6	12.8
Wood/plank with zinc roof	6.2	6.8	7.7	4.8	4.5	8.9	5.8	3.6
Zinc with zinc roof	5.9	6.5	4.8	5.6	6.5	4.7	6.4	9.3
Concrete house with zinc roof	67.5	65.6	63.7	67.1	69.6	59.5	62.3	65.4
Others	5.7	3.7	5.5	4.2	3.8	6.4	4.3	3.2

The common house plan in the communities is 4 rooms and a big parlour giving a total of five rooms. In most cases, husband and wife share two rooms while the children take the other two. The kitchen is often built separately from the main house, typically made of mud walls with thatch roof, or mud with zinc roof.

6.1.12 Project Site and Surroundings

The project site is located within the Ukwa West LGA and 620m east of the Ugwunagbo LGA, within Abia State, in the south eastern geopolitical zone of Nigeria. The total land take for the project is approximately 22.3 hectares, which is currently vacant.

The land in and around the project area largely comprises farmland (mostly with a cassava crop) and fallow land at various stages of regeneration. Much of the natural vegetation has been modified or cleared by farming and other anthropogenic activities. There are no natural watercourses on or immediately surrounding the site, and no associated aquatic habitats. The region is low-lying, and characterised by heavy rainfall

Eight communities are located within around 5km of the proposed project site. Farming is the primary economic activity. The existing road network varies in condition; the A3 is the nearest main road to the site, from which site access will be. A train line also runs approximately 2km from the site.

6.1.13 Ecosystem Services

The IFC PS6 guidance now recognises the importance of ecosystem services, whereby if a project is likely to adversely impact on ecosystem services, as determined by the impact assessment process, a systematic review to identify priority ecosystem services, and any impacts on Affected Communities must be avoided and impacts on the ecosystem services minimised. Ecosystem services are addressed within IFC PS6 however it is a multi-disciplinary topic and cross cutting issue which is relevant to several performance standards.

Ecosystem services are defined by the IFC (2012) as the benefits that people, including businesses, derive from ecosystems. They are organized into four types: (1) provisioning services (the products people obtain from ecosystems); (2) regulating services (the benefits people obtain from the regulation of ecosystem processes); (3) cultural services (the nonmaterial benefits people obtain from ecosystems); and (4) supporting services (the natural processes that maintain the other services). These would be relevant to the Project in terms of any medicinal plants, timber for charcoal and any lowland rainforest resources affected.

6.2 Legal and Regulatory Framework

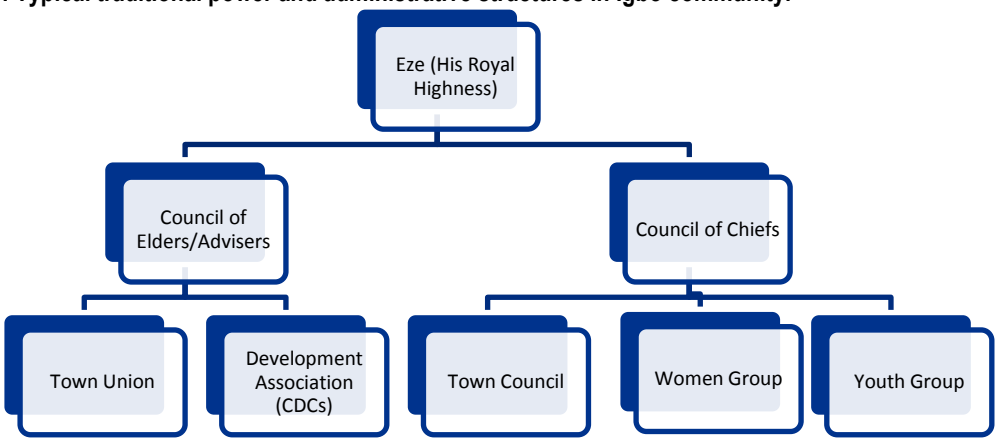
6.2.1 Traditional Governance

The traditional ruler known as the Eze is the current traditional leader of the local communities. The office of the Eze is elective and rotational. Anyone elected Eze occupies the office for life except if dethroned by the community for working against their interests, committing a heinous crime or if medically incapacitated. The Eze is assisted directly by a Cabinet made up entirely by males, mostly appointed by him. Members are chiefs and distinguished indigenes appointed to the cabinet by the Eze. They function as the Eze's advisers and aides.

Along with the Eze, the Town Union administers communities' affairs. The Town Union is responsible for policy formulation and development planning. Each of the constituent villages in the two communities has a Village Head selected from the kindreds (extended families) that make up the village. The Village Heads report to the Eze and his cabinet.

The typical traditional power and administrative structures are shown in Figure 6-17, for Igbo community.

Figure 6-17 : Typical traditional power and administrative structures in Igbo community.



In addition to these there are also the women and youth groups. Membership of these groups is voluntary for all eligible members. Women are eligible for membership into the women's group by birth or marriage into the community, while eligibility into the youth group is by birth for people of both sexes aged between 18 and 40 years. The "elders" (women and men) in the community are attributed a high level of authority because of their experience and are often decision-makers on behalf of the community.

Conflict Resolution

Typically, the household head, the leadership of the socio-cultural groups and the Eze's council are all institutions relied on to resolve intra-communal conflicts, depending on their origin and the level at which they occurred. The leadership of the Christian denominations in the communities also play key roles in the resolution of conflicts, especially among their members. Traditionally, the apex body for conflict resolution in the community is the Eze and the Cabinet. Their decisions on intra communal matters are usually final and binding on the parties involved but they may also decide to seek redress in the courts of law. Criminal offences are usually handed over to the police and not handled by the community.

Security

Security is provided in the area by the Nigeria Police which has a Divisional Police office at Mbaso, a community in the Ugwunagbo LGA. There are also units of the Joint Military Task Force (JTF) on security located in some of the local communities. These are assisted by local vigilante groups in the communities. The presence of the

JTF was caused by incidences of kidnapping of persons for ransom which was experienced in Ihie and Ogwe communities between 2009 and 2010. There have been no reported incidents in these areas since 2011.

6.2.2 Land Use and Management

Nigerian Land Use Act of 1978

Since 1978, the major legislation regulating land acquisition within Nigeria is the Land Use Act of 1978 which states that all land in a State is to be held in trust by the State Governor for the benefit of all Nigerians. By law, foreigners may also acquire land wherever it is located in the country from either the State governments or from other holders.

Since the Land Use Act confers all land to the respective State government, a prospective buyer can apply to the Governor of the State for a Certificate of Occupancy which is for a period of 99 years.

However, The Federal Government of Nigeria also has power to grant Certificate of Occupancy in respect of lands comprised in the Federal Capital Territory (i.e., Abuja and its designated environs), or vested in the Federal Government but located in States' territories.

Local Governments may also grant 'customary Certificate of Occupancy' where the land in question is not in an urban area. An application to the particular Government must be made, or any appropriate owner, for the issuance of a right of occupancy which is called the Certificate of Occupancy

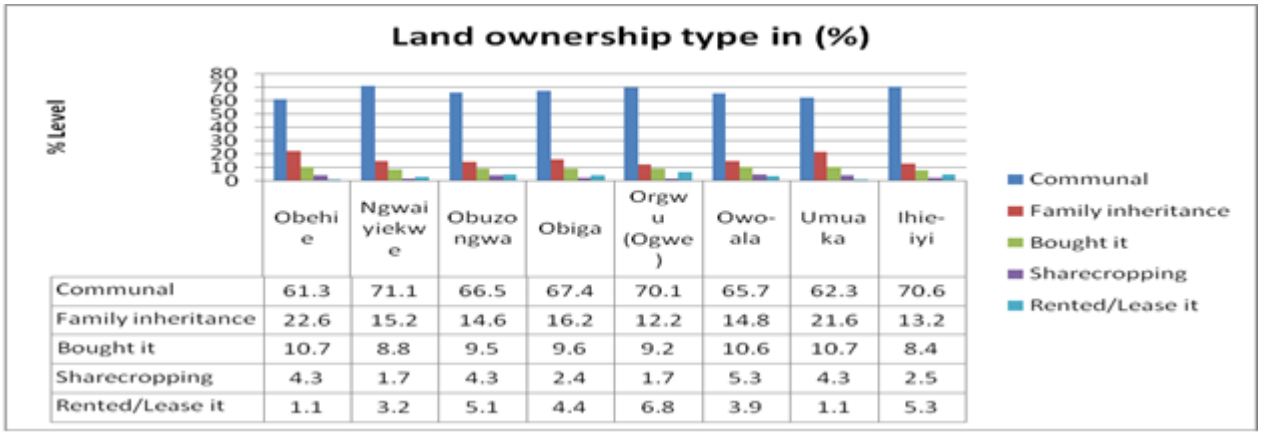
Land Ownership Tenure System in the Project Area

Generally, land is considered Nigeria's most important long-term resource and can be a very contentious issue in many areas where land availability is limited. Land in Nigeria falls under four broad ownership classifications which consist of individually-owned, family-owned, communally-owned, and government-owned lands. The two forms of land-ownership that are most common in the studied communities are *family* inheritance and *communal land ownership*. Certain lands in the communities are owned by the founding families, known as family ownership managed by the eldest man in the family, while some portions of land are equally owned by the entire community.

The six principal methods of land acquisition in the project vicinity include: inheritance, purchase, lease, pledge, exchange, and gift. Lands are frequently passed down through family inheritance. In recent times as urbanisation increases in villages and towns, private individual or company ownership of land is becoming more common, even being sold to those from outside of the community. Lands made available to government and corporations (oil companies) for major public projects/utilities (schools, hospitals/clinics for example) often come from communally owned land as well as lands used by the community to set-up civic centre/town hall, markets, schools and places of religious worship.

According to the survey (Figure 6-18), 66.8% of lands in the Project Area of Influence are communally owned, 16.3% owned by family inheritance, 9.6% individually purchased, while 3.3% are utilised via sharecropping and 4% rented/leased. In terms of farming in the study area, arable land is generally used for sharecropping for between 2 and 5 years.

Figure 6-18 : Local Land ownership System According to Survey Respondents



	Obehie	Ngwaiyiekwe	Obuzongwa	Obiga	Orgwu (Ogwe)	Owo-ala	Umuaka	Ihie-iyi
Communal	61.3	71.1	66.5	67.4	70.1	65.7	62.3	70.6
Family inheritance	22.6	15.2	14.6	16.2	12.2	14.8	21.6	13.2
Bought it	10.7	8.8	9.5	9.6	9.2	10.6	10.7	8.4
Sharecropping	4.3	1.7	4.3	2.4	1.7	5.3	4.3	2.5
Rented/Lease it	1.1	3.2	5.1	4.4	6.8	3.9	1.1	5.3

The site is currently vacant and was purchased from two families at market price in 2013. The site was acquired pursuant to the Land Use Act, and cash payments were made to representatives of the families via local banks using bank drafts. Each representative signed the land sale documents along with the representatives of Main Infrastructure Limited. The land was not inhabited at the time of purchase and therefore, resettlement was not required in addition to the acquisition.

The families as described in the land sale documents are:

1. Umunwankwonta kindred family, with their address as Orgwu village, Ogwe, Asa in Ukwa West Local Government Area of Abia State and;

2. Umuwulu kindred family, with their address as Orgwu village, Ogwe Asa, in Ukwa West Local Government Area, Abia state.

There are likely many individual conventional families subsumed under the kindred families and this was factored into the agreed price. Documentation of the purchase was verified and can be provided as required. The site is now fenced, owned and secured by OPGCL.

The land purchase was completed on a willing buyer, willing seller basis and no involuntary resettlement was required. No subsequent meetings were required further to the acquisition, however, during the ESIA review, the land owners were consulted about the siting of the project on their land and other potential socio-economic impacts of the project.

6.2.3 Occupational Health & Safety

Unlike other aspects of the report, there is no baseline for occupational health and safety to refer to so only impacts and mitigation aspects are considered with respect to this. Specific occupational health and safety issues associated with power projects include the potential for exposure to confined spaces, heat, air quality and noise impacts.

7. Environmental and Social Impact Assessment Methodology

7.1 Overview of the ESIA Process

An ESIA is a systematic, scientific and participatory process to assess potential environmental and social impacts of a development, including consideration of project alternatives and cumulative impacts with other planned developments. The ESIA process ensures that new developments, and extensions to existing developments, are located and designed in such a way as to minimise environmental and social impacts.

The objectives of an ESIA are:

- To identify environmental constraints and opportunities within the study area, taking account of the characteristics of the development and the local environment;
- To identify potential impacts and interpret the nature of these impacts;
- To describe the mitigation measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment, including the appropriateness of avoidance and prevention measures; and
- To determine the significance of any residual environmental effects following mitigation measures
- To underpin the ESMP for implementation, management, monitoring and reporting of mitigation measures.

7.2 The ESIA Study Report

This document is the ESIA study report; the following sections present an overview of the general impact assessment methodology applied to the assessment of potential impacts arising from the project elements. The findings of this assessment relevant to each of the environmental and social aspects listed in Sections 5 and 6 are outlined in Section 8, with a description of any mitigation measures required outlined in Section 9. Impacts predicted as being of medium to high significance prior to the consideration of mitigation are assessed against appropriate mitigation measures to predict the residual impact significance.

This ESIA Study Report is supplemented by the Environmental and Social Management Plan which is provided as Section 10 of the ESIA. The ESMP summarises the mitigation action plan and shows how these will be implemented, managed, monitored and reported.

This ESIA Study Report enables the WBG, local community and other key stakeholders to determine whether or not the proposals (including recommended mitigation) are acceptable. This report also informs the permitting process as the recommended mitigation measures and other actions included in the ESMP form conditions of the Permit.

In order to evaluate environmental impacts and determine their effects and significance, it is important that assessment criteria are identified. The various methodologies that have been used within each specialist area or discipline are made clear within the appropriate sections of this ESIA Study Report.

Each specialist impact assessment section includes the following information:

- **Predicted effects:** an evaluation of the proposed project's impacts in quantitative and qualitative terms. In general, the effect of an impact is assessed by a combination of sensitivity of the environment and the degree of alteration from the baseline state (both positive and negative) which can be predicted. Environmental sensitivity may be categorised by a multitude of factors such as the threat to a rare or endangered species, transformation of landscapes or changes to soil quality or land use. Impacts can have both direct and indirect effects, be cumulative, short-term, medium-term or long-term, permanent or temporary and have positive or negative effects. Impacts can be analysed in terms of the source of pollution and the pathways by which they travel to arrive at a receptor;

- **Significance of effects:** Project impacts are determined to be 'significant' or 'not significant'. Significance is a combination of magnitude and sensitivity to change and is evaluated in terms of the geographic effect, duration and frequency, irreversibility, and any regulatory standards which may apply. For effects where an assessment of significance cannot be determined (e.g. for reasons of uncertainty), this issue will be highlighted and an explanation given as to why significance could not be determined.
- **Mitigation measures:** a description of the measures proposed to minimise potential significant adverse effects; and
- **Residual impacts:** determination of the project's remaining level of effect after all the required and recommended mitigation measures are implemented.

7.3 Procedure for Assessment of Environmental Impacts and their significance

The methodology developed and adopted for the impact assessments provides a tool for assessing and evaluating the significance of effects and is based on the following criteria:

- The type of effect (i.e. whether it is positive/acceptable, negative/unacceptable, neutral or uncertain);
- Duration and/or frequency of occurrence (short-term/frequent, long-term/long return period, intermittent);
- The policy importance or sensitivity of the resource under consideration in a geographical context (whether it is international, national, regional or local, as defined in Table 7-1); and
- The magnitude of the effect in relation to the resource that has been evaluated, quantified if possible, or rated qualitatively as high, medium or low, as defined in Table 7-2.

Both professional judgement and the results of modelling analysis are used to assess the findings in relation to each of these criteria to give an assessment of significance for each effect. Effects are considered to be major, minor or negligible and can be negative or positive. Where positive impacts are identified mitigation is not required.

Table 7-1: Geographical Context and Policy Importance

Geographical Context	Topic Definition
International	Important at global, African or trans-boundary levels
National	Important in the context of Nigeria
Regional	Important in the context of Abi State
District	Important in the context of the Ugwunagbo and Ukwa West LGAs
Local	Important within the site and up to 1 km from the site

Table 7-2: Magnitude Criteria

Magnitude of effect	Negative effects	Positive effects
High	Widespread community concern. Failure to meet legal compliance requirements. Fatality or serious health disability. Severe or possibly irreversible damage to an important ecosystem or resource.	Widespread community benefit. High contribution to safety or prevention of fatalities. High level of technology transfer. Prevents serious damage to an important ecosystem or resource.

Magnitude of effect	Negative effects	Positive effects
Medium	Local community opposition and levels of complaint. Regulatory concerns. Lost time injury or short-term health effects. Medium-term damage to an ecosystem or resource.	Contributes to local development and economy. Provides confidence to regulators. Prevents medium-term damage to an ecosystem or resource.
Low	Minor community opposition or complaints. Able to comply with legal requirements. Local/minor health effects requiring short-term treatment. Short-term, minor damage to an ecosystem or resource.	Low level of community support. Economic benefits not distributed locally.

As a guide Table 7-3 presents a significance evaluation tool which calculates the significance of the effect by a combination of importance/ sensitivity and magnitude.

Table 7-3: Evaluation of Significance of Effect

Sensitivity of Impact	Magnitude of Impact		
	Low	Medium	High
International	Minor / Major	Major	Major
National	Minor / Major	Major	Major
Regional	Minor / Major	Minor / Major	Major
District	Negligible / Minor	Minor / Major	Minor / Major
Local	Negligible	Minor	Minor / Major

Mitigation measures are measures proposed through the consideration of alternatives, physical design, project management or operation to avoid, reduce or remedy any significant adverse effects on people and the environment resulting from the proposed development.

The mitigation strategy employed is a hierarchical one which aims to primarily avoid potential impacts, to reduce those that remain, and lastly, where no other measures are possible, put forward compensatory measures. This approach is outlined as follows:

- Minimisation of environmental effects through avoidance and therefore minimising the number of reduction and remediation measures required to be ‘built-in’ to the project design;
- Minimisation of any remaining potential effects (e.g. by the use of appropriate construction methods or timing); and
- Thirdly, where avoidance or reduction are not feasible, measures to remedy any remaining effects predominantly during the construction phase of the project have been promoted (e.g. habitat management and landscaping proposals).

7.4 Other Developments and Cumulative Effect Assessment

It is a key part of any ESIA process that the additional or cumulative impacts associated with nearby existing or proposed developments, or where relevant any trans-boundary effects, be considered, and the results reported. This cumulative effect assessment is concerned with identifying situations where a number of effects from separate projects combine to cause a significant effect on a particular resource.

Projects being developed by others can be considered if operational, under construction, holding permits or in the permitting process. The details of the existing and proposed surrounding developments are provided in

Section 8. The cumulative impacts, taking into consideration these existing and potential developments, have been assessed for each environmental and aspect and findings are included in Section 8.

An ESMP has been produced as part of the ESIA and is presented in Section 10. The ESMP is sufficiently robust to support International Lending requirements as stipulated in IFC Performance Standard 1 – Environmental and Social Assessment and meet the requirements of the EPA EIA requirements.

The ESMP ranks and prioritises recommended environmental and social actions, describing time period for implementation. In addition, the ESMP indicates the roles and responsibilities of project personnel and third parties such as local and regional administrations and sub-contractors.

The ESMP will be developed into a full Environmental and Social Management System (ESMS) that will be aligned with ISO14001 that provides a formal and internationally acceptable structure that will be the central repository for all environmental and social plans and procedures. The ESMP will be reviewed and updated (as needed) throughout the duration of the project.

8. Associated and Potential Impacts[7]

8.1 Overview

8.1.1 Impacts associated with main project components

According to the Nigerian Environmental Impact Assessment Act of 1992, impact assessment is required for all major public and private projects that might significantly affect the environment. This process is intended to provide reasoned predictions of the possible consequences of a proposed development project or activity as well as recommend mitigation measures to minimize, eliminate or offset those aspects that will adversely impact on the environment.

This chapter describes the impacts or changes to the existing environment that could occur as a result of the proposed power plant project. The procedure for assessment of impacts and the terminology of the assessment is outlined in Section 7. The procedure involves matching the various activities of the proposed project (as described in Section 4 of this report) with the components of the existing environment (as described in Sections 5 and 6). The proposed mitigation measures to mitigate against the impacts identified are presented in Section 9. Section 9 also includes an assessment of residual impacts for any impact which cannot be fully mitigated or for which a high level of uncertainty exists for the efficacy of the mitigation measure.

Sources of potential environmental, health and safety and social impact are considered for the construction phase (Sections 8.2-8.6) followed by those in the operational phase (Section 8.7-8.9) and decommissioning phase (Section 8.10). Section 8.11 considers cumulative impacts that may result from the presence of other existing or planned developments in the area.

A summary of the potential environmental, social and safety impacts (both positive and negative) considered is provided in **Error! Reference source not found.**, below. Positive impacts are indicated in blue.

Table 8-1: Summary of potential environmental, social and safety impacts

Pre- Construction Phase – Environmental Impacts	
Air quality emissions	negligible/minor
Noise emissions	negligible/minor
Loss, of wildlife habitat	minor/major
Loss of vegetation	minor/major
Geology, hydrogeology and hydrology impacts	minor
Impacts of pre-construction waste generation	minor
Landscape/visual impacts	negligible/minor
Construction Phase – Environmental Impacts	
Air quality emissions	negligible/minor
Noise emissions	minor/major
Loss, degradation or fragmentation of wildlife habitat	minor/major
Loss of vegetation	minor/major
Contamination of ecological habitats	minor/major
Geology, hydrogeology and hydrology impacts including soil erosion, contamination of ground and groundwater and presence of unknown contaminants in soil and groundwater.	minor

[7] The language in this section consists of the original BGI text , but has been supplemented by the summary of impacts table provided byJacobs.

Impacts of construction waste generation	minor/major
Presence of demolition/construction plant and construction of power plant on landscape	minor/major
Construction Phase – Health and Safety Impacts	
Injury or death from workplace accidents and incidents	minor/major
Injury/ death/ damage to assets due to road traffic incidents	minor/major
Injury to personnel during site clearing and equipment operation	minor/major
Construction Phase – Social Impacts	
Creation of employment	minor/major
General economic development from indirect employment	minor
Impact of influx of jobseekers on social conflict, disease and security	minor/major
Increased economic activity and financial empowerment of local residents	minor/major
Operational Phase – Environmental Impacts	
Air quality impacts	negligible/minor
Energy Efficiency and Greenhouse Gas (GHG) Emissions	major
Increases in ambient noise level and vibration	minor/major
Indirect or accidental release of substances and ground contamination effects on local habitats and species	minor
Discharge of sanitary sewage, stormwater and wastewater during operation	minor/major
Accidental contamination of groundwater or community supply boreholes.	minor
Increase in waste generation	minor
Fire / explosion	minor/major
Landscape / visual	minor/major
Operational Phase – Health and Safety Impact	
Safety and security risks associated with power plant operations	minor/major
Disease increase	minor
Operational Phase – Social Impacts	
Local employment, business growth & development due to the availability of electricity	minor
Potential impacts on services (indirect employment)	minor
Ecosystem services	minor
Decommissioning – Environmental, Health and Safety, and Social Impacts	
Air emissions including fugitive dust, and exhaust fumes/dust from vehicles	negligible/minor
Noise / vibration from demolition activities	minor/major

Loss, degradation, or fragmentation of wildlife habitat	minor
Direct impacts on habitats and species e.g. mortality	minor
Transport of contaminated soils on vehicles and/or introduction/spread of non-native species	minor
Accidental spillage / leaks causing contamination of soils, groundwater and/or surface water, and/or damage to sensitive ecological receptors	minor/major
Mobilisation / excavation of unknown contaminants in soils or groundwater with potential human health effects	minor/major
Pollution of the surrounding environment, and potential harm to human health through improper/uncontrolled management and disposal of wastes	minor/major
Odour from wastes	negligible
Harm to human health and the environment through improper management and disposal of hazardous wastes	minor/major
Visual amenity impacts as a result of plant/machinery required for decommissioning	minor
Injury or harm to site workers / communities as a result of badly designed plant and decommissioning management, or to unsafe working conditions	minor
Asset damage from work place accidents/ incidents	minor
Traffic accidents and congestion	minor/major
Community unrest and conflicts as a result of potential employment uncertainty	minor/major
Exposure to disease	minor/major
Reduction of employment	minor
Community consultation and handling of community grievances	minor/major

8.1.2 Impacts associated with the transmission line

A 300m long section of transmission line is proposed, which is required for Phases 2 and 3 of the project. Given the length of the transmission line and in light of the context of the area adjacent to the main power plant site (as set out in Section 4.4.4), it is not considered that there are any significant environmental, health or social issues associated with the proposed transmission line that require further assessment. The land is not currently in use for farming or grazing and is not considered to be of ecological importance.

Environmental and social impacts of relevance to the transmission line during construction (including pre-construction), operation and decommissioning would be related to:

- a need to protect the soils and surface vegetation during construction;
- labour and working conditions including occupational health and safety; and
- community, health and safety issues associated with the line.

Recommended mitigation is outlined in Section 9.5.

Further development of the ESMP presented within this ESIA prior to construction is however recommended to provide more robust management and mitigation measures in relation to the transmission line. This will be of particular relevance to: construction activities, decommissioning of the transmission line, including post-construction reinstatement of land required for the transmission line towers (or temporarily required for construction of the line), and any associated rights of way.

8.2 Sources of Potential Environmental Impacts during Pre-Construction

Anticipated pre-construction work activities will include:

- Mobilising equipment to the construction site;
- Road grading for access roads; and
- Establishing temporary construction facilities including a worker's camp.

The potential environmental impacts that could occur during the pre-construction phase of the project are summarised in the discussion below.

8.2.1 Air Quality

Heavy duty diesel vehicles could be used to transport equipment to the project site pre-construction. Diesel exhaust is known to contain several compounds that may be detrimental to human health over the long-term with repeated exposure. Although there are no mobile source emission regulations in Nigeria, in keeping with good international industry practices, the proposed project would keep diesel emissions to a minimum. There is also the potential for dust generation during development of the workers camp.

However, air emissions from pre-construction activities are not expected to significantly affect the air quality in the region outside the proposed project site.

Impact Assessment

The magnitude of construction related air quality effects from the project is assessed as minor. The duration of impacts on the surrounding environment will be short-term. Therefore, significance of the effects of the construction activities is assessed as negligible/minor.

Residual Impacts

With implementation of mitigation measures to minimise dust and diesel emissions, impacts would be reduced and would not be considered significant.

8.2.2 Noise

Activities to be undertaken during pre-construction are not anticipate to be a major source of noise. However, there may also be some noise emissions from increased traffic movements. Heavy duty diesel trucks could be used to transport raw equipment to the site and there will be limited noise associated with the development of the workers camp.

Impact Assessment

Pre-construction noise impacts would likely minimal and the magnitude of noise impacts from pre-construction is assessed as minor/negligible. The duration of impacts on the surrounding environment would be short-term. The significance of noise effects from pre-construction activities is, therefore, assessed as minor/negligible. Standard measures for the management of the impact of traffic noise are included within the ESMP.

Residual Impacts

No long term residual noise impacts are anticipated since noise associated with site preparation and development of the workers camp would cease upon completion of these activities. Residual short-term impacts would be limited to the construction area only given the distance to nearby residential receptors, over 400m from the site. Therefore, overall residual noise impacts from construction are anticipated to be negligible.

8.2.3 Ecology

Pre-construction Impacts to habitats and species and may arise from:

- Vehicular traffic;
- Presence of people;
- Development of hardstanding and structure;.
- Noise and vibration from use of machinery;
- Emissions to the air from machinery and dust; and

There will be some habitat and species disturbance during pre-construction. Natural vegetation and plant biodiversity loss would result from site clearing for development of the workers camp. In addition, lack of water, increased exposure to sunlight and lack of nutrients often cause plants to be more prone to stress, disease, and infestation. However, the project area only supports highly disturbed secondary lowland rainforest (which has a lower biodiversity than primary lowland rainforest or less disturbed secondary lowland rainforest). In addition, it is unlikely that there are existing plant species that are unique to the project site.

Impacts could include loss of vegetation during site clearance. Noise/illumination during pre-construction also constitute nuisance to wildlife. The patchy distribution of wildlife in the proposed development area could be attributable to previous forest conversion.

Impact Assessment

Based on all of the above, the magnitude of ecological effects from preconstruction are considered minor/major. However, the effects will be limited and there will be no damage to any species or habitats of concern. Therefore, the significance of the effects of pre-construction activities on ecology is assessed as minor/major prior to mitigation.

Residual Impacts

Residual ecological impacts associated with the pre-construction could include permanent loss of wildlife habitat on the project site and possible relocation to a potentially less favourable habitat for those species that remain in the vicinity of the proposed project site. However, considering that the conservation value of these ecological habitats is considered low, the limited scale of roadway gradin and development of the workers camp, and the fact that there are no protected and vulnerable species populations in the area and given the localised nature of impacts, overall residual impacts on ecology are considered to be of negligible significance.

8.2.4 Geology, Hydrogeology and Hydrology

Soil and water erosion

Clearing and grading for access roads could result in soil erosion. However, because of the relatively flat topography of the construction site, it is expected that soil losses will be minimal. Temporary drainage will be used during the course of pre- construction to accommodate anticipated rainfall and runoff from the disturbed areas.

Impact Assessment

The magnitude of geology, hydrogeology and hydrology effects from pre-construction of the project and associated transmission line is assessed as minor. Because erosion would be minimal, the significance of geology, hydrogeology and hydrology effects from pre-construction is therefore assessed as minor prior to mitigation.

Residual Impacts

With the implementation of appropriate management and mitigation measures to address any potential erosion impacts, the significance of residual impacts is therefore assessed as negligible.

8.2.5 Waste

Pre-construction activities are not anticipated to be a major source of waste. Worker camp construction could result in some solid waste materials, which would be disposed of in accordance with national waste standards.

Impact Assessment

The magnitude of any effect that waste from pre-construction of the project may have on the environment is assessed as minor. The significance of the impact of waste from pre-construction activities is, therefore, assessed as minor.

Residual Impacts

With implementation of mitigation measures to manage waste, impacts would be reduced, and would be considered negligible.

8.2.6 Landscape and Visual

Visual impacts due to landscape modification could be experienced by local residents near the workers camp. However, this facility will likely be small scale and temporary.

Impact Assessment

The magnitude of pre-construction-related landscape and visual effects from the project is assessed as low. The duration of these impacts will be relatively short-term. Therefore, significance of the effects of the pre-construction activities is assessed as minor/negligible.

Residual Impacts

Landscaping of the site will take place post-construction including the workers camp. Soils excavated during pre-construction may be used for landscaping if suitable. Long-term residual impacts would therefore be considered negligible.

8.3 Sources of Potential Environmental Impacts during Construction

8.3.1 Overview

Construction of the power plant will involve the following stages:

- Clearing of vegetation and removal and stockpiling of topsoil;
- Bulk earthworks including site grading and excavation work;
- Establishing and preparing concrete foundations for major plant and buildings; and
- Construction of buildings and installation of equipment followed by commissioning.

The potential environmental impacts that could occur during the construction phase of the project are summarised in the discussion below.

8.3.2 Air Quality

The most significant issues that could potentially impact ambient air quality during construction are combustion gas emissions and nuisance dust. The principal sources of combustion gases would include the operation of a concrete batch plant, diesel powered construction machinery, and vehicle exhaust.

As with any construction site, dust may be generated as a result of surface preparation and earthworks, including earth moving and materials handling. Internal site traffic moving on un-surfaced routes/roads within the development site may cause sufficient disturbance of loose surface materials to generate dust, particularly

during the dry season. However, most roads to the proposed project site are paved and, therefore, dust emissions from traffic movement would be restricted to the site itself.

Heavy duty diesel trucks would be used to transport raw materials such as sand, aggregate and cement to the project site for concrete production. Diesel exhaust is known to contain several compounds that may be detrimental to human health over the long-term with repeated exposure. Exposure of on-site workers to diesel exhaust could be significant. Diesel exhaust emissions from construction vehicles for the project would be generated on a short-term basis. Although there are no mobile source emission regulations in Nigeria, in keeping with good international industry practices, the proposed project would keep diesel emissions to a minimum.

Due to the nature of the construction process, potentially dust emitting activities would not be constant and emissions would be limited to the operating periods for each item of plant and the combination of machinery being used at any one time. The location of emission sources would also change as construction progresses. Air emissions from construction activities are not expected to significantly affect the air quality in the region outside the proposed project site. The nearest residential receptors are over 400m from the development site and are therefore unlikely to be affected by construction phase emissions which will be highly localised. The main risks from dust and particulate air emissions generated during construction would be to construction site workers and personnel.

Impact Assessment

The magnitude of construction related air quality effects from the project is assessed as minor/major. The duration of impacts on the surrounding environment will be short-term. Therefore, significance of the effects of the construction activities is assessed as negligible/minor.

Residual Impacts

With implementation of mitigation measures to minimise dust and diesel emissions, impacts would be reduced and would not be considered significant.

8.3.3 Noise

The most significant noise emissions during construction would be associated with the following activities:

- Earthworks and Site Preparation;
- Piling;
- Creation of Hard Standings;
- Construction of Foundations;
- Building Erection; and
- Creation of Roads.

The above construction works are estimated to generate high noise levels in the range 83-87 dB LAeq at a distance of 10m. Therefore, personal hearing protection should be worn by all construction workers. Given the separation distances to the nearest dwellings which are 400m away, construction noise levels are not predicted to impact noise sensitive receptors for any significant duration.

In addition to noise emissions from major construction work, there may also be some noise emissions from increased traffic movements. Heavy duty diesel trucks would be used to transport raw materials such as sand, aggregate and cement to the project site for concrete production.

Impact Assessment

Impacts would be short-term and, as the site is some distance from the nearest sensitive receptors, (over 400m), noise impacts would be considered minimal. As such, the magnitude of noise impacts from construction

of the project on human health or the environment is assessed as minor/major. The duration of impacts on the surrounding environment would be short-term. The significance of noise effects from construction activities is, therefore, assessed as minor/major. Standard measures for the management of the impact of construction and traffic noise are included within the ESMP.

Residual Impacts

No long term residual noise impacts are anticipated since noise associated with site preparation and construction would cease upon completion of these activities. Residual short-term impacts would be limited to the construction area only given the distance to nearby residential receptors, over 400m from the site. The potential impacts to human health for construction workers can be mitigated by the use of appropriate PPE and implementation of adequate work procedures and good management practice. These will be included as actions in the ESMP. Therefore, overall residual noise impacts from construction are anticipated to be negligible.

8.3.4 Ecology

Construction impacts to habitats and species and may arise from:

- Clearance of vegetation;
- Vehicular traffic;
- Presence of people;
- Ground and excavation works;
- Construction of hardstanding and structure;.
- Noise and vibration from use of machinery;
- Emissions to the air from machinery and dust;
- Lighting of the development (on nocturnal species);
- Disturbance to hydrology (sedimentation, drainage); and
- Environmental incidents and accidents (e.g. spillages).

The majority of impacts on ecological resources would occur during construction phase activities. The potential impacts on wildlife and habitat are described in more detail below.

Loss, degradation or fragmentation of wildlife habitat

During the construction process, habitats and species on the project site will be disturbed and/or displaced, and those adjacent to the site have the potential to be disturbed and/or displaced.

Natural vegetation and plant biodiversity loss would result from clearing, grubbing, scalping, removal of trees and stumps, and removal and disposal of all vegetation and debris within the limits of clearing. Vegetation could also be indirectly affected in areas adjacent to clearing. Conditions at the edge of clearings could be altered making it unsuitable to support certain plant species due to changes in the amounts of nutrients, light, and water (i.e., too little or too much). In addition, lack of water, increased exposure to sunlight and lack of nutrients often cause plants to be more prone to stress, disease, and infestation. Thus, some species grow well under cooler, moister, shaded forest conditions, but do not do well on the edge of land where temperature, light, and moisture conditions are different from inside the forest.

It is anticipated that the impacts of ground and vegetation clearing and other associated effects of developing and operating the proposed project will only result in limited loss of some biodiversity at the local level (i.e., within the immediate vicinity of the proposed project). This is due to the fact that the project site is relatively small and only supports highly disturbed secondary lowland rainforest (which has a lower biodiversity than primary lowland rainforest or less disturbed secondary lowland rainforest). In addition, it is unlikely that there are existing plant species that are unique to the project site.

Loss of vegetation

Impacts could include loss of vegetation during construction. Terrestrial vegetation influences elements of the environment including landscape, fauna, microclimate and groundwater. Vegetation clearance causes habitat loss and fragmentation of wildlife migration routes, and would as a result of the interactions between the elements, impact on the associated fauna. Direct impacts during tree felling will include destruction of bird nests and injury/disturbance to arboreal wildlife (including fruit bats, birds and snakes). Noise/illumination during construction and operation activities also constitute nuisance to wildlife. The patchy distribution of wildlife in the proposed development area could be attributable to previous forest conversion. Forest conversion for any purpose results in a reduction in available habitats and wildlife stocks, as well as the probable elimination from particular locales of less adaptive species. However, the conservation status of the small mammals in the area has remained satisfactory (survival not threatened) as they have naturally high fecundity as well as adaptability to changing habitat conditions.

Contamination of ecological habitats

There is the potential for accidental release of contaminants during construction works. The contaminants could migrate into soils and groundwater and pollute ecological habitats and indirectly affect species. Measures to mitigate against impacts to geology, hydrogeology and hydrology are presented in Sections 9.1.5 and 9.4.6.

Impact Assessment

Based on all of the above, the magnitude of ecological effects from construction is considered high, as effects will be irreversible in the construction area. However, the effects will be localised and there will be no damage to any species or habitats of concern. Therefore, the significance of the effects construction activities on ecology is assessed as minor/major prior to mitigation.

Residual Impacts

Residual ecological impacts associated with the proposed project could include permanent loss of wildlife habitat on the project site, minor degradation of wildlife habitat immediately adjacent to the project site, possible relocation to a potentially less favourable habitat for those species that remain in the vicinity of the proposed project site.

Residual ecological impacts associated with the proposed project could include permanent loss of wildlife habitat on the project site, minor degradation of wildlife habitat immediately adjacent to the project site, possible relocation to potentially less favourable habitat of those species that remain around the proposed project site.

However, considering that the conservation value of these ecological habitats is considered low, and the fact that there are no protected and vulnerable species populations in the area and given the localised nature of impacts, overall residual impacts on ecology are considered to be of negligible significance.

8.3.5 Geology, Hydrogeology and Hydrology

Soil and water erosion

Clearing and grubbing activities within the limits of the project site could result in soil erosion. However, because of the relatively flat topography of the construction site, it is expected that soil losses will be minimal. Temporary drainage will be used during the course of construction to accommodate anticipated rainfall and runoff from the disturbed areas.

Fuel / chemical spills

Construction related impacts to soils could occur from the accidental release of contaminants such as fuels and lubricants. These types of materials will likely be stored in the laydown area and possibly in the workers' camp, all of which will remain on site throughout construction. As there are no watercourses present in the vicinity of the site the risks to surface waters is considered to be low, however there is the potential for spills to migrate

into groundwater and potentially contaminate local groundwater supply (as discussed in the Geology, Hydrogeology and Hydrology Impacts Section). This risk will be addressed in the ESMP. Accidental spills could result in localized soil contamination. Given the low quantities of hazardous materials stored and used in the construction phase it is not envisaged that any potential contamination impacts would be significant or long-term.

8.3.6 Unidentified Contamination

There is the potential for unknown soil and groundwater contamination to be encountered during the construction phase. This could cause harm to human health if workers are exposed and may cause harm to the environment if the contamination is mobilised and can migrate into groundwater and / or off-site.

Impact Assessment

The magnitude of geology, hydrogeology and hydrology effects from construction of the project and associated transmission line is assessed as minor/major. Because potential contamination would be localised if it occurs, the significance of geology, hydrogeology and hydrology effects from construction is therefore assessed as minor prior to mitigation.

Residual Impacts

With the implementation of appropriate management and mitigation measures, including prompt emergency response following an accidental release, no long-term impacts to land or water quality are expected and short-term impacts would be low in magnitude and temporary in nature. The significance of residual impacts is therefore assessed as negligible.

8.3.7 Waste

The scale of and severity of waste impacts from construction would depend upon the nature of the waste and the medium into which they are disposed. This is also true of accidental release of waste. Since further details about the timing and amount of waste to be generated by the project are not available at this time, potential impacts cannot be discussed quantitatively. However, the impacts discussed below consider the potential harm that may arise associated with each type of potential impact.

The wastes generated during project construction would include:

- General construction wastes, including cement bags;
- Accumulated concrete washings from washing down empty concrete trucks;
- Building rubble;
- Waste metal (including welding rods, disc cutters, piping etc.);
- Waste oils and lubricants;
- Waste paints and chemicals/ solvents;
- Empty paint, oil and chemical/ solvent containers;
- Empty oxygen and acetylene tanks (if oxy-acetylene welding and cutting required);
- Packaging materials such as wood, cardboard and plastic;
- Scrap metal from construction and packaging;
- Electrical cabling and electrical components;
- Domestic wastes, including food wastes;
- Sewage effluent;
- Paper; and
- Glass.

Typically, the largest component of solid waste from construction would be insulation material, timber, concrete, wiring, etc., which constitutes up to 15% of the total construction materials on site. These wastes are normally routed to a landfill which, given the likely considerable volume of waste material, has the potential to have a negative impact on local communities. As there are no landfills in the area, a waste management programme would be needed to maximise recycling and use appropriate disposal methods for wastes that cannot be recycled.

Paints can contain solvents and heavy metals. The release of paints to the land and/ or water environment can have a significant deleterious effect on the ecosystem to which it is released. Furthermore, paints and coatings used will have a high BOD and COD content, and heavy metals within the paints can have a bioaccumulation effect. Solvents within the paints can have a duel effect by increasing short term VOC concentrations in the air and the generation of low level ozone on decomposition.

The main risk associated with a release of solvents into the ground would be contamination of groundwater and, depending on the volatility of the solvent, could also result in a short-term negative effect on local air quality.

Certain solvents are also carcinogenic and care should be given to their disposal for health and safety reasons. All solvents must be checked prior to disposal.

Untreated sewage effluents would have a deleterious effect upon any receiving waters if released. During the construction phase this impact would be greater than during the operational phases due to the numbers of individuals working on the site at any one time. In order to avoid or reduce this impact, cesspits/portaloos will be used onsite, as a minimum precaution. Any sewage associated with the project will be treated in accordance with national standards and good international industry practice.

Impact Assessment

The magnitude of any effect that waste from construction of the project may have on the environment is assessed as minor/major. The significance of the impact of waste from construction activities is, therefore, assessed as minor/major.

Residual Impacts

With the appropriate mitigation and emergency response measures there are not predicted to be any long-lasting significant environmental impacts. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.3.8 Landscape and Visual

The presence of demolition and construction plant, such as cranes, diggers and scaffolding, as well as the erection of the power plant itself, will result in negative impacts on the surrounding landscape. Visual impacts due to landscape modification will likely be experienced both by local residents and at settlements further afield.

Impact Assessment

The magnitude of construction-related landscape and visual effects from the project is assessed as low. The construction period for Phase 1 of the power plant and the transmission line is expected to be approximately 2 years and 7 months. The duration of impacts of active construction will therefore be relatively short-term. Therefore, significance of the effects of the construction activities is assessed as minor/major.

Residual Impacts

As detailed in the ESMP, landscaping of the site will take place upon completion of construction works. This will both mitigate visual impact and reduce erosion from surface waters during heavy rains and flood periods. Soils excavated during construction may be used for landscaping if suitable. Residual impacts would therefore be considered negligible.

8.4 Sources of Potential Health and Safety Impacts Pre-Construction Phase

8.4.1 Community Health and Safety

During pre-construction, materials will be delivered to the site and there will be a small increase in traffic. This could lead to an increase in the potential for other health related impacts associated such as increases in noise, dust, risk of accidents and exposure to hazardous materials. In order to minimise disturbance and community health and safety concerns, project deliveries will be scheduled for daytime hours whenever possible. The introduction of increased HGV traffic and general increasing traffic volumes presents a safety risk to the community. In addition, there will be the potential for increased road traffic accidents from increased construction traffic. Emergency response for potential accidents during construction will also be an important consideration. Appropriate health and safety standards would need to be applied at the site to address effects these potential community health and safety considerations.

As discussed in the traffic section, a ring-road system will be provided within the site boundary and shall service all the buildings and houses, so as to meet traffic and other requirements of production, daily life and fire-fighting. The road within the plant area shall be the urban type with concrete curbing and a general width of 7.5m. An assessment of the potential impacts on the transport network will be undertaken prior to construction, in order to consider traffic flows and health and safety concerns.

There could also be health and safety impacts associated with mobilisation of equipment for construction of the transmission line if accidents were to occur. However, this will be addressed via a relevant emergency response plan.

Impact Assessment

Community safety impacts from increased roads and traffic is considered of a minor magnitude prior to mitigation. Effects would likely be short-term and localised. Therefore, the significance of effects on community health and safety during pre-construction activities is therefore assessed as minor.

Residual Impacts

With the appropriate mitigation and traffic and noise management measures there are not predicted to be any long-lasting significant environmental impacts. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.5 Sources of Potential Health and Safety Impacts Construction Phase

8.5.1 Occupational Health and Safety

The construction phase of the proposed project will involve activities including, but not limited to: excavation, erection of temporary facilities, foundation preparation, and electrical and mechanical work. These activities will expose the workforce to potential hazards.

Potential occupational health and safety issues during construction activities include:

- Falls and slips;
- Failures of support systems and/or platforms;
- Collision with mobile plant or vehicles;
- Road safety relating to water trucks;
- Exposure to dust and to hazardous materials;
- Burns;
- Crushing by heavy plant or collapse of structures;
- Falling debris;

- Adverse weather conditions;
- Falls into voids during piling; and
- Contact with concrete.

Hazards cited as of particular concern in IFC Thermal Power Plant Guidelines include:

- Non-ionizing radiation;
- Heat;
- Noise;
- Confined spaces;
- Electrical hazards;
- Fire and explosion hazards;
- Chemical hazards; and
- Dust.

The existing dirt access road to the Site will require upgrades/tarring and resurfacing. This may require stripping of topsoil, and filling with sand from a borrow pit. There will also be cutting of trees and woody debris, including the clearance of brush and vegetation within the entire area. This impact is considered to be significant but of short duration.

Impact Assessment

Occupational health and safety impacts will be addressed by conformance with relevant national and international health and safety standards during construction. Effects would likely be short-term and localised and risks would be highest during the peak construction period. Since the magnitude of effects would be considered high if an incident did occur, the significance of effects on occupational health and safety during construction activities is assessed as minor/major, as the likelihood of effects will be low with proper training and conformance to safety standards.

Residual Impacts

Following implementation of appropriate mitigation measures residual impacts would be considered minor/major..

8.5.2 Community Health and Safety

During construction, materials will be delivered to the site and during operations traffic flow is predicted to increase gradually. This would lead to an increase in the potential for other health related impacts associated such as increases in noise, dust, risk of accidents and exposure to hazardous materials. Project deliveries will be scheduled for daytime hours whenever possible due principally to safety reasons. The introduction of increased HGV traffic and general increasing traffic volumes presents a safety risk to the community and to workers. In addition, there will be the potential for increased road traffic accidents from increased construction traffic. Emergency response for potential accidents will also be an important consideration. Appropriate health and safety standards would need to be applied at the site to address effects associated with accidents.

Large numbers of workers on-site during construction could also increase the risk of communicable disease. In addition, dust from construction can cause temporary respiratory effects and possibly exacerbate existing respiratory illnesses for workers. Personal safety issues are also a concern including threats to personal security and property as a result of unruly or disruptive behaviour by workers or other individuals on-site.

Impact Assessment

Community safety impacts from increased traffic on roads, increased risk of communicable diseases and exposure to hazards would be considered of a minor/major magnitude prior to mitigation. Effects would likely be short-term and localised and risks would be highest during the peak construction period. Therefore, the significance of effects on community health and safety during construction activities is therefore assessed as minor/major.

Residual Impacts

With the appropriate mitigation and traffic and noise management measures, there are not predicted to be any long-lasting significant environmental impacts. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.6 Sources of Potential Socio-Economic Impacts - Construction Phase

8.6.1 Creation of Employment and Economic Growth

Employment impacts arising from the construction phase of the project would include:

- Generation of direct employment by the project; and
- Economic development created as a result of indirect employment by suppliers of goods and services to the project.

Direct employment created during construction is considered a beneficial effect of the Project. Employment estimates provided by One Energy provided in March 2015 consist of the following:

During project construction, employment impacts are considered to be largely positive. Current estimates provided by AECOM consist of a peak of 900 construction workers, with an average of 400. The construction period for Phase 1 of the power plant and the transmission line is expected to last approximately 2 years and 7 months. Although it is not clear how many of these jobs will be able to be sourced from the local community, the project will provide a good source of employment and economic growth for the area during construction. Oma and AECOM have confirmed that CMEC will build a worker camp on site, but it is also expected that many of the workforce will come from the local communities and will not require accommodation on site.

Positive Impacts

8.6.2 Direct Employment

The project will have a minor/major beneficial impact on employment during construction and operations, both in the project area of Influence, in the wider geographical region. Considerable construction and operational employment opportunities could be generated and provided that local training of the workforce is undertaken, then the overall benefits of direct employment can be maximised. However, the influx of migrant workers would result in minor adverse impact from the increased demand for services during the construction period which can result in growth challenges for the area.

The project is expected to bring different groups of people together (residents and workers), which has the potential to encourage development of relationships. It is hoped that interactions will lead to the exchange of knowledge and information, and increased knowledge of other places and people. It is also expected that the project will financially empower some local residents and workers.

8.6.3 Indirect Employment

Construction workers and contractors will require numerous vendors, suppliers and service providers to meet the daily operating needs of the project together with the domestic needs of its employees. This could include goods and services such as food vendors, laundry, supply of vehicles and transportation services, security patrols, as well as some construction equipment.

In addition, the project will induce secondary/tertiary economic activity due to the influx of migrants from outside the Project's Area of Influence that will require housing, food, and other types of resources and services. There will be opportunities for utilising local goods and services for the project and related activities.

Typically, 3.2-3.5 jobs in service and supply sectors are created for each direct job generated by oil and gas projects.[8] At the local and regional levels this is likely to stimulate growth in other industries. This would be considered a minor beneficial impact.

Negative Impacts

8.6.4 Social conflicts and increased demand for services due to influx

Despite the considerable employment opportunities offered during construction, the level and range of skills and applicable working experience available in the adjacent communities, particularly in rural areas, is limited by education and relevant skills training. In addition, during the peak construction period, workers from outside the area would likely be required due to the volume of workers required, which may create conflict between in-migrants and the local population. This may create the potential for resentment and further conflict in the community. In addition, as the demand for goods and services in the project area expands during the construction period, there will be a need for additional capacity, training and resources to address the daily commerce needs of the construction workers in particular informal businesses in the area such as food provision which is typically run by women. Lack of understanding of local customs and the meaning of cultural practices by outsiders can also lead to community conflicts. Cultural heritage assets such as sacred groves/shrines could also be affected by the project unless properly managed..

8.6.5 Disease and Security Impacts Associated with Influx

An increase in local population as a result of the recruitment of workers and the phenomenon of camp followers could result in changes in the demographic structure of the communities. The age and sex structure could also be altered because it is envisaged that most workers on the project would be males aged 18-45. The significance of these changes would depend on the number of workers that migrate into the community from outside the area.

Coinciding with the influx of migrant workers is typically an increase in demand for goods and services during the construction period. This can facilitate a rapid expansion in supply-side businesses operating in the area, with associated increases in formal employment and informal labour. This expansion would likely result in additional migration into the area. Entertainment and recreation activities are likely to increase as a result, especially at Ihie junction which lies approximately 200m from the proposed plant site, including at night time.

Whilst the presence of migrant and/or expatriate employees during construction will provide social and economic community benefits, as described above, there is also the potential for negative impacts including the following:

- Inappropriate behaviour and lack of respect for local leadership and cultural norms on the part of non-local or expatriate workers;
- Security issues, including threats to personal security and property as a result of unruly or disruptive behaviour by workers or other individuals on-site;
- Conflict resulting in part from resentment by skilled nationals and local residents if they perceive that expatriates have been hired into jobs for which they are suitably qualified;
- Increased incidence of community conflicts and/or resentment of non-local nationals by local residents due to non-integration with the local community;
- Increased incidence of teenage pregnancies, prostitution and criminal activities in the project area;

[8] Macroeconomic Impacts of the Domestic Oil & Gas Industry, NPC, September 15, 2011 (PWC multipliers used).

- Increased prevalence of HIV/AIDS and other sexually transmitted diseases, both within the workforce and the local community, as a result of large numbers of workers on-site during the peak construction period, and the potentially higher incidence of prostitution;

- Spread of other communicable diseases. If HIV/AIDS increases in the region, there is a high probability that the risk of other associated diseases could increase. The local health system, would likely also be impacted by this;

- Close living conditions, and large numbers of workers and in-migrants sharing sanitation and other facilities, as well as potentially poor hygiene practices, could also increase the risk of respiratory disease, as well as food and water-borne diseases (e.g. cholera, typhoid). In addition, dust from construction would exacerbate respiratory illnesses for workers;

- Increased local demand for consumer goods and housing, with resulting increased prices, resulting in financial hardship and lack of benefits for local people; and

- Increased pressure on infrastructure, services (such as healthcare) and roads, particularly with the establishment of informal settlements.

Impact Assessment

Impacts associated with influx of workers increasing the risk of communicable diseases, social conflicts, and safety and security would be considered a minor/major adverse impact. Effects would likely be short-term and localised and risks would be highest during the peak construction period. It will be necessary for the EPC Contractor and Project parties to ensure appropriate labour and working conditions and that facilities are in place for their workforce.

No impacts on cultural heritage assets are anticipated, however the EPC contractor shall engage with the local community to ensure that any relevant areas are avoided.

Impacts associated with increased economic activity and financial empowerment of local residents would be considered a minor/major positive impact. Effects would likely be relatively short-term, for the duration of construction.

Residual Impacts

Following implementation of appropriate management and measures, social impacts are expected to be reduced to less than significant levels.

8.7 Sources of Potential Environmental Impacts - Operational Phase

Sources of potential environmental impacts that could result from operation and maintenance of the plant are described below.

8.7.1 Air Quality

This section provides an assessment of the potential air quality issues associated with the proposed OMA Power Plant Project. The facility will have a number of air emission sources, which will give rise to emissions of pollutants during the operational phases.

This section provides:

- An outline of the scope of the air quality assessment including a description of the potential sources of emissions to air;
- A method statement detailing the relevant assessment criteria;
- A summary of the baseline conditions;

- A study of the potential air quality impacts during each of the development operational phases;
- Proposed mitigation measures; and
- Predicted residual impacts and conclusions.

An assessment of emissions to air has been undertaken to determine the potential air quality impacts of the proposed OMA Power Plant Project. The assessment has primarily been undertaken using a dispersion modelling technique, and concentrations of pollutants have been predicted at sensitive locations within the vicinity of the development site. The predicted concentrations have been compared to relevant ambient air quality guidelines specified for the protection of human health as described above in section 5.4 and Appendices III and VII.

For the purposes of the air quality assessment, the project has been assessed in three separate phases to determine the full range of potential air quality impacts as follows:

Phase 1: 4 x gas turbines operating in simple cycle mode;

Phase 2: 6 x gas turbines operating in simple cycle mode; and

Phase 3: 6 x gas turbines operating in combined cycle mode (through the addition of waste heat boilers to each gas turbine which will provide steam to two steam turbine generators). At this stage, the exhaust stack location will change from the gas turbine to the waste heat boiler. Two different configurations of HRSG have been assessed for Phase 3, representing both a horizontally aligned Heat Recovery Steam Generator (HRSG) (Phase 3a) and vertically aligned HRSG (Phase 3b).

Sources of Emissions to Air

During the operational phase of the proposed project, atmospheric emissions will principally be generated from the natural gas-fired turbine generators (GTGs). Atmospheric emissions from the GTGs will predominately consist of oxides of nitrogen (NOx), carbon monoxide (CO) and carbon dioxide (CO2). Emissions of other substances associated with the combustion of fossil fuels (e.g. sulphur dioxide and particulate matter) are negligible for the combustion of natural gas and are therefore not included in the air quality assessment.

Oxides of nitrogen – NOx produced from gas turbines comprises nitric oxide (NO) and nitrogen dioxide (NO_2) – the proportion of NO and NO_2 within the exhaust gas varies but typically NO is the predominant species. The NOx emissions are produced during combustion (i.e., the reaction of natural gas with air). NO is less potentially harmful than NO_2 and it is NO_2 that is associated with adverse effects upon human health. NO in the exhaust gas is oxidised in the atmosphere to form NO_2. However, the reverse process converting NO_2 to NO also takes place in the atmosphere.

Carbon Monoxide – CO emissions are a measure of combustion completion as higher values of CO indicate more incomplete combustion or less oxidation of CO to CO_2.

Carbon Dioxide – CO_2 is one of the major greenhouse gases under the United Nations Framework Convention on Climate Change. As stated previously, the proposed project will use natural gas, a less carbon intensive fossil fuel to generate electricity thereby ensuring that the least amount of CO_2 is generated per unit of energy. Further information on greenhouse gas emissions is provided in the air quality section.

On this basis, the assessment of emissions to air focuses on emissions of NOx and CO, as levels of sulphur dioxide and particulate matter are negligible for the combustion of natural gas.

There are no significant sources of odour within the proposed OMA Power Plant facility and therefore odours are not considered further. The proposed development will include emergency generators and a fire pump which are fuelled by diesel. Other than very short periods of testing, these will only operate in emergency situations and are therefore not considered within the air quality assessment.

Emission Limits

The International Finance Corporation (IFC) "Environmental, Health and Safety Guidelines for Thermal Power Plants" specifies emission guidelines for a range of electricity generating combustion plants and those applicable to the proposed OMA Power Plant are shown in Table 8-2.

Table 8-2: IFC Emission Guidelines for Natural Gas-Fuelled Combustion Turbines >50 MWth

Pollutant	Emission Standard, mg/Nm^3* (NDA / DA)
Oxides of Nitrogen (NOx)	51 (25 ppm)

* at 273K, dry gas, 1013 mbar, 15% O_2

These emission guidelines make provision for the current state of ambient air quality in the project area, by means of categorising the receiving atmospheric environment as either a "non-degraded airshed" or a "degraded airshed", with the following definitions:

- Non-degraded airshed (NDA) – if all national legislated and IFC (WHO) air quality standards are complied with; and
- Degraded airshed (DA) - nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly.

In this case, the same emission standard applies for both degraded and non-degraded airsheds. Based on the information regarding existing air quality within the vicinity of the proposed OMA Power Plant facility, the area would be designated as a NDA.

The General Electric Frame 9E gas turbine is proposed to be utilised for the proposed OMA Power Plant facility and the emissions from the proposed gas turbines will meet the IFC emission standard of 51 mg/Nm3 (25 ppm) set out in Table 8-2. The formation of NOx can be controlled by modifying operational parameters of the combustion process. The combustion temperature and air to fuel ratio will be monitored to ensure operations occur at optimal proportions so as to minimise the production of NOx. It is understood that the NOx control system is expected to be a dry low NOx (DLN) system, which is a system that uses staged combustion and lean pre-mixed fuel-air mixtures to achieve low NOx emissions. Accordingly, the generation of CO will also be kept to a minimum by optimally maintaining the required air to fuel ratio so that complete combustion occurs. Although no emission standards are specified by the IFC for CO, emissions will be minimised through the process controls as discussed above.

Dispersion Modelling Methodology

Air dispersion modelling using appropriate dispersion modelling software is an internationally accepted tool that can be used to determine if the design and location of emission sources result in acceptable air quality in the vicinity of a development site. This determination is made by comparing the maximum predicted dispersion modelling results at appropriate locations to the ambient air quality guideline stated in the applicable government regulations or other international standards. As such, if the predicted dispersion modelling results are within the air quality limits and the plant contribution is within acceptable thresholds, the plant design is assumed to be acceptable for regulatory approval.

For this assessment, the UK Atmospheric Dispersion Modelling System (ADMS) version 5 code was applied. ADMS is listed as appropriate for assessing "more complex and refined models" in the IFC "Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" guideline document.

The dispersion modelling procedure is summarised as follows:

- Information on the design of the proposed OMA Power Plant facility including site layout, stack location, design of the proposed gas turbines and relevant emissions data was obtained from Geometric Power Ltd and its contractors/plant suppliers. Details of the buildings and structures on site were also obtained and

the buildings module in ADMS was used to account for the effect of site buildings on the dispersion of pollutants.

- Three years of hourly sequential meteorological data (2011 – 2013) from the nearest weather station which records all the necessary parameters for dispersion modelling was used for the assessment. The nearest weather station is Port Harcourt, however, there is very low data capture for the weather parameters required for dispersion modelling from this weather station (approximately 10-50 data points per month when data are reported). The closest station with useable data is Douala, Cameroon which is approximately 285km to the east southeast of the proposed development site.
- A number of human receptors in the vicinity of the facility were identified at which the ambient concentrations of released substances were modelled. These represented individual properties located within the nearest residential areas or towns. There are no sensitive habitats such as national parks within the vicinity of the proposed OMA Power Plant and no further consideration of habitats was required – the receptors represent human exposure only. As well as at discrete receptors, concentrations were modelled on a receptor grid with 50 m spacing, covering a 5 km x 5 km square centred on the proposed OMA Power Plant development site – this enabled generation of contour plots of the predicted ground level concentrations of the modelled pollutants..
- The above information was entered into the dispersion model.
- The dispersion model was run to provide predicted ground-level concentrations of the released substances (NOx and CO). To ensure a conservative assessment, the results interpretation was based on the highest modelled concentration at any of the sensitive receptor locations for any of the three years of meteorological data. The combustion sources included in the model were also assumed to run at 100% load continuously for the year. Concentrations of NOx were converted to nitrogen dioxide (NO_2) as this is the pollutant associated with health effects
- The modelled concentrations of pollutants due to gas turbine emissions were combined with estimated baseline concentrations of NOx and CO in the vicinity of the site.
- Modelled concentrations were assessed against the relevant ambient air quality guidelines, taking the background levels into account.

The full description of the dispersion modelling methodology, gas turbine emissions data, study inputs, uncertainties and assumptions are provided in the Air Quality Technical Assessment (Appendix VII).

Ambient Air Quality Guidelines

The relevant national ambient air quality standard or guidelines for the protection of human health are those applied by the Federal Ministry of Environment (FMEnv) and guidelines are also provided by the IFC, the latter being based upon WHO air quality guidelines. The relevant ambient air quality guidelines are set out in Table 8-3.

Table 8-3: Ambient Air Quality Guideline Values

Pollutant	Averaging Period	Air Quality Guideline (µg/m^3)	
		FMEnv	IFC / WHO
Nitrogen dioxide	1 hour	-	200
	24-hour	75 – 113	-
	1 year (annual mean)	-	40
Carbon monoxide	1-hour	-	30,000
	8-hour	22,800	10,000
	24-hour	11,400	-

The predicted concentrations of NO_2 and CO from the project were compared to the relevant IFC / WHO ambient air quality guidelines. Although these are generally more stringent than the FMEnv ambient air quality standards, the predicted concentrations were also compared to the FMEnv standards for completeness.

The IFC "Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" specifies the following with regard to the general approach to the air quality assessment:

"Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines (see Table 1.1.1), or other internationally recognized sources;*
- *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed"*

The results of the dispersion modelling study were assessed against the above IFC requirements.

Dispersion Modelling Results

The results in Table 8-4 to Table 8-7 present the maximum pollutant concentrations at the modelled receptor locations as a result of emissions to air from the proposed OMA Power Plant facility. The results presented are the maximum concentrations for any of the three years of meteorological data included in the assessment.

The tables give the following information:

- Ambient Air Quality Guideline (AAQG);
- The estimated baseline concentration of the pollutant;
- Process Contribution (PC), the maximum modelled concentration of the substance due to the emissions from the IPP facility alone;
- Predicted Environmental Concentration (PEC), the maximum modelled concentration due to process emissions combined with the estimated baseline concentration; and
- PC and PEC as a percentage of the ambient air quality guideline.

Phase 1

The results for Phase 1 (i.e. 4 x GTGs operating in open cycle mode) are shown in Table 8-4.

Table 8-4: Maximum modelled concentrations at sensitive receptors – Phase 1

Pollutant	Averaging Period	AAQG (µg/m^3)	Source	Baseline concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / AAQG	PEC / AAQG
Nitrogen dioxide	Annual mean	40	IFC/WHO	28.1	0.2	28.4	0.6%	71%
	24 hour mean (maximum)	75 - 113	Nigerian	28.1	1.6	29.7	2.1%	40%
	1 hour mean (maximum)	200	IFC/WHO	56.2	13.3	69.6	6.7%	35%
Carbon monoxide	24 hour mean (maximum)	11,400	Nigerian	2,548	4.5	2553	0.04%	22%
	8 hour running mean (maximum)	10,000	WHO	2,548	13.1	2,561	0.1%	26%

Pollutant	Averaging Period	AAQG (µg/m^3)	Source	Baseline concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / AAQG	PEC / AAQG
	1 hour mean (maximum)	30,000	WHO	5,097	74	5,171	0.2%	17%

The results for Phase 1 set out in Table 8.4 show that the maximum predicted annual mean NO_2 concentration at any of the modelled sensitive receptor locations is 0.2 µg/m3. This equates to approximately 0.6% of the IFC / WHO annual mean AAQG of 40 µg/m3. The total concentration (i.e. the PEC) is within the guideline value. The maximum 1-hour mean NO_2 concentration is 13.3 µg/m3 which is 6.7% of the IFC / WHO AAQG of 200 µg/m3. The total predicted concentration is 69.6 µg/m3 which is within the AAQG. The maximum 24-hour mean NO_2 concentration was 1.6 µg/m3 which is only 2.1% of the lower range of the Nigerian ambient air quality standard of 75 – 113 µg/m3. The PEC is forecast to be within the guideline range.

The predicted maximum concentrations of CO due to emissions from the proposed OMA Power Plant facility (i.e. the PC) are less than 1% of the relevant AAQG values and the total concentrations are well within the guideline values.

On the above basis, the emissions to air from the proposed OMA Power Plant facility meet the requirements of the IFC "Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" which require that the emissions from a project do not lead to exceedance of the relevant AAQGs and do not contribute more than 25% of the AAQG value.

Contour plots displaying annual mean NO_2 and 1 hour mean NO_2 process contributions for Phase 1 are shown in Figure 5 and Figure 6 of the Air Quality Technical Appendix respectively. The contour plots display the process contributions for the year that resulted in the maximum concentration on the modelled grid.

Phase 2

The results for Phase 2 (i.e. 6 x GTGs operating in open cycle mode) are shown in Table 8-5.

Table 8-5: Maximum modelled concentrations at sensitive receptors – Phase 2

Pollutant	Averaging Period	AAQG (µg/m^3)	Source	Baseline concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / AAQG	PEC / AAQG
Nitrogen dioxide	Annual mean	40	IFC/WHO	28.1	0.3	28.4	0.7%	71%
	24 hour mean (maximum)	75 - 113	Nigerian	28.1	2.4	30.5	3.2%	41%
	1 hour mean (maximum)	200	IFC/WHO	56.2	17.7	73.9	8.8%	37%
Carbon monoxide	24 hour mean (maximum)	11,400	Nigerian	2,548	6.1	2554	0.1%	22%
	8 hour running mean (maximum)	10,000	WHO	2,548	18.2	2,567	0.2%	26%
	1 hour mean (maximum)	30,000	WHO	5,097	98.4	5,195	0.3%	17%

The results for Phase 2 set out in Table 8-5 show that the maximum predicted annual mean NO_2 concentration at any of the modelled sensitive receptor locations is 0.3 µg/m3. This equates to approximately 0.7% of the IFC

/ WHO annual mean AAQG of 40 µg/m3. The total concentration (i.e. the PEC) is within the guideline value. The maximum 1-hour mean NO_2 concentration is 17.7 µg/m3 which is 8.8% of the IFC / WHO AAQG of 200 µg/m3. The total predicted concentration is 73.9 µg/m3 which is within the AAQG. The maximum 24-hour mean NO_2 concentration was 2.4 µg/m3 which is only 3.2% of the lower range of the Nigerian ambient air quality standard of 75 – 113 µg/m3. The PEC is forecast to be within the guideline range.

The predicted maximum concentrations of CO due to emissions from the proposed OMA Power Plant facility (i.e. the PC) are less than 1% of the relevant AAQG values and the total concentrations are well within the guideline values.

On the above basis, the emissions to air from the proposed OMA Power Plant facility meet the requirements of the IFC "Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" which require that the emissions from a project do not lead to exceedance of the relevant AAQGs and do not contribute more than 25% of the AAQG value.

Contour plots displaying annual mean NO_2 and 1 hour mean NO_2 process contributions for Phase 2 are shown in Figure 7 and Figure 8 of the Air Quality Technical Appendix respectively. The contour plots display the process contributions for the year that resulted in the maximum concentration on the modelled grid.

Phase 3a

The results for Phase 3a (i.e. 6 x GTGs operating in combined cycle mode - Horizontal HRSG) are shown in Table 8-8.

Table 8-6: Maximum modelled concentrations at sensitive receptors – Phase 3a

Pollutant	Averaging Period	AAQG (µg/m^3)	Source	Baseline concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / AAQG	PEC / AAQG
Nitrogen dioxide	Annual mean	40	IFC/WHO	28.1	2.3	30.4	6%	76%
	24 hour mean (maximum)	75 - 113	Nigerian	28.1	11.3	39.4	15%	53%
	1 hour mean (maximum)	200	IFC/WHO	56.2	59.5	115.7	30%	58%
Carbon monoxide	24 hour mean (maximum)	11,400	Nigerian	2,548	31.4	2580	0.3%	23%
	8 hour running mean (maximum)	10,000	WHO	2,548	93.8	2,642	0.9%	26%
	1 hour mean (maximum)	30,000	WHO	5,097	332	5,429	1.1%	18%

The results for Phase 3a set out in Table 8.6 show that the maximum predicted annual mean NO_2 concentration at any of the modelled sensitive receptor locations is 2.3 µg/m3. This equates to approximately 6% of the IFC / WHO annual mean AAQG of 40 µg/m3. The total concentration (i.e. the PEC) is within the guideline value. The maximum 1-hour mean NO_2 concentration is 59.5 µg/m3 which is 30% of the AAQG of 200 µg/m3. The total predicted concentration is 115.7 µg/m3 which is within the ambient air quality guideline value. The maximum 24-hour mean NO_2 concentration was 11.3 µg/m3 which is 15% of the lower range of the Nigerian ambient air quality standard of 75 – 113 µg/m3. The PEC is forecast to be within the guideline range.

The predicted maximum concentrations of CO due to emissions from the proposed OMA Power Plant facility (i.e. the PC) are less than 1% of the relevant AAQG values, except for the maximum 1-hour mean concentration which is 1.2% of the AAQG. The total concentrations are well within the relevant guideline values.

With the exception of the maximum 1-hour mean NO_2 concentrations, the emissions to air from the proposed OMA Power Plant facility for Phase 3 with a horizontally aligned HRSG meet the requirements of the IFC "Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" which require that the emissions from a project do not lead to exceedance of the relevant AAQGs and do not contribute more than 25% of the AAQG value. The maximum 1-hour mean NO_2 concentrations are predicted to be 30% of the AAQG.

Contour plots displaying annual mean NO_2 and 1 hour mean NO_2 process contributions for Phase 3a are shown in Figure 9 and Figure 10 of the Air Quality Technical Appendix respectively. The contour plots display the process contributions for the year that resulted in the maximum concentration on the modelled grid.

Phase 3b

The results for Phase 3b (i.e. 6 x GTGs operating in combined cycle mode - Vertical HRSG) are shown in Table 8-7.

Table 8-7: Maximum modelled concentrations at sensitive receptors – Phase 3b

Pollutant	Averaging Period	AAQG (µg/m^3)	Source	Baseline concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / AAQG	PEC / AAQG
Nitrogen dioxide	Annual mean	40	IFC/WHO	28.1	1.8	29.9	4.5%	75%
	24 hour mean (maximum)	75 - 113	Nigerian	28.1	7.5	35.6	10.0%	47%
	1 hour mean (maximum)	200	IFC/WHO	56.2	54.6	110.8	27.3%	55%
Carbon monoxide	24 hour mean (maximum)	11,400	Nigerian	2,548	20.8	2569	0.2%	23%
	8 hour running mean (maximum)	10,000	WHO	2,548	62.5	2,611	0.6%	26%
	1 hour mean (maximum)	30,000	WHO	5,097	304	5,401	1.0%	18%

The results for Phase 3b set out in Table 8.7 show that the maximum predicted annual mean NO_2 concentration at any of the modelled sensitive receptor locations is 1.8 µg/m3. This equates to approximately 4% of the IFC / WHO annual mean AAQG of 40 µg/m3. The total concentration (i.e. the PEC) is within the guideline value. The maximum 1-hour mean NO_2 concentration is 54.6 µg/m3 which is 27.3% of AAQG of 200 µg/m3. The total predicted concentration is 110.8 µg/m3 which is within the AAQG value. The maximum 24-hour mean NO_2 concentration was 7.5 µg/m3 which is 10% of the lower range of the Nigerian ambient air quality standard of 75 – 113 µg/m3. The PEC is forecast to be within the guideline range.

The predicted maximum concentrations of CO due to emissions from the proposed OMA Power Plant facility (i.e. the PC) are less than or equal to 1% of the relevant AAQG values and the total concentrations are well within the relevant guideline values.

With the exception of the maximum 1-hour mean NO_2 concentrations, the emissions to air from the proposed OMA Power Plant facility for Phase 3 with a vertically aligned HRSG meet the requirements of the IFC

"Environmental, Health and Safety Guidelines: Environmental, Air Emissions and Ambient Air Quality" which require that the emissions from a project do not lead to exceedance of the relevant AAQGs and do not contribute more than 25% of the AAQG value. The maximum 1-hour mean NO_2 concentrations are predicted to be 27% of the AAQG.

Contour plots displaying annual mean NO_2 and 1 hour mean NO_2 process contributions for Phase 3b are shown in Figure 11 and Figure 12 of the Air Quality Technical Appendix respectively. The contour plots display the process contributions for the year that resulted in the maximum concentration on the modelled grid.

Impact Assessment

Considering the modelling results and the fact that the nearest receptors would be over 400 meters away, the magnitude of the effect that operational activities will have on air quality is assessed as low. The significance of effect of the operational activities is therefore assessed as negligible/minor without mitigation. The modelling results account for mitigation measures already incorporated into the plant design. Additional mitigation measure including management of operations and environmental monitoring measures are discussed in Section 9.4.1.

Residual Impacts

The results of the detailed air quality assessment show that there will not be any significant residual impacts to air quality for Phases 1 and 2 of the proposed OMA Power Plant project. All predicted concentrations are well within the applicable IFC/WHO ambient air quality guidelines and the contribution from the development is less than 25% of the guideline values. This is classed as a low magnitude impact with negligible significance.

If the project proceeds to Phase 3, further detailed assessment will be required in order to determine whether the stack height is appropriate and if any additional mitigation measures are required. The impact for Phase 3 for the current indicative design is classed as potentially minor/major impact with minor / major significance. It is anticipated that, with appropriate amendments to the design, the impact for Phase 3 could be reduced to a low magnitude impact of negligible / minor significance, similar to Phases 1 and 2.

8.7.2 Energy Efficiency and Greenhouse Gas Emissions

The GHG emissions from the project over its lifetime have been quantified. The predicted emissions have been compared with Nigeria's carbon grid factor and annual carbon emissions. The GHG emissions for the project using alternatively fuelled technologies have also been considered.

The IFC/World Bank requirements in relation to avoiding, minimising and offsetting emissions of carbon dioxide from new thermal power plants are detailed in IFC EHS Guidelines for Thermal Power Plants and IFC Guidance Note 3 (2012)[9]. This Note provides guidance on the various available GHG emissions estimation methodologies and recommends the IPCC (2006) Guidelines as the most authoritative methodology[10].

Based on this guidance, the following approach has been undertaken to determine GHG emissions and comparison with alternative fuels and the Nigerian electricity grid factor:

- Calculation of annual primary energy consumption of the power plant in phases 1 and 2.
- Conversion to carbon emissions using IPCC carbon conversion factors.
- Calculation of the lifetime carbon emissions based on the project life time.
- GHG comparison with alternative fuels.
- Calculation of carbon grid factor based on the efficiency of steam cycle operation.
- Relative contribution of the Power Station to the Nigeria's GHG emissions.

[9] IFC (2012). Guidance Note 3: Resource Efficiency and Pollution Prevention.
[10] IPCC (2006). Guidelines for National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC). Volume 1 (General Guidance and Reporting), Volume 2 (Energy),

A number of recognised data sources are available providing guidance on carbon emissions from Stationary combustion in the energy industries. The IFC guidelines recommend using the carbon factors IPPC Guidelines (2006). Table 8.8 below outlines the estimate annual carbon emissions using natural gas alongside a comparison of Coal and Oil fuels. This carbon factor is based on primary energy consumption. Carbon emissions are based on the 15°C temperature scenario, which has the highest carbon emissions. Detailed calculations are included in Appendix VI.

Table 8-8: Annual Carbon Emissions for 4 Gas Turbines in Phase 1& 2

	Carbon Factor (kg CO_2/MJ	Carbon Emission kiloton Carbon Emissions (ktCO_2/yr)*
Natural Gas	**0.05610**	**3,583**
Other Bituminous Coal	0.09460	6,042
Crude Oil	0.07330	4,682
	*Conversion of 1kilotonne (kt) to 1,000,000 kg CO2	

The following Table 8-9 shows the carbon emissions from Phases 1 and 2 over the project lifetime of 25 years. It also shows the savings of using natural gas as the fuel source compared with Coal and Oil over the project lifetime. This scenario is based on Phases 1 and 2 becoming operational in year 1, when in reality there will be some time before the additional capacity of Phase 2 comes on line.

Table 8-9: Lifetime Carbon Emissions for 4 Gas Turbines in Phase 1 and 2

	Carbon Emission kiloton CO_2/yr*	Carbon Saving on Alternative Fuel (%)
Natural Gas	**89,582**	
Other Bituminous Coal	151,059	41%
Crude Oil	117,047	23%

According to the EIA (2012)[11] the carbon emissions from electricity generation in Nigeria in 2011 was 0.405 kg CO2 per kWh.

This compares to the proposed power station after Phase 3 in steam cycle configuration (51% efficiency) of 0.4kgCO2 per kWh. The power station emissions will therefore be comparable (with a slight improvement) on the average grid carbon factor. As outlined in the Project Description, over 70% of generating and planned thermal power units in Nigeria use the GE Frame 9E units so it would be likely that this project would have a similar carbon factor as the national grid average.

Impact Assessment

The magnitude of the effect that operational activities will have on GHG emissions is assessed as minor/major as, despite inherent mitigation measures in design which aim to maximise the efficiency of the plant and reduce carbon emissions, the project will still have a significant associated carbon footprint and will contribute to global GHG emissions. The impacts from GHG emissions are cumulative with other anthropogenic emissions such that impacts are global in nature. Therefore, the significance of effect of the operational activities is assessed as major. Additional mitigation measure to minimise impacts are detailed in Section 0. It is noted that the carbon emissions for the operational phase of the project will be significantly lower than for crude oil and coal fired power plants.

Residual Impacts

The mitigation measures will ensure that the plant operates with maximum efficiency, but impacts would remain minor/major..

[11] EIA (2012) CO_2 Emissions and Fuel Combustion Highlights

8.7.3 Noise

Overview

The operation of the equipment associated with the plant has the potential to result in noise impacts at residences, schools, healthcare facilities and other nearby sensitive receptors.

Depending on the magnitude of the impact and the activities being conducted near a receptor, the following range of effects may result from noise associated with project operations:

- Small changes in behaviour such as turning the volume up, speaking more loudly, occasionally closing windows and a perceived reduction in quality of life.
- Material changes in behaviour such as avoiding certain activities during noisy periods, keeping windows closed most of the time, difficulty concentrating on tasks, reduced speech intelligibility and diminished quality of life.
- Health impacts such as annoyance, reduced cognitive performance, sleep disturbance (arousal, motility, sleep quality and reported awakening), the autonomous release of stress hormones, increased risk of hypertension (high blood pressure) and ischaemic heart diseases (including myocardial infarction).

A detailed noise modelling assessment was undertaken for the project (provided in the Appendix VIII of this report) to assess the likely impacts due to operational noise. A three-dimensional noise model was used to predict daytime and night-time noise levels due to the operation of all three Phases. This section provides an overview of this assessment and includes the following:

- Assessment criteria for noise;
- Sources of noise;
- Methodology;
- Results; and
- Potential noise impacts assessment.

Noise assessment criteria

International guidelines for ambient noise levels are set out by the IFC/World Bank in their General Environmental, Health, and Safety (EHS) Guidelines (2007) as shown in Table 8-10, below. According to these guidelines, it is required that noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3dB(A).

Table 8-10: IFC/WBG General EHS Guidelines: Noise Level Guidelines (dB)

Receptor	Daytime 07:00-22:00 hrs ($L_{Aeq\ 1hr}$)	Night-time 22:00-07:00 hrs ($L_{Aeq\ 1hr}$)
Residential; institutional; educational.	55	45
Industrial; commercial	70	70

The guidelines are commonly interpreted as being relevant to the long-term operational noise emissions from the project, rather than the short term construction noise levels. The IFC/WBG EHS guidelines also present examples of noise reduction options that should be considered where noise levels exceed these guideline values, along with recommendations for noise monitoring to be carried out either to establish existing ambient noise levels or to verify operational noise levels.

The IFC/WBG has also published EHS Guidelines for Thermal Power Plants, which set out industry-specific examples of good international industry practice. In respect to noise, these guidelines note that amongst the principal sources of noise in thermal power plants are turbine generators and auxiliaries, boilers and auxiliaries, fans and ductwork, pumps, compressors, piping, valves and cooling towers.

Noise impacts, control measures, and recommended ambient noise levels for thermal power plants are presented in Section 1.7 of the General EHS Guidelines.

The noise guidelines presented in Section 1.7 of the General EHS Guidelines are based on the 1999 World Health Organisation (WHO) Guidelines for Community Noise.

Although the General IFC EHS guidelines do not stipulate any environmental vibration criteria, the IFC requires potential impacts from vibration to be mitigated.

Noise Sources

The noise assessment considered noise emissions arising from the operation of the following plant associated with the three phases of the project which, briefly, comprise:

Phase 1:

- Four General Electric (GE) ‘Frame 9’ 113MW gas turbines operating in simple cycle mode.
- Six electrical transformers.
- Associated infrastructure and buildings.

Phase 2:

- Six GE ‘Frame 9’ 113MW gas turbines operating in simple cycle mode.
- Nine electrical transformers.
- Associated infrastructure and buildings.

Phase 3:

- Six GE ‘Frame 9’ 113MW gas turbines operating simultaneously in combined cycle mode with the exhaust gases being directed through six waste heat boilers for energy recovery.
- Two steam turbines, situated in dedicated buildings.
- Two air cooled condenser arrays.
- 11 electrical transformers.
- Associated infrastructure and buildings.

The key noise sources associated with the three phases of the project are:

- Gas Turbines: The gas turbines generate noise as a result of the flow of air and combustion gas. Noise is emitted from the gas turbine casings, and from the associated air intakes and exhausts. In simple cycle (also known as ‘open cycle’) mode the exhaust gases are discharged via 40m tall vertical flues (fitted with attenuators) connected to the gas turbine exhausts. In combined cycle mode, a significant proportion of the exhaust gas is directed through Waste Heat Boilers (WHB) and then exits through additional 40m tall vertical flues. The WHBs generate steam to feed the Phase 3 steam turbines.
- Air Inlet Filters: Air to the gas turbines is filtered before entering the inlet plenum to minimise the potential for pollen, dust and sand to cause damage. The filters collect particulates in the air, and must be cleaned periodically by high-pressure air pulses, which blow the particles off the filter surface.
- Electrical Transformers: Noise from electrical transformers is caused by magnetostriction (where the metal sheets forming the core extend and contract in response to the alternating magnetic field), and from the cooling system.

- Air Cooled Condensers (ACC): ACCs are heat exchangers that use the ambient air to cool and condense steam which has been through the steam turbine, in order for it to be recirculated to the waste heat boilers. Each ACC comprises an array of large fans, which blow cool air over finned tubes containing the steam. Each fan and its associated finned tubes is referred to as a cell. Noise is generated by the fan gearbox, fan blades and the movement of air across the heat exchange surface.
- Steam Turbines: Steam turbines convert thermal energy in the form of pressurised steam to mechanical work and ultimately, electrical power through a generator. Noise is generated in the turbine by rotating parts and pressure changes in the steam.

Noise Modelling Methodology

Noise modelling software provides a way of constructing a three-dimensional computer model of terrain, ground characteristics and noise sources which enables the prediction of noise at any point within the modelled area.

In order to compute the environmental noise emission level from plant items and operations at the representative noise sensitive receptors, noise emission modelling was undertaken using the CadnaA noise prediction software. The software was configured to use the noise prediction methodology set out in ISO9613[12], which is suitable for the prediction of noise levels in the community from sources of known sound emission.

The noise prediction method described in part 2 of ISO9613 is general, and is suitable for a wide range of engineering applications where the noise level outdoors is of interest. The noise source(s) may be moving or stationary and the method considers the following major mechanisms of noise attenuation:

- Geometrical divergence (also known as distance loss or geometric damping);
- Atmospheric absorption;
- Ground effect;
- Reflection from surfaces; and
- Screening by obstacles.

The method predicts noise levels under metrological conditions favourable to noise propagation from the sound source to the receiver, such as downwind propagation, or equivalently, propagation under a moderate ground based temperature inversion as commonly occurs at night.

All of the scenarios consider operation under steady-state conditions, rather than during start-up, maintenance or emergency conditions, In particular, pulsing cleaning to clear debris from the gas turbine air intakes has not been considered; this activity can lead to high noise levels, but is short in duration

Input data

The site layout, position and the height of buildings / plant in the noise model are derived from drawing F2013021T-Z04 Rev 09 by China power Construction Engineering Consulting Central Sothern Co. Ltd., which is included in Appendix VIII of this document for convenience.

The ground level in and around the site is assumed to be generally flat, and therefore no topographic screening effects have been considered in the noise model. The intervening ground between the project and the closest dwellings is generally natural scrub land, and therefore is considered to be acoustically porous.

Sound Power Levels

At this time, detailed noise emission data for the proposed equipment selections is not available. Therefore, the following A-weighted sound power levels described in table 8.11 have been used in the noise predictions, which are based upon empirical formulae in technical literature, noise measurements of similar equipment, or other manufacturer's data for similar equipment. These values were agreed with Geometric Power prior to

[12] International Standard: ISO 9613-2: 1996(E): Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation.

commencement of this noise assessment. The detailed 1/1 octave band data which comprises each broadband value is provided in Appendix B of the Noise Assessment Technical Appendix (Appendix VIII) to this report.

Table 8-11: A-weighted sound power levels for equipment

Equipment	Representation in Model	Sound Power Level, dB(A)	Source of Noise Data
Gas Turbine Casing	Omnidirectional Point Sources at 5m a.g.l.	108.4	Measured noise spectrum for GE LM6000 gas turbine scaled to 85 dB(A) at 1m.
Gas Turbine Generator	Omnidirectional Point Sources at 5m a.g.l.	108.4	As per Gas Turbine Casing
Gas Generator Air Intake	Point source at 6m a.g.l. in front of vertical reflecting plane.	95.6	Measured data for GE LM6000 gas turbine.
Silenced Flue Gas Stack	Point source at 40m above ground level, adjusted for stack directivity towards ground.	99.9	Measured data for GE LM6000 gas turbine.
GTG Transformer	Point source at 5m above ground level.	102.5	NEMA empirical method (Standard Transformer 140MVA)
STG Transformer	Point source at 5m above ground level, adjusted for directivity towards ground.		
WHB Stack	Point source at 40m above ground level, adjusted for directivity towards ground.	99.9	As Per Silenced Flue Gas Stack
Air Cooled Condenser Array	Horizontal area source situated 5m above ground level.	105	Based on experience and data from previous projects
Air Fin Fan Cooler	Axial fan 5m3/s at 200Pa	78.2	Library

These sound emission levels should be considered maximum permissible values for equipment as the design progresses to ensure that the environmental effects are no worse than stated in this assessment.

Noise sensitive receptors

A total of 102 potentially noise sensitive receptors were identified in the vicinity of the IPP development site, detailed in the Noise Assessment Technical Appendix VIII and shown on Figure 1 of the Noise Assessment Technical Appendix to this report (Appendix VIII). The noise levels predicted at receptors for each of the three development phases are given, and shown on Figures 2 to 4 of the Noise Assessment Technical Appendix (Appendix VIII).

Results

The noise emissions of the plant will be the same night and day, and therefore the predicted levels have been compared to the IFC night-time criterion for residential properties of 45 dB LAeq,1h to be conservative.

The highest noise levels are predicted for receptors to the south of the project in the Port Harcourt Aba Road area. All of the predicted noise levels are below the recommended daytime ambient noise levels are presented in Section 1.7 of the General EHS Guidelines for residential, institutional and educational facilities. However the recommended night-time ambient noise levels will be exceeded in all three phases of operation:

- During Phase 1, it is expected that the night noise criterion will be exceeded at 19 properties, by between 0.2 - 3.2 dB.
- During Phase 2, it is expected that the night noise criterion will be exceeded at 25 properties, by between 0.3 – 5.5 dB
- During Phase 3, it is expected that the night noise criterion will be exceeded at 27 properties, by between 0.2 – 5.6 dB

As the recommended noise levels set out in the General EHS Guidelines are predicted to be exceeded, it is appropriate to consider the effects of the predicted noise levels and mitigation measures that may be employed to reduce noise emissions from the project.

Furthermore, the WHO has set out international guidelines for indoor noise levels to avoid sleep disturbance. Above 55 dB Lnight, outside, the situation is considered increasingly dangerous for public health: adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed, and there is evidence that the risk of cardiovascular disease increases. Correspondingly, the night noise guidelines put forward an Interim Target of 55 dB Lnight, outside. This is considered to be an appropriate Significant Observed Adverse Effect Level (SOAEL) for this assessment.

The highest noise levels predicted as a result of the project are below the SOAEL of 55 dB Lnight, outside. However, noise levels in the predicted range (40-55 dB Lnight, outside) are associated with increased likelihood of adverse health effects including self-reported sleep disturbance, environmental insomnia, increased use of sleep-inducing drugs and sedatives, and changes in behaviour. The most common change in behaviour is to close bedroom windows whilst sleeping, which may cause other issues with overheating and fresh air which impact on quality of sleep. It is therefore considered good international industry practice to mitigate, as far as possible, noise levels above 40 dB Lnight, outside.

Conclusions

The predicted noise levels for all three phases of the project would result in the IFC night-time noise criterion for residential properties of 45 dB $L_{Aeq,1hour}$ being exceeded at sensitive receptors (between 0.2 and 5.6 dB). Therefore, potential mitigation measures are outlined in Section 9.4.3.

Updated socio-economic survey work completed for the project in 2015 showed that some of the receptors considered in the noise assessment may not in fact be residential uses. As a result, it is recommended that a Noise Management Plan be developed for the project in consultation with the Lender Group and following confirmation of the nearby residential receptors to determine the most effective mitigation strategies to address night time noise exceedances.

Impact Assessment

The magnitude of noise effects from operational activities is assessed as minor/major. The significance of effect of the operational noise is therefore assessed as minor/major. However, provided that mitigation measures are taken via a Noise Management Plan to ensure noise emission levels are adequately reduced, no long-term residual noise impacts are anticipated during operation of the proposed project.

Residual Impacts

Provided that measures are taken to ensure noise emission levels meet World Bank guidelines, no long-term residual noise impacts are anticipated during operation of the proposed project. The magnitude of effects will be low and therefore the significance of effect minor

8.7.4 Ecology

On completion of the plant construction, the only potential ecology impacts would be associated with any indirect or accidental release of substances and ground contamination and its subsequent effects on local habitats and species.

Impact Assessment

The magnitude of ecology effects from operational activities is assessed as being minor. The significance is assessed as minor as effects are considered unlikely since measures will be taken consistent with good international industry practice to avoid or manage any spills or contamination.

Residual Impacts

Residual ecological impacts associated with the proposed project could include permanent loss of wildlife habitat on the project site, minor degradation of wildlife habitat immediately adjacent to the project site, possible relocation to a potentially less favourable habitat for those species that remain in the vicinity of the proposed project site.

Residual ecological impacts associated with the proposed project could include permanent loss of wildlife habitat on the project site, minor degradation of wildlife habitat immediately adjacent to the project site, possible relocation to potentially less favourable habitat of those species that remain around the proposed project site.

However, considering that the conservation value of these ecological habitats is considered low, and the fact that there are no protected and vulnerable species populations in the area and given the localised nature of impacts, overall residual impacts on ecology are considered to be of negligible significance.

8.7.5 Water and Wastewater

Wastewater can pose a number of potential risks if humans consume or are otherwise exposed to pathogenic microorganisms, heavy metals, or harmful organic chemicals such as endocrine-disrupting compounds. Of these, pathogenic microorganisms are generally considered to pose the greatest threat to human health. A wide variety of pathogenic microorganisms may be found in wastewater, including bacteria, viruses, protozoans and parasitic worms. Amongst many others, diseases associated with such pathogens may include typhoid, dysentery, gastroenteritis, diarrhoea, vomiting, and malabsorption. The concentration of pathogens in wastewater is dependent on the source population. The susceptibility to infection by such pathogens can vary between human individuals, for example, children, the elderly and those who are already sick may succumb to infection more easily or experience more serious symptoms.

Wastewater from the project if not properly treated could result in the risk of disease or health effects as described above. A key potential receptor susceptible to the discharge of waste effluent from the site would be the community water supply borehole located down- (hydraulic) gradient from the site. If appropriate mitigation measures are not employed, there is the potential for contaminants to infiltrate to groundwater and migrate to the community water supply.

Impact Assessment

The magnitude of the effect that wastewater from operational activities may have is considered minor/major. Based on all of the above, the significance of effect of the operational activities is therefore assessed as minor/major prior to mitigation.

Residual Impacts

No long–term residual impacts are expected following deployment of the specified mitigation measures. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.7.6 Groundwater

On-site storage of any potentially contaminating fluids for the project is not anticipated to contain volumes sufficient to result in an accidental release that could significantly impact upon the major regional rivers.

However, accidental spills of fuels or other materials pose a potential for contamination of ground water with potential for migration to down gradient community water supply boreholes. Given the predominantly sandy geology and aquifer conditions, contaminants from accidental spills at the site could rapidly percolate to the water table located approximately 27 meters below ground surface. As there are no nearby surface water features, the community water supply boreholes are the key potential receptor for accidental contamination via release to groundwater.

In addition to potential impacts to community supply boreholes associated with contamination, it is also possible that water abstraction at the site could potentially impact upon water availability from the community boreholes. Chapter 4 indicates that a cumulative peak instantaneous groundwater flow of 162 m3/h (potentially plus 1%) is required to support the water usage of Stages 1, 2 and 3.

However, it is considered unlikely that the water supply abstraction at the plant will impact on the community supply boreholes based the following information:

- Baseline information on the regional coastal sands aquifer indicates that it is a large regionally extensive aquifer and generally able to supply significant yields. It is noted that the test pumping exercise was undertaken at flow rates much less than the peak instantaneous rate;
- The community boreholes were monitored during the borehole drilling and test pumping investigation and results indicate that there was no drop in groundwater level at the community boreholes during the test. It is noted that this is to be expected given the aquifer lithology and distance from the pumping well.

Following the results of the hydrogeology investigation, given the distance, it is considered highly unlikely that there will be a significant impact on water availability at the community supply boreholes due to water abstraction at the plant.

Impact Assessment

The magnitude of any effect that operational activities may have on groundwater is assessed as minor/major. The significance of effect of the operational activities is therefore assessed as minor prior to mitigation.

Residual impacts

Despite use of appropriate mitigation measures, there is still the potential for some residual impacts from accidental release of contaminants to ground. Given the use of good management practices and implementation of effective emergency response, the impacts will be low in magnitude, with no long-term effects and not considered significant

8.7.7 Solid Waste

Although the project is not anticipated to generate significant volumes of solid waste, some solid waste will be generated during the operational phase of the project that will require off-site disposal.

Typical wastes generated during the operational phase include:

- Maintenance wastes include:
- Waste oils and lubricants;
- Scrap metal;

- Waste electrical and electronic components;
- Batteries;
- Contaminated rags;
- (Potentially) Contaminated spill response equipment;
- Contaminated safety clothing, gloves, masks, and equipment;
- Waste wood;
- Waste paints and solvents;
- Contaminated plant and machinery, including filters;
- Domestic and food wastes;
- Sewage wastes;
- Sludges (potentially contaminated); and
- Oily water and run-off.

There will be a potentially significant effect if wastes are not properly controlled and leakages causing soil and water contamination could result. Waste stored improperly can also be unsightly and may harbour pests or cause diseases when stored too long and allowed to degrade prior to proper disposal. This impact will be managed by implementing good international industry practice management procedures, including a designed waste management plan, to be outlined in the ESMS followed by regular inspection.

Impact Assessment

Given the potential of the project to generate waste that will require off-site disposal and the potential impacts if it is not properly disposed of, the magnitude of the effect that waste from operational activities may have is assessed as minor/major. Since proper management procedures are planned (through the waste management plan), the significance of effect of the operational activities is therefore assessed as minor. Effective waste management measures are outlined in Section 9.4.7.

Residual Impacts

No long–term residual impacts are expected following mitigation. With appropriate mitigation and waste management the magnitude of effects will be low and therefore the significance of effect minor.

8.7.8 Fire / explosion

Accidental leakages or explosion could lead to fire outbreaks which could result in the loss of habitats, direct or indirect mortality of species, contamination of watercourses, and produce chemicals and gases harmful to the environment.

Impact Assessment

Potential impacts from fire/explosion will be addressed by conformance with relevant national and international health and safety standards during construction. Risks would be highest during the peak construction period, and could be either localised or affecting the wider area. Although the magnitude of effects could be very high if an incident did occur, the overall significance during construction is considered minor/major, as the likelihood of such an incident will be low, provided proper training is given to staff, and site safety procedures are complied with.

Residual Impacts

With the appropriate mitigation and emergency response measures there are not predicted to be any long-lasting significant environmental impacts. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.7.9 Landscape and Visual

The constructed elements are detailed in Section 4.4, including the plant components themselves as well as ancillary buildings, security fencing etc. The indicative layout can be seen in Figure 4-1 and Figure 4-4. The plant will also include a stack at a height of 40m for Phase 1. This ESIA also considers impacts associated with a 300m long stretch of overhead transmission line, which is required for later planned phases.

Visual impacts due to landscape modification will likely be experienced both by local residents and at settlements further afield.

Impact Assessment

The presence of the constructed power plant will result in negative impacts on the surrounding landscape. The transmission line will lie within the middle of two existing transmission lines and thus no significant negative impacts are associated with this component. The magnitude of operational landscape and visual effects from the project as a whole is assessed as medium. Based on the expected 20 year life-cycle of the proposed power plant (with 5 years optional extension), the duration of impacts will be relatively long-term, and is assigned a sensitivity of regional. The significance of the effects of the operation on landscape and visual assets is therefore assessed as minor/major.

Residual Impacts

As detailed in the ESMP, landscaping of the site will take place upon completion of construction works. This will both mitigate visual impact and reduce erosion from surface waters during heavy rains and flood periods. Soils excavated during construction may be used for landscaping if suitable. The significance of visual impacts would no longer be significant post mitigation.

8.8 Sources of Potential Health and Safety Impacts – Operational Phase

8.8.1 Community Health and Safety

Similarly to the construction phase, there will be a gradual increase in traffic and HGVs during project operations which could result in the potential for increased road traffic accidents. Emergency response for potential accidents during operations will also be an important consideration. Accidental leakages and explosion could lead to fire outbreaks which could result in the loss of human lives, damaged properties and other serious health implications. Accidental release of fumes and other toxic emissions emanating from the processing could result in respiratory infections to workers as well as residents around the project site.

8.8.2 Occupational Health and Safety

Specific occupational health and safety issues associated with power projects include the potential for exposure to confined spaces, heat and air quality and noise impacts.

In addition to these occupational health concerns, there are also health and safety risks associated with operations and decommissioning activities and emergency situations.

- **Confined Spaces:** Confined space hazards in this and any other industry sector are potentially fatal. Confined space entry by workers and the potential for accidents may vary among power facilities depending on design and on-site equipment. Therefore, confined spaces on site could result in adverse health and safety impacts to workers.
- **Heat:** Occupational exposure to heat occurs during construction activities, and during operation and maintenance of pipes, wells, and related hot equipment. Therefore, heat associated with operational and construction equipment on site could result in adverse health and safety impacts to workers.
- **Noise and Air Quality:** Workers could be exposed to noise particulate emissions during construction activities diesel engines, drilling and other heavy machinery are utilised. Operational noise and air quality emissions could also expose workers to excessive noise and air quality emissions.

- **Other Concerns:** Potential occupational health and safety issues during construction activities would also include:
    - Falls and slips;
    - Failures of support systems and/or platforms;
    - Collision with mobile plant or vehicles;
    - Road safety relating to water trucks;
    - Exposure to dust and to hazardous materials;
    - Explosions;
    - Burns;
    - Crushing by heavy plant or collapse of structures;
    - Falling debris;
    - Adverse weather conditions;
    - Falls into voids during piling; and,
    - Contact with concrete.

Impact Assessment

Impacts on worker and occupational health and safety associated with confined spaces, air quality and noise concerns, heat, potential accidents and emergency concerns would be considered of medium magnitude, and minor/major adverse significance. Implementation of proper health and safety plans/management system would reduce these risks significantly.

There may also be community, health and safety risks associated with operation of the transmission line if accidents occur.

Community safety impacts from increased traffic on roads, increased risk of communicable diseases and exposure to hazards would be considered of medium magnitude and minor significance. Effects would likely be short-term and localised and risks would be highest during the peak construction period. Children and other vulnerable people including the elderly and those with existing health problems would likely be most susceptible to the community health risks.

Residual Impacts

Following implementation of appropriate mitigation measures no residual impacts are expected.

8.9 Sources of Potential Socio-Economic Impacts - Operational Phase

8.9.1 Resettlement

The project site itself has no inhabitants (legal residents or squatters). No physical resettlement impacts or economic displacement impacts are anticipated from the proposed project.

8.9.2 Employment

Employment impacts arising from operations phase of the project would include:

- Generation of direct employment by the project.
- Economic development created as a result of indirect employment by suppliers of goods and services to the project.

During project operations, employment impacts are considered to be beneficial. Permanent jobs associated with the project would include approximately 40-50 positions, with additional contract staff required for roles as drivers, and security and cleaning personnel, etc. Operational accommodation will be provided for up to 10 shift workers on site. It is not clear whether or not these jobs will be able to be sourced from the local community as this would largely depend upon skill levels and training in the local and regional community. Despite the fact that employment opportunities are offered by the local power industry, local communities are often limited in their ability to take advantage of them. The level and range of skills and applicable working experience available in the community can be limited by education and relevant skills training. Without targeted training support from the project, the ability to acquire a position, and successful performance once hired, will favour experienced (skilled) personnel for professional roles, the majority of whom would likely come from outside the local area, state or region. This could create the potential for resentment from the local community towards outsiders.

The project will also provide a good source of potential indirect employment and economic growth for the area, although it will be relatively small.

Impact Assessment

Direct Employment

The project would have a minor beneficial impact on employment during construction and potentially during operations both in the project area of influence and in the wider geographical region. Considerable construction and a few potential operational employment opportunities could be generated by the project and providing that local recruitment and employment procedures are applied, and training of the workforce is undertaken for the project, then the overall benefits of direct employment can be maximised. As the project moves towards decommissioning and closure, there will be a subsequent decrease in the workforce requirements.

Indirect Employment

Plant staff and contractors will require vendors, suppliers and service providers to meet the daily operating needs of the project together with the domestic needs of its employees. This could include goods and services including food vendors, laundry, supply of vehicles and transportation services, security patrols, as well as some construction equipment. There will be opportunities for utilising local goods and services for the project and related activities.

Typically, 3.2-3.5 jobs in service and supply sectors are created for each direct job generated by oil and gas projects.[13] At the local and regional levels, this is likely to stimulate work for agricultural producers, as well as induce growth in other industries such as retail, hospitality, transportation, etc. This would be considered a minor beneficial impact.

8.9.3 Ecosystem Services

The key ecosystem services which have the potential to be affected by the project are fuel sources, medicinal plants or wetland-related resources. However, the ecology assessment does not predict significant impacts upon these resources. The project is most likely to have a negative impact on the wetland if spillage of contaminants in the project area occurs. This would be addressed by the mitigation measures proposed under geology, hydrology and hydrogeology, therefore impacts to ecosystems services are considered to be unlikely to occur, and of minor significance.

Residual Impacts

Following implementation of appropriate mitigation measures no residual impacts are expected.

8.10 Sources of Potential Decommissioning Impacts

As detailed in Section 4.11, a decommissioning / abandonment plan will be developed and agreed with FMEnv to consider the end of the plant's operational term. The impacts expected in association with the

[13] Macroeconomic Impacts of the Domestic Oil & Gas Industry, NPC, September 15, 2011 (PWC multipliers used).

decommissioning of the plant cannot be characterised in detail at this stage of the project lifecycle, however it is likely that many will be similar to those impacts associated with the construction phase. Potential impacts anticipated are set out in the following sections.

8.10.1 Air quality

The most significant issues that could potentially impact ambient air quality during decommissioning are combustion gas emissions and nuisance dust. The principal sources of combustion gases would include the operation of a diesel-powered demolition machinery and vehicle exhaust.

Dust may be generated as a result of any earthworks and demolition activities, particularly during the dry season. It is not anticipated that significant use of un-surfaced routes/roads would be required.

Heavy duty diesel trucks may be used to transport material offsite. Diesel combustion products comprise several compounds that may be detrimental to human health with repeated exposure. Exposure of on-site workers to diesel exhaust could be significant, although the decommissioning phase is likely to be relatively short-lived. There are no mobile source emission regulations in Nigeria, however with compliance with good international industry practices, the proposed project will keep diesel emissions to a minimum.

Depending on the nature of the decommissioning activities, any potentially dust-emitting activities are likely to be intermittent and varied in location. Air emissions are not expected to significantly affect the air quality in the region outside the proposed project site. At the present time the nearest residential receptors are over 400m from the development site and are therefore unlikely to be affected. The main risks from dust and particulate air emissions generated would be to site workers and personnel.

Impact Assessment

The magnitude of air quality impacts during decommissioning the project is assessed as minor/major. The duration of impacts on the surrounding environment will be short-term. Therefore, significance of the effects is assessed as negligible/minor.

Residual Impacts

Mitigation measures to limit the impacts of any noisy works required will be set out within the detailed ESMP for the decommissioning phase. Following implementation of appropriate mitigation measures no residual impacts are expected.

8.10.2 Noise

Depending on the nature of the decommissioning activities, noise emissions could be associated with the following activities:

- Dismantling of plant machinery;
- Demolition;
- Excavation to remove hard standings or foundations;
- Vehicle movements; and
- Operation of mobile plant.

If any noisy works are required, personal hearing protection should be worn by all workers. Given the separation distances to the nearest dwellings which are 400m away, noise levels are not predicted to impact noise-sensitive receptors for any significant duration. Heavy duty diesel trucks may be required for transporting plant and materials on / off site, which typically generate more noise and vibration than smaller vehicles.

Impact Assessment

Impacts would be short-term and, as the site is some distance from the nearest sensitive receptors, noise impacts would be considered minimal. As such, the magnitude of noise impacts on human health or the environment is assessed as minor/major. The duration of impacts on the surrounding environment would be short-term. The significance of noise effects is, therefore, assessed as minor/major. Standard measures for the management of the impact of construction/demolition and traffic noise are included within the ESMP.

Residual Impacts

Following implementation of the mitigation measures within the ESMP, as appropriate to the nature of the decommissioning works, no residual long-term noise impacts are expected. In the short-term, any residual impacts would be limited to the works areas only, given the current distance to nearby residential receptors, over 400m from the site. The potential impacts to human health for construction workers can be mitigated by the use of appropriate PPE and implementation of adequate work procedures. Therefore, overall residual noise impacts from decommissioning are anticipated to be negligible.

8.10.3 Ecology

Impacts on habitats and species are likely to be associated principally with:

- Vehicular traffic incidents;
- Demolition or excavation works;
- Noise and vibration from use of machinery;
- Emissions to the air from machinery and dust;
- Lighting of the development (on nocturnal species);
- Introduction of non-native species;
- Disturbance to hydrology (sedimentation, drainage); and
- Environmental incidents and accidents (e.g. spillages).

Whilst no loss or fragmentation of habitat is expected to be associated with site decommissioning, and any, degradation of habitats would be minimal; the increased presence of people and vehicles during this period may contribute to heightened levels of disturbance to wildlife. Noise and air quality emissions may also potentially be elevated in the short term. Any plant or materials brought on site from outside the country or region also has a potential to bring with it invasive and/or non-native species, resulting in their spread.

There is the potential for accidental release of contaminants during site decommissioning. The contaminants could migrate into soils and groundwater, polluting ecological habitats and indirectly affecting species.

Good site practices, for example use of directional lighting if work after dark is unavoidable, the avoidance of sensitive breeding periods for highly disturbing activities, and implementing pollution prevention strategies to minimise the chance of contamination, will all help minimise the extent of impacts.

Impact Assessment

The magnitude of ecological effects from decommissioning is expected to be medium, as the majority of disturbing works will have taken place during construction. Any effects are likely to be localised and there will be no damage to any species or habitats of concern. Therefore, the significance of the effects on ecological receptors is assessed as minor prior to mitigation. The significance of the potential impact of the transport of contaminated soils or non-native species, on vehicles or otherwise, is also considered minor.

Residual Impacts

Following implementation of appropriate mitigation, including management of all materials brought on and off site, residual ecological impacts associated with decommissioning could include minor degradation of wildlife

habitat immediately adjacent to the project site, and displacement of species to potentially less favourable habitat.

Based on the relatively low conservation value of the majority of habitats, and the absence of protected and vulnerable species known from the area, overall residual impacts on ecology are considered to be of negligible significance.

8.10.4 Geology, hydrogeology and hydrology

No significant soil erosion is anticipated during decommissioning. As detailed in Section 8.3.5. there exists the potential for an accidental fuel or chemical spill to occur, releasing contaminants into the soil environment or surface water, and with possible knock on effects on groundwater, ecological receptors and human health.

Given the low quantities of hazardous materials stored and used during decommissioning it is not envisaged that any potential contamination impacts would be significant or long-term.

Impact Assessment

The magnitude of geology, hydrogeology and hydrology effects of the project and associated transmission line is assessed as minor/major. Because potential contamination would be localised if it occurs, the significance of geology, hydrogeology and hydrology effects is assessed as minor prior to mitigation.

Residual Impacts

Following the implementation of appropriate measures to minimise the potential for spillages of hazardous substances to occur, to safeguard the water supply from community boreholes, and prevent discharge of any sediment-laden waters, the significance of residual impacts is considered negligible, based on the small residual possibility of for accidental release of contaminants. No long term impacts are, however, anticipated.

8.10.5 Waste

As detailed in sections 8.3.7 and 8.7.7, solid waste and wastewater can be associated with a wide variety of pathogens, and with pollution of the environment, if not disposed of appropriately.

The scale and nature of waste impacts would depend upon the nature of the waste and the medium into which they are disposed. This is also true of accidental release of waste. Materials for disposal will depend on the intended plan for the plant at its end of operation life, but will likely be broadly similar to those during the construction process.

Such wastes are normally routed to a landfill, which, given the likely considerable volume of waste material, has the potential to have a negative impact on local communities. As there are no landfills in the area, a waste management programme would be needed to maximise recycling and use appropriate disposal methods for wastes that cannot be recycled. Hazardous wastes could be particularly harmful if released to the environment.

Paints can contain solvents and heavy metals, the release of which can have a significant deleterious effect on ecosystems. Some heavy metals have a bioaccumulation effect, which can exacerbate the hazard. Solvents within the paints can have a dual effect by increasing short term VOC concentrations in the air, and the generation of low level ozone on decomposition.

The main risk associated with a release of solvents into the ground would be contamination of groundwater and, depending on the volatility of the solvent, could also result in a short-term negative effect on local air quality.

Certain solvents are also carcinogenic and care should be given to their disposal for health and safety reasons. All solvents must be checked prior to disposal.

Untreated sewage effluents would have a deleterious effect upon any receiving waters if released. Sanitary facilities will be provided throughout the decommissioning process. Sewage will be treated in accordance with national standards and good international industry practice.

Impact Assessment

The magnitude and significance of environmental and health impacts of waste, including hazardous waste, during decommissioning are assessed as minor/major.

Waste can also result in unpleasant or noxious odours however this is not likely to occur at a high level, and is considered of negligible significance.

Residual Impacts

The implementation of an appropriate waste management plan to limit impacts on facilities used by local communities and to maximise recycling opportunities will be important to minimise residual impacts from waste during decommissioning. Based on the potentially large volumes involved it and the minimal facilities currently available in the area, a minor residual effect may remain.

8.10.6 Landscape and visual

The extent and nature of landscape and visual impacts will depend on the intended plan for the plant at its end of operation life, but may include the presence of cranes or demolition plant on site. Visual impacts due to landscape modification will likely be experienced both by local residents and at settlements further afield.

Impact Assessment

An increase in plant presence/activity on site will represent a negative impact on the surrounding landscape, of low magnitude. The duration of impacts will be relatively short-term, therefore, significance of the effects is assessed as minor.

Residual Impacts

A minor short-term residual effect may be associated with the presence of decommissioning plant, however this would be short-lived (for the duration of decommissioning), and no long-term residual impacts are anticipated.

8.10.7 Occupational health and safety

Impacts on site personnel are possible during decommissioning as a result of an increase in non-routine operations, compared with the operational phase. As during construction (Section 8.5.1), this includes injury or harm as a result of badly designed plant, poor management, or to unsafe working conditions. Asset damage may also result from workplace accidents/incidents.

Impact Assessment

Occupational health and safety impacts will be addressed by conformance with relevant national and international health and safety standards during decommissioning. Effects would likely be short-term and localised. Although the magnitude of effects could be high if an incident did occur, the significance of effects activities is assessed as minor/major, based on the likelihood of effects being low, provided site personnel are given proper training and adhere with safety standards.

Residual Impacts

Following implementation of appropriate mitigation measures to manage risks to the workforce, minor/major impacts are expected.

8.10.8 Community health and safety

Community health and safety impacts during decommissioning may occur in relation to traffic accidents and increased activity of HGVs. However, overall project traffic is likely to decrease over time during the decommissioning period as deliveries and staff would be reduced.

Any emergency situation such as a fire, explosion, security threat or release of contaminants or noxious fumes could pose a hazard to local communities. Consequences may include loss of human lives, damaged properties, or serious health implications. Emergency responses for potential accidents will be an important consideration.

Impact Assessment

Impacts on community health and safety associated with plant decommissioning are considered of medium magnitude. Effects would likely be short-term and localised. Children and other vulnerable people including the elderly and those with existing health problems would likely be most susceptible to the community health risks. The significance of effects is therefore assessed as of minor/major significance.

Residual Impacts

With the appropriate mitigation and traffic and noise management measures there are not predicted to be any long-lasting significant environmental impacts. The magnitude of effects will be low and therefore the significance of effect minor following mitigation.

8.10.9 Social

The size of the decommissioning workforce will be dependent on the end of life plan for the plant, however some workers will be required during this period. It is likely that the decommissioning phase will represent a decrease in workforce over time. There could also be some economic downturn which would lead to some social apprehension in the community associated with closure of the pant.

Impact assessment

Although there may be a short-term need for workers to demolish project structures, this is not expected to require a substantial amount of workers or to continue during for a significant period of time.,

The workforce and contractors will be gradually reduced during this period which could create a negative social impact on the local community if not well managed.

With appropriate consultation, job transition programs and community engagement plans in place, community unrest or conflict is considered unlikely, but should it occur would represent a minor/major impact..

Residual Impacts

Following implementation of appropriate management and mitigation measures, social impacts are expected to be reduced to less than significant levels.

8.11 Cumulative Impacts

The various environmental impacts of the proposed project have been identified and appropriate mitigation measures proposed to reduce these. Although there are noise and air quality emissions associated with the project, the anticipated cumulative impacts to air quality and noise are not expected to be cumulatively significant as there are no other significant sources of industrial emissions in the local area,. The project is also anticipated to result in numerous air quality benefits, especially with respect to reduced emissions due to lowered dependence on hydrocarbon-powered generators.

From an environmental perspective, the main considerations regarding cumulative impacts of a power station would include:

- Noise;
- Air pollution;
- Greenhouse gas and carbon emissions,
- Habitat loss and fragmentation; and
- Collision of bird species with power lines.

Currently, it is understood that there are two other power stations in the area: the Aba Power Plant (also owned by GP), located 20km away, and the Alaoji Power Plant (owned by the Niger Delta Power Holding Company) which is a combined cycle gas turbine plant located 10km away. These plants are located some distance away, and given that the main air emissions of concern would be short-term exceedances and given the fact that it is unlikely that exceedances from two plants would occur at the same time, cumulative air quality impacts are likely to be less than significant. From a noise perspective, the plants are located some distance away and combined noise impacts would not be likely to influence each other. Therefore, given the distance, the environmental effects of combined industry operations in the local area are unlikely to be substantial.

The air quality assessment indicated that there will be little or no change in the air quality as a result of the operation of the proposed power station. Therefore, it is considered likely that there will not be any significant cumulative impact on air quality as a result of the project.

In terms of the impact on Nigeria's annual carbon emissions, according to the US Department of Energy[14] the total carbon emissions from the consumption of energy in 2012 were 86,398 kt CO2. The calculated annual carbon emissions from the power plant from all 6 Frame 9 Gas Turbines (Phases 1 and 2) is 3,350 kt CO2, adding 3.9% to the total annual carbon emissions of the country.

Due to the limited footprint of the power station and given that the closest plants are located some distance away, habitat fragmentation and loss of former farm land is not considered to be significant. In addition the species and habitats present on site are considered of low conservation importance such that cumulative impacts on ecology would be of low magnitude and of negligible significance. The OMA power station is not anticipated to significantly contribute to bird collisions with power lines on a cumulative basis since it is located over 10km away from the nearest wetland habitat and area where large birds would be expected to be present.

Given all of the above, the magnitude of cumulative impacts is assessed to be low and of negligible significance.

[14] DEA (2012) http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=regions&syid=2010&eyid=2012&unit=MMTCD

9. Mitigation Measures

This chapter outlines the mitigation measures proposed for the project to mitigate and minimise the potential environmental and social impacts identified in Section 8. The proposed mitigation measures for each environmental aspect are outlined in Section 9.1 for the construction phase and Section 9.4 for operational phase. Mitigation relevant to impacts associated with decommissioning are included within the ESMP, Section 10.

9.1 Mitigation Measures for Environmental Impacts in the Pre-Construction and Construction Phase

9.1.1 Air Quality

The following mitigation measures will be implemented to ensure air quality impacts are minimised:

- Concrete batch plant and equipment shall be designed and used in a manner which minimises dust generation:
- Access roads shall be tarred to limit additional dust rising during construction trucks and other vehicles passage;
- Project roads and areas between stockpiles will be covered or treated to with water or other environmentally benign dust-suppressant material to the extent feasible;
- Dust from stockpiles will be controlled by covering or by treating with water or some other environmentally benign dust-suppressant material;
- Careful location, grading and management of stockpiles of soil and similar materials will be undertaken to prevent wind-blow;
- Sealing and / or re-vegetation of completed earthworks will be undertaken as soon as reasonably practicable;
- Open-bodied vehicles transporting materials will be covered with a tarp or water or treat materials as appropriate to reduce emissions;
- Spills of batching materials (e.g., fly ash, sand, aggregate, or additives) would be cleaned up or controlled to minimize dust;
- To the extent practicable, the batch plants would be located downwind of the site and away from the local community;
- All dry material transfer points will be ducted through an appropriate filter unless there are no visible emissions from the transfer point;
- All transfer points will be equipped with a wet suppression system to control fugitive particulate emissions unless there are no visible emissions;
- All bulk storage silos including auxiliary bulk storage trailers would be equipped with appropriate type filter;
- The dust collection system employed will be capable of controlling particulates using the best technology available.
- All conveyors will be covered unless the material being transferred results in no visible emissions.

With regard to combustion emissions from on-site plant and machinery, the following shall be considered:

- Diesel powered construction equipment and vehicles will be well maintained to minimise exhaust emissions; and
- Idling reduction education for onsite diesel powered equipment and mobile vehicles.

Further mitigation measures relating to dust and traffic are provided within the ESMP.

9.1.2 Noise

The following mitigation measures will be employed to mitigate against construction traffic noise:

- The use of personal protective equipment will be enforced at worksite, to be detailed in the ESMS;
- All noise-emitting equipment shall be properly maintained to minimize the noise impact on the area and shall be compliant with the applicable World Bank standards (Table 9-1);
- The roadworthiness of trucks shall be ensured to minimize the noise impact;
- Movement of vehicles shall be restricted to day time; and
- Noise complaints shall be logged and kept onsite by the construction contractor.

9.1.3 Water and Wastewater

Construction phase impacts on the local water environment will largely be controlled through the application of good international industry practice including consideration of drainage on the construction site and appropriate control and storage of potential pollutants such as fuels or cementitious material used in the construction process.

All workers will be trained in the handling, storing, and disposal of hazardous materials. Emergency procedures will be in place so that in the event of an accidental release the spill can be contained and effects mitigated. Emergency spill containment material and clean-up equipment will be distributed and stored in appropriate places so that any spill can be cleared up as quickly as possible to minimize any adverse effects.

Site inspection and reporting is to be undertaken by a designated person during the construction phase to ensure that good work practice is being adhered to.

9.1.4 Ecology

The potential construction related ecological impacts are presented below with proposed mitigation measures where appropriate.

Loss of Vegetation

Impacts associated with the loss of vegetation as a result of the proposed project will be minimized through the implementation of the following mitigation measures:

- The limits of clearing will be delineated on appropriate scale site maps and the limits of clearing flagged to clarify to site workers the extents of the vegetation removal required, and thus minimize the loss of natural vegetation;
- Trees and shrubs that are to be retained will be marked with flagging, and compaction of the adjacent soils will (where possible) be avoided;
- Local, native plant species will be used in areas to be landscaped. Native species are best adapted to the local conditions, are more likely to become established, require minimal maintenance, and are less likely to cause problems from the introduction of non-native species (due to competition with native species);
- Salvaged and stockpiled topsoil will be used to the extent possible in re-vegetation efforts, erosion control, and landscaping;
- Use temporary fencing to prevent inadvertent damage to habitats adjacent to the construction area;
- Ensure the way-leave area width is at its minimum for least removal of vegetation; and
- Siting temporary works areas within land to be developed subsequently.

Direct Impacts on Habitats and Species

It is considered that all wildlife that is able to move, in advance of, and during clearing operations would likely move into adjacent areas and therefore would not be injured or killed during vegetation clearance or construction operations. It is noted that the available species are not endemic or threatened.

To mitigate against minor disturbance of species the following measures will be employed:

- Limiting use of lighting at night time;
- Management of noise and vibration, where practical;
- Education of workers on the need to protect habitats and species. Hunting to be prohibited.

Site inspection and reporting is to be undertaken by a designated person during the construction phase to ensure that good work practice is being adhered to.

Ecological Impacts from Contamination

- Potential for pollutants and surface water run-off to infiltrate to ground or migrate off site to be minimised by appropriate containment and drainage and emergency response measures.

Additional mitigation measures for indirect impacts associated with potential accidental releases of pollutants are as for those outlined in mitigation measures for geology, hydrogeology and hydrology impacts, Section 9.1.5, below.

9.1.5 Geology, Hydrogeology and Hydrology

Soil and Soil Erosion

To avoid and/or minimize adverse impacts due to soil erosion the following mitigation measures will be implemented:

- Covering of stockpiled topsoil, installation of wind fences, and reseeding of disturbed areas;
- Post-construction and restoration activities to reduce the long-term impacts from soil erosion will be implemented, for example:
  - debris removal and disposal;
  - the dismantling of all temporary facilities such as staging and laydown areas, and
  - reseeding of areas disturbed by construction activities with vegetation similar to that removed.
- Final site grade will be designed to facilitate drainage and avoid flooding or pooling.
- Disturbed areas will be restored to their original condition to the extent practicable.

Contamination of Soil and Groundwater

To mitigate against accidental release of chemicals in the soil and groundwater, the following mitigation measures will be employed:

- Workers will be trained in the handling, storing and disposal of hazardous and non-hazardous materials.
- In the event of an accidental release of hazardous materials, emergency procedures and management plans will be in place so that any spills or leaks can be contained immediately.
- Storage of potentially hazardous construction materials will take place on hard surfacing and within appropriate containers. Where necessary, these would be covered and incorporate spill or leak containment measures.
- Chemicals that would react together if brought into contact will be located in segregated storage areas.
- Emergency spill containment material and clean up equipment will be readily available.

- Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses without treatment. This should include any areas where cement or wet concrete is processed or stored.

To mitigate against creation of preferential pollution pathways in construction, all drilling and construction techniques will be in line with GIIP (i.e. full impermeable grouting of borehole casing to prevent a rapid contaminant source-receptor pathway).

Regarding water use, despite the low likelihood of any noticeable effect on water availability at the community supply boreholes, these will be monitored during drilling and test pumping of the remaining production wells. The boreholes will also be monitored during commissioning of the plant (specifically commissioning of the boreholes).

Site inspection and reporting is to be undertaken by a designated person during the construction phase to ensure that good work practice is being adhered to. In the event that significant geology, hydrogeology and hydrology impacts are observed, a stop work order would be given and maintained until an appropriate investigation into the issue has been completed and addressed to the satisfaction of the project, the community and lenders.

Unidentified Contamination

It is recommended that any geotechnical intrusive investigation work undertaken prior to construction incorporates environmental soil and groundwater sampling to determine if there are any contaminants present. If the results indicate contamination is present then a remedial strategy should be developed and implemented to remove or ensure contaminants are reduced to safe levels prior to construction.

Following environmental sampling and any remedial works required, there is the residual risk of encountering 'hotspots' of unknown soil and groundwater contamination during the construction phase. All workers should be trained in the identification of potential contamination and, if contamination is suspected, then work should be stopped immediately and samples of suspected contaminated materials sent for laboratory analysis. Work should not resume until the results have been received and appropriate mitigation measures implemented. Workers should wear appropriate PPE at all times throughout construction work.

9.1.6 Solid Wastes

A Construction Waste Management Plan (CWMP) will be required to be developed under the ESMP to mitigate against the impacts from wastes. The following waste hierarchy will be employed for the management of waste:

1. **Prevention** - preventing and reducing waste generation;
2. **Reuse and preparation for reuse** - giving the products a second life before they become waste;
3. **Recycle** - any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes composting and it does not include incineration; and
4. **Disposal** - processes to dispose of waste (for example landfilling, incineration, pyrolysis, gasification).

The practice for waste management will aim to prevent the generation of wastes and, if this is not possible will explore options 2 to 4 in turn with disposal of wastes only undertaken when other options are not practicable. It is noted that there are no landfills in the local area, therefore the CWMP will need to maximise recycling and use appropriate disposal methods for wastes that cannot be recycled.

The following measures are recommended to minimise construction waste and promote recycling:

- Wherever possible excavated soil should be used to complete landscaping and levelling requirements on the construction site to minimise the need to remove such material off-site; and
- Grade and sort benign waste such as wood off-cuts on site into different categories and make this available at no cost to the local community to take away and reuse.

The CWMP will include the management of the following waste streams:

- Solid Waste: Solid Waste will initially be sorted into color-coded bins according to the type of material indicating the level of hazard associated with the colour. See Figure 9-1 below for an illustrative example.
- Waste metals: All waste metals generated on site during the construction Phase should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination, where available. "Clean" waste metals can be recycled within the community.
- Building rubble: Wherever possible, uncontaminated building rubble will be utilised within the site for hardcore or other land reclamation purposes. Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism. Mitigation measures must be implemented to prevent run-off from the stockpiles of building rubble on site.

Figure 9-1 Example of Waste Segregation

Source: http://www.123rf.com/stock-photo/recycling.html

- Top soils and excavation wastes. Wherever possible these materials will be utilised for land reclamation purposes within the site. There is no history of any previous contamination of the site and therefore the top soils and excavation wastes can be re-used for landscaping, screening and filling purposes without prior treatment. Mitigation measures must be implemented to prevent run-off from the stockpiles of top-soil and excavation materials on site.
- Waste oils, lubricants, paints and solvents: Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container which has a bund wall built into it (for example 2 below). The container itself will be located in a bunded area of hard standing, to prevent leaks and spillages from entering the ground and the groundwater. The waste oil, lubricants and containers will be taken from site and disposed of at the nearest suitable recycling facility.
- Waste wood: Wherever possible, waste wood can be recycled in the community. However, where disposal is required, waste wood that is not contaminated by, or has not been treated with, halogenated organic compounds or heavy metals can be recovered for use as fuel.
- Electrical cabling and electrical components including batteries: Electrical cabling and components could be recycled informally in the community. Spent batteries will need to be stored in a suitable storage facility on site prior to transport to a suitable disposal facility.
- Sewage effluent: During the construction Phase, until suitable facilities are constructed, portaloos and portable showers should be used. The portaloos should be emptied by suitably licensed operators who will

dispose of the effluent to a suitable treatment facility. Alternatively, temporary facilities with a cesspit/ septic tank shall be constructed. Shower and wash facilities should drain to a cesspit/ septic tank until suitable treatment facilities are provided on site. Once available, permanent washing and toilet facilities shall be utilised and shall drain to a cesspit/ septic tank and thence to a package treatment facility capable of meeting IFC standards prior to discharge to the watercourses.

- Biodegradable food wastes: Wherever possible these shall be composted on site.
- Oxygen and acetylene tanks (or other such tanks for welding and cutting gases): Gas cylinders used for welding and cutting gases shall be returned to the provider of the gases for reuse.

Site inspection and reporting is to be undertaken by a designated person or contracted control firm during the construction phase to ensure that good work practice is being adhered to.

Figure 9-2 : Examples of oil drums in bunded storage, which would be located within a bunded area of hardstanding.

Source: http://www.chemstore.co.uk/chemical-fire-proof-and-gas-storage/bunded-chemical-stores/temperature-controlled/, ehttp://www.unisanuk.com/4-drum-bunded-hardcover-drum-storage-unit.php

Residual Impacts

Following implementation of appropriate mitigation measures no residual waste impacts are expected during construction. The impacts from solid wastes generation will be of low magnitude and negligible significance.

9.2 Mitigation Measures for Health and Safety Impacts in the Pre-Construction and Construction Phase and Operational Phases

9.2.1 Occupational health and safety

To ensure the protection of the workforce, occupational health standards and use of appropriate PPE will be implemented in accordance with good international industry practices including Nigerian regulatory requirements and World Bank guidelines. As such, the exposure to occupational health and safety issues will be consistent with the level of risk normally expected at any other large civil-engineering project.

In line with the requirements of PS2 (Section 2.6.2), the following mitigation measures will be implemented to address potential safety issues associated with early site preparation:

- Modification, substitution, or elimination of hazardous conditions where possible;
- Provide personnel with a Health and Safety orientation prior to early site preparation activities that addresses the safe operating and work execution plan;
- Enforce the use of appropriate PPE at work site;
- Specific identification of potential hazards to workers, particularly those that may be life-threatening;
- Documentation and reporting of occupational accidents, diseases, and incidents;
- Substances and task-specific training of personnel; and
- Emergency prevention, preparedness, and response arrangements.

Details of the above procedures and mitigation measures will be contained within the ESMS, and will be updated and reviewed over the life of the project.

9.2.2 Community Health and Safety

The following mitigation measures are recommended to reduce potential community health and safety effects:

- All project operations vehicles and contractor vehicles will have a speed limit set for travel through settlements and areas where there are no posted speed limits.
- A Worker Policy and Code of Behaviour shall be developed which includes guidance on visits, prescribed actions for conduct violations and a grievance mechanism for complaints.
- The EPC contractor shall engage with the local community to ensure that any relevant cultural heritage areas are avoided.
- An HIV/AIDS awareness and prevention program shall be implemented to provide the community with tools and education materials to reduce the spread of HIV/AIDS.
- An important aspect of minimising the spread of communicable diseases within the community is worker health screening, particularly as many workers are local people. A worker health screening programme shall be developed and implemented during the peak construction period or at any time when workers on site number more than 100.

- Worker accommodation plans will be developed according to international requirements under IFC Performance Standard 2.

- First Aid and Safety training will be provided to workers and Community Emergency Response Plans will be developed and tested including workers and nearby residents in the vicinity of Project-related traffic. These will include emergency response related to traffic accidents and potential releases of chemicals and other hazardous materials.

The impacts assessment identified transport movements to be the main risk to community health and safety. To mitigate against this the OPGCL contractor will carry out a pre- and post-works assessment of the roads that will be used during the project and develop a process that ensures overall safety along roads particularly near communities, to be included within the ESMS.

The following additional mitigation measures to minimise adverse impacts due to traffic will be employed:

- A Traffic Management Plan shall be implemented for any construction and operational traffic to reduce the potential for accidents.

- The main access road to plant will be upgraded / tarred which will have a positive effect on local traffic.

- Temporary traffic control and diversion arrangements shall be provided at strategic points on local roads, where necessary.

- An effective journey management schedule shall be maintained to reduce the risk of accidents.

- A transportation and materials management system for safe transportation of equipment and materials to site shall be developed and implemented, to be included within the ESMS.

9.3 Mitigation Measures for Socio-Economic Impacts in the Construction and Operational Phases

Although employment impacts are anticipated to be beneficial, the following enhancement measures are proposed to ensure that the employment process is well managed and the community conflicts are minimised.

Enhancement Measures

The following enhancement measures shall be applied to sustain and maximize the expected positive impacts of the project while minimizing any negative impacts on the project area of influence:

- Ensure a transparent hiring process is conducted help the community to understand strategic staffing decisions for the project to avoid conflict.

- OPGCL or OMA Power shall give preference to local community members in the Project Area of Influence, to the extent feasible, with respect to the employment of unskilled labour. OMA Power and its contractors shall maintain the policy of recruiting local labour through the community leaderships who provide community members to help fill such slots when available. OMA Power reserves the right to satisfy any outstanding positions for employment outside the local communities as needed.

- OMA Power shall adopt and sustain a meaningful dialogue with the community's representatives including youths in regards to reasonable demands for employment and wages. This will be managed as a matter of policy by Oma through its community liaison office, which shall engage contractors and community leaders in pre-mobilization dialogue to foster good understanding and fair wages for local workers. This process may give rise to the signing contractual agreements to operate/work between contractors and communities. However, this is subject to Oma Power discretion. OMA Power shall involve non-executive members of the local communities in skill acquisition and other educational training programmes (if deemed necessary).

- OMA Power shall endeavour to contribute to community enhancement projects in the community including the provision of community and social infrastructure in the Project Area of Influence.

- OMA Power shall maintain its community relations policy in order to maintain good community relations.

9.4 Mitigation Measures for Environmental Impacts in the Operational Phase

9.4.1 Air Quality

Mitigation measures to minimise emissions of NOx and CO to air are included within the design of the proposed OMA Power Plant. In addition, ambient air quality monitoring and emissions monitoring will be undertaken, as described below:

- Ambient Air Quality Monitoring.

  Air quality monitoring will be carried out at, or close to, the location(s) of receptors predicted to experience the highest increment in long term NO_2 concentrations. The air emission modelling has identified two receptors at which monitoring will be required. These are approximately 1 – 2 km downwind of the plant. Detailed monitoring procedures will be developed as part of the overall environmental management plan. The specific monitoring location(s) will be agreed with the FMEnv prior to the commencement of the monitoring survey. A suitable background monitoring location will also be included in the survey. The survey will be carried out using passive samplers in line with the requirements of the IFC "Environmental, Health and Safety Guidelines for Thermal Power Plants" where the PC is less than 25% of the ambient air quality guideline (i.e. Phases 1 and 2).

- Stack Emissions Monitoring.

  To further ensure conformity with current standards, a Continuous Emission Monitoring System (CEMS) will be included in the power plant. This will provide continuous assessment of the stack emissions to verify if the NOx concentration (measured as NO_2) meet the project commitment not to exceed 25 ppm at the stack. Appropriate maintenance and/or operating changes will be implemented, if necessary, to maintain design parameters.

9.4.2 Energy Efficiency and Greenhouse Gas Emissions

It is recommended that OMA evaluate technically and financially feasible and cost-effective options to reduce or offset project-related GHG emissions during the design and operation of the project.

It is important to analyse the need for power and heat, the available space, and weight restrictions to design an optimal solution to balance capital costs, energy costs and overall plant efficiency. Mitigation measure to consider throughout the design and management of operations include:

- Pumps/motors – use of high efficiency motors, variable speed drives or multi speed motors (depending on circumstances) and motor load sensing for start/stop control.
- Lighting - use high efficiency lights (e.g. LEDs) where appropriate, use motion and photo sensors, use as much natural light as possible.
- Waste – encourage reduction of waste through prevention and re-use. Where waste arises, opt to recycle before considering other disposal routes.
- Water – encourage reduction in water use by staff, mend any water leaks, treat blow down water for re-use.

Given the location and nature of the project, it is also recommended that the project:

- Monitor, Calculate and Disclosure GHG Emissions Annually

  For projects that are expected to produce more than 25,000 tonnes of CO2e annually, the project is required to quantify direct emissions from the facilities owned or controlled within the physical boundary as well as indirect emissions associated with the offsite production of electricity used by the project. The project will quantify and disclose these carbon emissions annually in annual reports, as part of the project's commitment to meeting the requirements of IFC Performance Standard 3.

In order to quantify and manage GHG emissions the following will be undertaken:

- An Emissions Inventory to be maintained throughout all phases of the project. This should be a live document, to ensure all emissions sources are up to date.
- Quantity of GHG emissions from fixed sources to be monitored.
- Emissions and sources of emissions to be monitored throughout the life of the project with a focus on sensitive receptors as identified in the EIA.

- Develop GHG Targets for Environmental Management System:

  IFC Performance Standard (PS) 1 requires the establishment of effective environmental and social management systems and PS3 requires the reduction of project GHG emissions. It is recommended that (a) the project's environmental management system include a target of reducing GHG emissions on an absolute and intensity basis; (b) GHG emissions be determined on an annual basis using the methodology described within IFC PS 3.

Other actions that could be considered and implemented to reduce and manage GHG emissions are as follows:

- Demand Side Measures to Reduce Need for New Generation:

  Typically, a country's electricity sector is structured such that increased consumer demand is satisfied through the construction of new power plants or expansion of existing plant rather than through measures to reduce consumer demand. In some jurisdictions, for example California, power utilities are required to demonstrate that they have implemented comprehensive energy efficiency programmes with customers before they are permitted to develop new power plants.

  Greater efficiency in the consumption of energy is commonly an attractive option for emissions reduction, due to its dual benefit of reducing both emissions and the size of the energy bill. However, despite many years of promotion, it is also the most overlooked option. In Clean Development Mechanisms (CDMs), for instance, demand-side energy efficiency projects only make up 1% of the Certified Emission Reduction (CER) generation. Among the many reasons for this is the fact that most developing countries focus on energy access, rather than energy saving.

- Make Provision for Potential Carbon Capture and Sequestration:

  Considerable effort is made around the world to develop carbon capture and sequestration (CCS) schemes. Of the 13 operational projects in the world, there is only one demonstration project in the power generation sector (Canada) which uses post combustion capture technology. On the Africa continent, there is one CCS plant in Algeria which uses pre-combustion capture as part of a gas processing facility. Other plants in other industrial sectors have adequately demonstrated integrated gasification combined cycle's (IGCC) capacity, efficiency and environmental performance but some uncertainty remains regarding availability, reliability and cost. There are currently 9 plants being built and 32 plants being planned in a number of countries, almost all of which are expected to receive explicit public subsidies. Given the current status of CCS in the power generation sector, the technology is not considered a timely proposition for this project.

- Carbon Credits / Offsets:

9.4.3 In a number of developed countries, large GHG emitters are participants in emissions trading schemes, under which they need to reduce GHG emissions to prescribed levels or face a penalty. Such participants can reduce emissions either directly (for instance, through biomass co-firing) or can purchase 'carbon credits' in the form of allowances from other scheme participants or emission reductions from projects in other countries. Participants in emissions trading schemes have clear market incentives to reduce their emissions as the penalty for non-compliance is typically much higher than costs of abatement or purchasing carbon credits. For emitters in developing countries, no such market incentives exist for GHG emissions under the Kyoto Protocol or any other international or national agreements. Instead, the focus is different. That is, developers of projects which reduce GHG emissions are eligible to obtain additional finance for their project through the Clean Development Mechanism of the Kyoto Protocol 2. Given that there is no regulatory requirement for the project to reduce its GHG emissions, it is not recommended that the project purchase carbon credits on the open market in order to reduce its emissions given the substantive cost involved and the limited benefits.

Noise

The proposed project shall operate in a manner that adheres to the World Bank guidelines for noise emissions, as outlined in Table 9-1 below.

Table 9-1: World Bank Noise Level Guidelines

Receptor	One Hour LAeq (dBA)	
	Daytime 07:00-19:00	Night time 19:00-07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Source: World Bank Pollution Prevention and Abatement Handbook, 1998

As detailed in section 8.7.3, the noise modelling indicates there will be an exceedance of night-time noise limits at sensitive receptors for all project phases. As a result, a Noise Management Plan shall be developed for the project. The recommended mitigation strategies that could be considered to reduce noise are included in Table 9-2 below. These strategies are based on the following measures for mitigation of noise recommended by EHS guidelines provided by the IFC:

- Use of noise control techniques such as: using acoustic machine enclosures; selecting structures according to their noise isolation effect to envelop the building; using mufflers or silencers in intake and exhaust channels; using sound absorptive materials in walls and ceilings; using vibration isolators and flexible connections (e.g., helical steel springs and rubber elements); applying a carefully detailed design to prevent possible noise leakage through openings or to minimize pressure variations in piping; and
- Modification of the plant configuration or use of noise barriers such as berms and vegetation to limit ambient noise at plant property lines, especially where sensitive noise receptors may be present.

Table 9-2: Noise Mitigation Strategies

Mitigation Strategy	Effectiveness	Cost and Operational Impact
Place gas turbines and generators in enclosures or buildings offering good sound insulation (R_w 20 dB or better). Specifying transformers with a sound power level (including fans) not exceeding 92.5 dB L_{WA} (ref $1x10^{-12}$ W).	Highly effective. Noise levels less than 45 dB $L_{Aeq,1hour}$ will be achieved at all sensitive receptors.	Highest cost and operational / design impacts.
Construction of a solid noise barrier (and/or bund) along the southern perimeter of the site, and local barriers around turbines and generators.	Moderate effect; some noise reductions, but noise levels at 14 receptors will still exceed 45 dB $L_{Aeq,1hour}$, by up to 2.5 dB.	High cost, some operational and design impacts.
A sound insulation grant scheme for residential properties where noise levels are shown to exceed 45 dB $L_{Aeq,1hour}$ at night.	External noise levels will be unaltered, but the sound insulation measures will enable occupants to sleep comfortably with windows closed.	Lowest cost, no operational impact other than administering grant scheme.

It is recommended that consultation with the Lender Group over the most appropriate mitigation strategy for the project be undertaken, and the selected strategy implemented.

In addition to the above, other mitigation measures to mitigate against general noise emissions for the project include:

- Appropriate design of the foundations for the gas turbines to ensure that all criteria including noise and vibration are fully accommodated.
- Foundations will be unitized and isolated to support the gas turbines generators and auxiliary/ancillary plant.
- Adequate clear working space between units for laydown and loading bays shall be provided.
- Suitably sized foundations shall be provided to accommodate central and local control rooms, switchgears, battery and HVAC (heating, ventilation, and air conditioning equipment) rooms, laboratory, offices, kitchen and toilet facilities.
- Design of buildings shall incorporate facilities for noise abatement such as double walls with rock wool insulation between them, and solar-reflective double-glazed windows and doors.

Noise modelling, confirmation of sensitive receptors, design reviews and performance tests will be conducted to confirm that noise limits are incorporated into the design of the project to ensure compliance with World Bank noise emission guidelines.

The personnel on site shall be provided with appropriate protective or corrective device to ameliorate noise effect. Measures are also to be taken at noise receptors located outside the project area boundary.

It is recommended that noise monitoring be undertaken at site boundaries and sensitive environmental receptors throughout the project lifetime. Monitoring requirements should comply with IFC guidelines which recommend a 48 hour monitoring period. A noise monitoring programme will need to be developed for the project and this is included as an action in the ESMP.

9.4.4 Water and Wastewater

Inherent mitigation measures for the safe treatment and disposal of water and waste water streams are outlined below:

- **Sanitary Sewage Discharge**

  Sewage and urinals from water closets will be channelled into a reinforced concrete underground septic tank. Digested sewage from the septic tank will pass through a drainage pipe into the water treatment plant where it will be treated in line with World Bank / IFC EHS guidelines. The maximum treatment capacity is about 5m3/h. Treated water from domestic sewage treatment station will then be discharged into the storm water system.

- **Stormwater Discharge**

  The rainwater storm drainage system will be designed with sufficient capacity to accept a 1 in 10 year frequency storm, plus an appropriate additional factor to allow for potential increase in rainfall frequency/intensity due to climate change.

  Stormwater from hardstanding areas with the potential to come into contact with contaminated materials (e.g. oil from vehicle traffic and parking lots) will be directed through an oil/water separator. Separated oil will be pumped out of the sump and removed by licenced waste contractor, whilst water effluent will be pumped to the water treatment plant.

  The discharge outfall from the storm drainage network will be design in order to prevent any detrimental impacts to adjacent property (e.g. erosion around the outfall and associated additional sediment generation; also increased overland flows due to rapid transmission of rainwater on new hardstanding) down gradient from the outfall.

  In addition to the storm water drainage system, the design of earthworks will also be configured to divert any surface storm water away from the critical areas of the plant where practicable.

- **Wastewater Effluent Discharge**

  The main sources of oily wastewater will be oil-contaminated water from hardstanding around GTGs , emergency diesel generators /diesel oil storage, oil tanks of transformers, lubrication system and maintenance workshop. All potentially oily wastewater from these areas shall be collected and treated in the oily wastewater treatment plant system.

  This will consist of an oil / water (O/W) separator which will settle and skim oil residues from the water and pump the waste oil to a storage container. Water from the O/W separator will be pumped to the water treatment plant for removal of potential contaminants.

  The system shall include an observation pond with sufficient capacity to provide adequate retention time to arrest any accidental breakthrough of oil or other potential contaminant spills and to allow testing.

  In summary, all discharged effluent will be treated in line with the more stringent relevant Nigerian and IFC EHS standards prior to discharge into the storm drainage network. This design mitigation in conjunction with appropriate contamination spill control and response procedures will be providing appropriate protection against soil and groundwater contamination.

- **Accidental Release**

  As in construction, there is the possibility that accidental spills of fuel, etc. could cause considerable contamination of watercourses. Every precaution will be taken to prevent accidents, and oil and fuel areas will be bounded. All workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of an accidental release there will be emergency procedures in place so that the spill can be contained immediately. Emergency spill containment material and clean up equipment will be distributed and stored in appropriate places so that any spill can be cleared up as quickly as possible to minimize any adverse effects.

No additional mitigation measures are proposed.

9.4.5 Ecology

As discussed in Section 0, no direct impacts are associated with operational phase activities. There may be some indirect impacts following accidental release/ loss of containment of polluting substances. Mitigation measures are provided in Section 9.4.6, below.

9.4.6 Geology, Hydrogeology, Hydrology

Mitigation regarding protection of land and groundwater from potential contamination will largely comprise minimisation and appropriate storage and management of such materials on side along with pollution prevention, control and response procedures in line with IFC PS3 and IFC EHS Guidelines. The following mitigation measures will be employed:

- Workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of an accidental release, emergency procedures and management plans will be in place so that the spill can be contained immediately and cleaned and disposed appropriately.
- Chemicals will be stored in designated bunded areas with bunds having the capacity to contain at least 110% of the volume of chemicals stored.
- Wherever possible, there will be no bund wall penetration and all pipework will be routed over the bund wall.
- Hard standing areas around potentially contaminating materials storage areas will drain to the oil/water separate and/or effluent drainage system.
- Operational storage tanks will be designed and constructed in accordance with internationally recognised standards (such as BS EN 14015 or API 650) ensuring they are robust and fit for purpose.
- Chemicals that will react together if brought into contact will be located in segregated storage and bunded areas.
- Operational areas and roads where spills or leaks of hazardous materials could occur will be constructed in low permeability hardstanding to minimise potential for infiltration of contaminants to ground.
- All tank filling points will be situated within bunds so that any accidental spillage is contained.
- OPGCL will have emergency response plans and procedures in place should there be any loss of containment. Emergency spill response and clean up procedures will be in line with international standards.
- Emergency spill containment materials and clean up equipment will be readily available.
- OPGCL will maintain an inventory of the chemicals needed for the operation of the power plant, such as dosing and treatment chemicals and lubricants. Details of locations and quantities on site, and their usage will be strictly logged and tracked, and stored in a separate storage building at site.
- Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses. Stormwater / surface water run-off will be channelled to oil separators / interceptors and silt traps prior to disposal to outfalls.

Periodic site inspection and reporting is to be undertaken by a designated person or contracted control firm to ensure that good work practice is being adhered to.

9.4.7 Solid Waste

A Waste Management Plan (WMP) for the operational phase will be developed for the project, as required by the EMMP to ensure wastes are handled and disposed of in the most efficient and sustainable way, minimising impacts to people and the environment. The waste hierarchy principles to be applied are the same as for the WMP required for the construction phase (CWMP), as outlined in section 9.1.6. The WMP shall identify the environmental standards to which the waste recycling, treatment or disposal facility shall operate, when handling, transporting and treating the wastes. It will be the responsibility of the contractor to identify suitable treatment and disposal facilities capable of meeting appropriate environmental standards, when creating, and then implementing the WMP for the construction, operation and decommissioning phases.

All wastes will require suitable storage on site prior to disposal to prevent loss of materials capable of causing pollution to the environment. Wastes generated during pre-construction, construction, operation, and decommissioning phases will require transportation to the final reclamation or disposal facilities in vehicles capable of preventing loss of containment during transportation.

The WMP will identify:

- The wastes that will be generated;
- Approximate quantities;
- Waste minimisation methods;
- On-site storage arrangements;
- Accidental release mitigation measures;
- Waste carrier details, and methods of off-site transportation;
- Final waste treatment, recycling or disposal destination; and
- Relevant international or local standards to be applied.

To ensure that wastes generated are properly handled, the following mitigation measures to be detailed in the WMP, are recommended:

- Segregation and storage of specific waste materials. Separate and clearly labelled bins, colour-coded for different waste streams to be used (e.g. plastics / paper / metal). Recycling of these streams to be undertaken where appropriate;
- Handling procedures for wastes are followed;
- Inventory of waste to be maintained;
- Personal protective equipment should be used;
- A waste management initiative of waste reduction, re use and re-cycling is to be implemented by OPGCL management;
- Transportation methods for transport of wastes to the final reclamation or disposal facilities. This must be in vehicles capable of preventing loss of containment during transportation;
- The identification of suitably licensed facilities for the disposal of wastes (where necessary) operating to appropriate international or local standards, and capable of treating, and recycling or disposing of the wastes without causing pollution to the environment. It is the responsibility of the contractor to establish the most suitable disposal, treatment or recycling facility to ensure correct treatment and disposal of all wastes is achieved without causing harm to the environment or to human health;
- All waste disposal and carrier contractors will require auditing by an independent body to ensure that they are capable of meeting the relevant international or local standards.

The WMP will include waste management procedures for each waste stream from the OPGCL plant which arises from the construction and operation of the power plant. OPGCL shall ensure that the waste contractor is appropriately licensed and carry out regular waste audits.

OPGCL's waste stream and waste management principles are set out in Table 9-3.

Table 9-3: OPGCL Waste Stream and Management Principles

Waste Type	Composition	Management option
Solid Waste	Spoil from excavations and earthworks, broken glass, packaging materials (wood, cardboard and plastic), empty chemical, oil and paint	Used cans, packaging and plastics will either be re-used by the company or the local community, having been sorted from the waste stream.

Waste Type	Composition	Management option
	containers, scrap metal from construction, waste associated with maintenance tasks including metal parts, lubricants, rags and domestic garbage.	All solid waste that is not reusable in the local community will be disposed of by OPGCL's registered waste contractor
Liquid waste/ wastewater	Spilled chemicals and waste oil, oily waste water and sludge from sewage	Liquid waste will be collected in sedimentation tank/s and treated before disposal. Wastewater will be subjected to treatment and re-used as potable water
Gaseous Waste	Primarily NOx and CO	The plant design will incorporate best available technology (BACT) options to minimize the impacts resulting from its operation. The impact of other pollutant gases will also be minimized by judicious choice of technology, fuel and stack design.
Hazardous and toxic liquids	Used or contaminated oils, used industrial solvents, industrial corrosives and acids used for cleaning, de-scaling and other related processes	All hazardous and toxic waste will be disposed of by OPGCL's registered waste contractor Any spilled oil shall be contained immediately as it occurs to avoid escalation or seep into the ground. The collected oil will be treated before disposal.
Hazardous Solid waste	No hazardous solid wastes are expected to be produced during construction or operation.	Not applicable

9.5 Mitigation Measures for Environmental Impacts in the Decommissioning Phase

9.5.1 Air Quality

The following mitigation measures will be implemented to ensure air quality impacts are minimised:

- Project roads and areas between any demolition or stockpile of materials will be covered or treated to with water or other environmentally benign dust-suppressant material to the extent feasible;
- Dust from demolition will be controlled by covering or by treating areas with water or some other environmentally benign dust-suppressant material;
- Careful location, grading and management of stockpiles of soil and similar materials will be undertaken to prevent wind-blow;
- Sealing and / or re-vegetation of completed earthworks will be undertaken as soon as reasonably practicable;
- Open-bodied vehicles transporting materials will be covered with a tarp or water or treat materials as appropriate to reduce emissions;
- Spills of batching materials (e.g., fly ash, sand, aggregate, or additives) would be cleaned up or controlled to minimize dust;
- All dry material transfer points will be ducted through an appropriate filter unless there are no visible emissions from the transfer point;

- All transfer points will be equipped with a wet suppression system to control fugitive particulate emissions unless there are no visible emissions;
- All bulk storage silos including auxiliary bulk storage trailers would be equipped with appropriate type filter;
- The dust collection system employed will be capable of controlling particulates using the best technology available.
- All conveyors will be covered unless the material being transferred results in no visible emissions.
- Diesel powered vehicles will be well maintained to minimise exhaust emissions; and
- Idling reduction education for onsite diesel powered equipment and mobile vehicles.

Further mitigation measures relating to dust and traffic are provided within the ESMP.

9.5.2 Noise

The following mitigation measures will be employed to reduce decommissioning noise impacts:

- The use of personal protective equipment will be enforced at worksite, to be detailed in the ESMS;
- All noise-emitting equipment shall be properly maintained to minimize the noise impact on the area and shall be compliant with the applicable World Bank standards (Table 9-1);
- The roadworthiness of trucks shall be ensured to minimize the noise impact;
- Movement of vehicles shall be restricted to day time; and
- Noise complaints shall be logged and kept onsite by the construction contractor.

9.5.3 Ecology

To mitigate against minor disturbance of species the following measures will be employed:

- Limiting use of lighting at night time;
- Management of noise and vibration, where practical;
- Education of workers on the need to protect habitats and species. Hunting to be prohibited.

Site inspection and reporting is to be undertaken by a designated person during the decommissioning phase to ensure that good work practice is being adhered to.

- Potential for pollutants and surface water run-off to infiltrate to ground or migrate off site to be minimised by appropriate containment and drainage and emergency response measures.

9.5.4 Other Impacts Decommissioning

Mitigation measures for other impacts associated with waste, community health and safety, geology, and hydrology impacts are described in detail under sections 9.1.5, 9.1.6, 9.2.1 and 9.2.2 above and are also included in the ESMP.

9.6 Mitigation Measures for Transmission Line Impacts in the Construction and Operational Phases

As outlined in Section 8.1.2, the ESMP should be further developed to provide more robust management and mitigation measures in relation to the transmission line. It should include full construction and operational management practice, and be developed and implemented from site preparation to decommissioning.

Independent third party review of the management and mitigation plans is recommended to ensure they meet good international industry practice and the requirements of the IFC Performance Standards.

Environmental and social actions of relevance to the transmission line will focus on:

- a need to protect the soils and surface vegetation during construction;
- labour and working conditions including occupational health and safety; and
- community, health and safety.

Recommended measures include the following:

- the disclosure of exclusion zones around the transmission line to the local community as part of ongoing consultation, engagement and disclosure activities;
- development of an emergency response plan and safety procedures for the transmission line and any nearby rights of way;
- ensure sufficient welfare facilities and emergency response infrastructure plans and procedures are developed by the project to ensure appropriate management and resources are in place in the event of an incident along the transmission line. Consideration of impacts in the event of an incident on the neighbouring pipeline should also be considered within the plans.

10. Environmental and Social Management Plan

10.1 Introduction

10.1.1 Overview

This document presents an Environmental and Social Management Plan (ESMP) for the Oma Power Generation Company Limited (OPGCL or Oma), Oma Power Plant Project ("the project"). This ESMP supplements the information provided within the Environmental and Social Impact Assessment (ESIA) originally prepared for the project by BGI Resources in February 2014, with supporting studies undertaken by Jacobs. It has been produced specifically to collate the mitigation measures and actions identified in the ESIA into a standard format for internationally financed projects, for the purpose of defining the specific responsibilities of the engineering, procurement and construction (EPC) contractor undertaking the construction works.

This ESMP will be used as a guide in the development of subsequent detailed management plans for pre-construction, construction operation and decommissioning phases. An Environmental and Social Management Systems (ESMS) team will be appointed for each project phase to develop this framework ESMP. For the operational phase, the ESMP will be developed and expanded into a full EMS either accredited or aligned to ISO 140001. ISO 140001 is an internationally accepted standard that outlines how to put an effective environmental management system in place. The recommendations stipulated within this ESMP must be adopted in the development of the detailed ESMS and international WBG/ IFC standards must be met for the duration of the project.

The ESMP has been prepared in accordance with environmental and social commitments of OPGCL and in compliance with the legal and regulatory requirements of Nigeria and of the International Finance Corporation (IFC) Performance Standards and Environmental, Health and Safety Guidelines.

10.1.2 Objectives and Scope of the ESMP

The objectives of this ESMP are to:

- Collate and describe all mitigation measures and actions identified through the ESIA process to enhance positive benefits and to eliminate or reduce key identified environmental, socioeconomic and health issues and impacts to acceptable levels. These measures will be implemented by the engineering, procurement and construction (EPC) contractor during the detailed design, construction and operation and decommissioning phases of the project

- Identify key environmental and social reporting requirements, such as audits of performance which the contractor will need to develop and undertake throughout all phases of the project.

- Identify and describe monitoring required to ensure the reporting commitments are met. The reporting requirements for the construction phase will be addressed by the EPC contractor. Reporting commitments for the operational phase will be detailed within the operational Environmental Management Systems (EMS) which will be developed by the plant operators.

The ESMP includes both general environmental and social requirements that are common to most construction projects, and specific environmental and social initiatives unique to the issues identified in relation to this project.

The actions within this ESMP will be used as a basis for the EPC Contractor to develop its own suite of Environmental, Health and Safety Management Manuals and Systems for the construction of the project.

This ESMP and associated detailed plans are live documents that will be updated as the project proceeds.

10.1.3 Implementation of the ESMP

Overview

This ESMP provides a framework document to be used throughout the lifetime of the Project. It forms the basis from which more detailed plans will be developed once an EPC contractor has been selected and further design details are available. The action and standards specified within this ESMP must be adopted in the development and implementation of detailed management plans. International (IFC) standards, national Nigerian Federal Ministry of Environment (FMEnv) standards and relevant national legislation must be met throughout the life of the Project. The parties involved in the implementation of the ESMP and their roles and responsibilities are outlined in Table 10-1. EMS teams will be appointed for each project phase and they will be responsible for ensuring implementation of the ESMP.

Roles and Responsibilities – Administration

Table 10-1 below outlines the roles and responsibilities of the parties involved in the implementation of the ESMP.

Table 10-1: Roles and Responsibilities

Party	Responsibilities
Oma Power Generation Company Limited (OPGCL)	Drafting of initial framework for the ESMP. This will be used as a guide in the development of subsequent detailed management plans for all Project phases. The recommendations of OPGCL must be adopted and international IFC standards used for the duration the Project. OPGCL will appoint an Owner's Engineer/contract a monitoring firm, whose responsibilities will include review and oversight of the EPC Contractor's environmental, health and safety plans to ensure conformance with the ESMP.
EPC contractor(s)	In supporting the implementation of the ESMP and associated actions, the EPC Contractor will be required to include, as a minimum, a team that comprises: • An environmental liaison officer (ELO), who shall be an environmental specialist with experience of construction site environmental and social management; • A project quality assurance engineer (QAE); and • A community liaison officer (CLO). The ELO shall be the focal point on environmental matters in relation to the construction phase of the proposed project and will report to the EPC Contractor's overall Project Manager as well as the Oma environmental manager. The ELO shall ensure strict adherence to the requirements of the ESMP, including design mitigation measure specifications.
EMS team for the construction phase	Drafting of the detailed ESMP for the construction phase, which will include all of the aspects covered in this ESMP. (An EMS team for the decommissioning phase will draft the detailed Decommissioning Management Plan in the future.) The implementation and enforcement of actions required by the detailed management plans, including any monitoring requirements and reporting. The training of workers in how to perform tasks required by the detailed management plans.

	The provision of all required items including safety equipment and emergency response equipment required by the management plans. Management of waste contractors and other external contractors and consultants used in the construction / decommissioning phases of the Project. Updating the management plans with any required changes as the Project progresses.
Waste Contractors	Responsible for the collection and disposal of wastes to appropriate disposal facilities. The contractors must abide by the standards specified within this ESMP and within the detailed management plans.
Plant Owner / Operator	The owner will appoint an EMS team to develop and implement Environmental, Health and Social Management Plans for the construction, operational and decommissioning phase.
EMS team for the operational phase.	Drafting of the detailed EMS or equivalent documents, which will include all of the operational aspects covered in this ESMP. The implementation and enforcement of actions required by the detailed management plans, including any monitoring requirements and reporting. The training of workers in how to perform tasks required by the detailed management plans. The provision of all required items including safety equipment and emergency response equipment required by the management plans. Management of waste contractors and other external contractors and consultants used in the operational phase of the Project. Updating the management plans with any required changes as the project progresses.
External Consultants	May be used to undertake monitoring works and reporting in both the construction and operational phase. The consultants must abide by the standards specified within this ESMP and within the detailed management plans drafted by the relevant EMS teams.
Nigerian FMEnv / Regulating Bodies	Ensure that monitoring and reporting requirements (as required by the EMSP and detailed management plans in accordance with FMEnv standards and guidelines). Enforce any actions that may be needed to ensure environmental quality standards are not breached and permit requirements are maintained.
International Financing Institution (IFI)	International Finance Institutions will develop their own Environmental and Social Action Plan (ESAP) that will include conditions to be met. The ESAP will include the requirement to comply with, among other plans, the ESMP.

Monitoring

Monitoring is required to ensure that the actions specified in the EMSP to mitigate environmental and social impacts are effective. Monitoring must be undertaken on the specified schedule indicated for relevant actions (e.g. daily, weekly, monthly, quarterly or annual basis). Where technical equipment must be used (e.g. for noise

monitoring), it must be regularly maintained and calibrated with appropriate certification. For air quality monitoring, a CEMS will be used.

Audit and Inspections

Internal audits and inspections are required throughout each project phase, on a regular basis, to ensure that the requirements of the ESMP are being undertaken. The audits and inspections should be undertaken to the standards specified within the detailed project EMS. The frequency of inspections will vary depending on the nature of activities. Inspection records should be maintained and kept up to date.

External audits and inspections by regulating authorities will also be undertaken throughout the lifetime of the project.

Reporting

Reporting of monitoring undertaken must be supplied to the relevant person/organisation(s) as specified within detailed management plans, to include:

- Construction Waste Management Plan;
- Health and Safety Plan including Emergency Response Plan;
- Traffic Management Plan;
- Worker Management Plan;
- Noise Management Plan; and
- Waste Management Plan.

During the operational phase, annual reporting of monitoring works required by this ESMP for all Project phases must be reported to the regulator and to the IFI where specified. Detailed reporting requirements and procedures are to be developed as part of the detailed management plans. A more detailed numbering reference system will be developed for each measure during the ESMP phase in order to keep track of the management of each.

Change Management and ESMP Updates

The ESMP is a working document and will be updated in line with any changes to Project requirements or as a result of actions required by internal / external audits. The EPC contractor is responsible for ensuring that changes are incorporated into the relevant procedures and implemented.

As the Project progresses and detailed design is concluded, a greater level of certainty will be available regarding the project's likely impacts and understanding of the environmental and social aspects requiring management during all phases. Where any additional issues are identified, these will be assessed as necessary through an update to the ESIA and subsequent amendments of this ESMP and associated detailed plans. Any amendments to the ESIA/ESMP will be re-submitted to the FMEnv and made available to the public.

10.2 Environmental and Social Management Plan Actions

Table 10-2 sets out the environmental and social mitigation measures and actions identified as required for consideration in design / pre-construction.

Table 10-3 sets out the environmental and social mitigation measures and actions identified as required in the construction and decommissioning phases for the project.

Table 10-4 sets out the environmental and social mitigation measures and actions identified as required in operational phase for the project.

10.3 Environmental and Social Management Costs

Although specific costs of each measure are not known at the stage, indicative costs are estimated below. ESMS construction monitoring is estimated at approximately 150,000 US dollars. Some of the biggest cost related monitoring activities during construction and approximate costs would include**:**

- Appointment of a Health, Safety and Environment (HSE) Manager for 18 months -110,000 USD;
- 1 HSE assistants for the 18 months - 30,000 USD;
- HSE Audits during Construction - 20,000 USD; and

The estimated budget for ESMS during operations would be approximately 200,000 US dollars (USD) per year. Some of the biggest cost related monitoring activities during operations and approximate costs would include**:**

- HSE Manager per year - 80,000 USD;
- HSE Assistant - 50,000 USD;
- Various Testing -40,000 USD; and
- HSE Audits -20,000 USD.

Table 10-2 : ESMP for OMA Power Generation Project – Mitigation Actions in Design / Pre-construction

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)
Geology, Hydrogeology and Hydrology (Mitigation Measures from 9.1.5 and 9.4.6 of the ESIA) and Wastewater Discharge Management and Groundwater Protection (Mitigation Measures from sections 9.1.3 and 9.4.4 of the ESIA)				
Design	Contamination of soils following spills, leaks of chemicals used.	Drainage design and management to ensure that potentially contaminated surface run-off does not flow directly into watercourses without treatment, including any areas where cement or wet concrete is processed or stored. Storm water discharge outfall to be appropriately designed to avoid the potential for offsite erosion.	Design contractor	FMEnv and IFC requirements. Soil physicochemical and microbiological characteristics.
Design	Soil and Groundwater Contamination	Chemicals will be stored in designated bunded areas with bunds having the capacity to contain at least 110% of the volume of chemicals stored. Wherever possible, there will be no bund wall penetration and all pipework will be routed over the bund wall. Hard standing areas around potentially contaminating materials storage areas will drain to the oil/water separate and/or effluent drainage system. Operational storage tanks will be designed and constructed in accordance with internationally recognised standards (such as BS EN 14015 or API 650) ensuring they are robust and fit for purpose. Chemicals that will react together if brought into contact will be located in segregated storage and bunded areas. Operational areas and roads where spills or leaks of hazardous materials could occur will be constructed in low permeability hardstanding to minimise potential for infiltration of contaminants to ground. All tank filling points will be situated within bunds so that any accidental spillage is contained. Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses. Stormwater / surface water run-off will be channelled to oil separators / interceptors and silt traps prior to disposal to outfalls.	Design contractor	FMEnv and IFC requirements.
Design	Soil and Groundwater Contamination	The drilling of two further boreholes, and test-pumping of these boreholes, will be undertaken to verify their adequacy in supplying Phases 2 and 3, and also to confirm that no significant impacts with regard to yield or water quality will be experienced at community boreholes.	Design contractor	FMEnv and IFC requirements.
Ambient Noise Management (Mitigation Measures from 9.1.2 and 9.4.3 of the ESIA)				
Design	Exceedance of night time noise emissions limits	Noise modelling has indicated there will be an exceedance of night time noise limits at sensitive receptors for all project phases. As a result, a Noise Management Plan shall be developed for the project. Noise modelling, confirmation of sensitive receptors, design reviews and performance tests will be conducted to confirm that noise limits are incorporated into the design of the project to ensure compliance with World Bank noise emission guidelines. The recommended mitigation strategies that could be considered to reduce noise are: • Place gas turbines and generators in enclosures or buildings offering good sound insulation (Rw 20 dB or better). • Specifying transformers with a sound power level (including fans) not exceeding 92.5 dB	Design contractor	FMEnv and IFC requirements.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)
		LWA (ref 1x10-12 W). • Construction of a solid noise barrier (and/or bund) along the southern perimeter of the site, and local barriers around turbines and generators. • A sound insulation grant scheme for residential properties where noise levels are shown to exceed 45 dB LAeq,1hour at night. • Appropriate design of the foundations for the gas turbines to ensure that all criteria including noise and vibration are fully accommodated. • Foundations will be unitized and isolated to support the gas turbines generators and auxiliary/ancillary plant. • Adequate clear working space between units for laydown and loading bays shall be provided. • Suitably sized foundations shall be provided to accommodate central and local control rooms, switchgears, battery and HVAC (heating, ventilation, and air conditioning equipment) rooms, laboratory, offices, kitchen and toilet facilities. • Design of buildings shall incorporate facilities for noise abatement such as double walls with rock wool insulation between them, and solar-reflective double-glazed windows and doors. • The personnel on site shall be provided with appropriate protective or corrective device to ameliorate noise effect. Measures are also to be taken at noise receptors located outside the project area boundary.		
Greenhouse Gas Emissions (Mitigation Measures from 9.4.2 of the ESIA)				
Design	Energy Efficiency – CO2 emissions reduction	It is recommended that OMA evaluate technically and financially feasible and cost-effective options to reduce or offset project-related GHG emissions during the design and operation of the project. It is important to analyse the need for power and heat, the available space, and weight restrictions to design an optimal solution to balance capital costs, energy costs and overall plant efficiency. Mitigation measure to consider throughout the design and management of operations include: • Pumps/motors – use of high efficiency motors, variable speed drives or multi speed motors (depending on circumstances) and motor load sensing for start/stop control. • Lighting - use high efficiency lights (e.g. LEDs) where appropriate, use motion and photo sensors, use as much natural light as possible. • Waste – encourage reduction of waste through prevention and re-use. Where waste arises, opt to recycle before considering other disposal routes. • Water – encourage reduction in water use by staff, mend any water leaks, treat blow down water for re-use. Given the location and nature of the project, it is also recommended that the project monitor, calculate and disclose GHG emissions annually. Actions that could be considered and implemented to reduce and manage GHG emissions are as follows: • Demand Side Measures to Reduce Need for New Generation: Typically, a country's electricity sector is structured such that increased consumer demand is satisfied through the construction of new power plants or expansion of existing plant rather than through measures to reduce consumer demand. In some jurisdictions, for example California,	Design contractor	IFC PS3 Requirements

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)
		power utilities are required to demonstrate that they have implemented comprehensive energy efficiency programmes with customers before they are permitted to develop new power plants. Greater efficiency in the consumption of energy is commonly an attractive option for emissions reduction, due to its dual benefit of reducing both emissions and the size of the energy bill. However, despite many years of promotion, it is also the most overlooked option. In Clean Development Mechanisms (CDMs), for instance, demand-side energy efficiency projects only make up 1% of the Certified Emission Reduction (CER) generation. Among the many reasons for this is the fact that most developing countries focus on energy access, rather than energy saving. • Make Provision for Potential Carbon Capture and Sequestration: Considerable effort is made around the world to develop carbon capture and sequestration (CCS) schemes. Of the 13 operational projects in the world, there is only one demonstration project in the power generation sector (Canada) which uses post combustion capture technology. On the Africa continent, there is one CCS plant in Algeria which uses pre-combustion capture as part of a gas processing facility. Other plants in other industrial sectors have adequately demonstrated IGCC's capacity, efficiency and environmental performance but some uncertainty remains regarding availability, reliability and cost. There are currently 9 plants being built and 32 plants being planned in a number of countries, almost all of which are expected to receive explicit public subsidies. Given the current status of CCS in the power generation sector, the technology is not considered a timely proposition for this project. • Carbon Credits / Offsets: In a number of developed countries, large GHG emitters are participants in emissions trading schemes, under which they need to reduce GHG emissions to prescribed levels or face a penalty. Such participants can reduce emissions either directly (for instance, through biomass co-firing) or can purchase 'carbon credits' in the form of allowances from other scheme participants or emission reductions from projects in other countries. Participants in emissions trading schemes have clear market incentives to reduce their emissions as the penalty for non-compliance is typically much higher than costs of abatement or purchasing carbon credits. For emitters in developing countries, no such market incentives exist for GHG emissions under the Kyoto Protocol or any other international or national agreements. Instead, the focus is different. That is, developers of projects which reduce GHG emissions are eligible to obtain additional finance for their project through the Clean Development Mechanism of the Kyoto Protocol 2. Given that there is no regulatory requirement for the project to reduce its GHG emissions, it is not recommended that the project purchase carbon credits on the open market in order to reduce its emissions given the substantive cost involved and the limited benefits.		
Community Health and Safety (Mitigation Measures from sections 9.2 -9.3 of the ESIA)				
Pre-construction	Support to local welfare facilities	First Aid and Safety training will be provided to workers and Community Emergency Response Plans will be developed and tested including workers and nearby residents in the vicinity of Project-related traffic. These will include emergency response related to traffic accidents and potential releases of chemicals and other hazardous materials.	Design contractor	IFC PS 4
Pre-construction	Injury/death/asset damage from work place accidents/ incidents	Occupational health standards and use of appropriate PPE will be implemented in accordance with best industry practices including FMEnv regulatory requirements, IFC PS2 and IFC HSE Guidelines. Project Safety Plan to be developed to address site clearing, tree felling, grading and equipment operations, to ensure that these activities are executed in a safe manner. Personnel to be provided with a Health and Safety orientation prior to early site preparation activities that address the safe operating procedures presented or referenced in the Project Safety Plan.	Design contractor	Requirements of IFC Performance Standard 2, IFC HSE Guidelines.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)
		Relevant personnel to be trained on equipment handling procedures, and given substance and task-specific training as required for their role. Daily HSE briefings/tool box meetings are carried out before commencement of work. PPE to be supplied to work personnel as appropriate to the task (e.g. hard hats, overalls, safety boots, gloves) together with instruction in correct use. Correct use of appropriate PPE to be enforced.		
Pre-construction	Injury/death/assets damage due to road traffic accidents and interference with other road users (market/commercial activities)	The final ESMP will include appropriate measures regarding community health and safety in line with IFC PS4 and HSE Guidelines. These will be updated and reviewed over the life of the project. The EPC will carry out a pre and post-assessment of the roads that will be used during the project and develop a process that ensures overall safety, particularly along roads near communities. Temporary traffic control and diversion arrangements to be provided at strategic points on local roads, where necessary. Effective journey management schedule, including materials management system for safe transportation of equipment and materials to/from site be maintained to reduce the risk of accidents. The use of appropriate and adequate signs shall be ensured. Drivers and equipment operators shall be educated on safe driving and operation strategies. All vehicles to be certified road-worthy (including fuelling) before being allowed to transport equipment, materials and personnel. Vehicle drivers to be certified competent before vehicle movement is permitted. Road load and speed limits to be observed.	Design contractor	Requirements of IFC Performance Standard 2 and 4.

Table 10-3: ESMP for OMA Power Generation Project – Construction and Decommissioning Actions

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Geology, Hydrogeology and Hydrology (Mitigation Measures from section 9.1.5 of the ESIA)					
Construction and decommissioning	Contamination of soils following spills, leaks of chemicals used.	Chemicals to be stored at suitable location (preferably on hard surfacing to minimise potential for infiltration) and secondary containment to be provided where possible. Workers to be trained in the handling, storing, and disposal of hazardous materials and emergency procedures in place for action following accidental release of hazardous materials. Vessels and pans that prevent spillages to be used during refuelling. Emergency spill containment material and clean up equipment to be available to	EPC contractor Decommissioning contactor (s)	FMEnv and IFC requirements. Site inspection records. Soil physicochemical and microbiological characteristics.	Site inspection and reporting to be undertaken during construction phase. Soil sampling and analysis to be undertaken during construction / decommissioning as appropriate (e.g. where contamination is suspected)

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		construction workers. Soil sampling and analysis to be undertaken in the event of any accidental spills. Drainage design and management to ensure that potentially contaminated surface run-off does not flow directly into watercourses without treatment, including any areas where cement or wet concrete is processed or stored. To prevent creation of preferential pollution pathways in construction all drilling and construction techniques will be in line with gross gas initially in place (GIIP) (i.e. full impermeable grouting of borehole casing to prevent a rapid contaminant source-receptor pathway)			and following any accidental release.
Construction and decommissioning	Risk of soil erosion.	The covering of stockpiled topsoil, installation of wind fences, and reseeding of disturbed areas. Final site grade will be designed to facilitate drainage and avoid flooding or pooling. Storm water discharge outfall to be appropriately designed to avoid the potential for offsite erosion. Standard post-construction and restoration activities to be implemented. These measures may consist of debris removal and disposal, the dismantling of all temporary facilities such as staging and laydown areas, and reseeding of areas disturbed by construction activities with vegetation similar to what was removed.	EPC contractor Decommissioning contactor (s)	Visual inspection records.	Site inspection and reporting to be undertaken during construction phase.
Construction and decommissioning	Mobilisation / excavation of any unknown contamination in soils and groundwater with potential human health effects and potential to migrate in the environment.	It is recommended that environmental soils and groundwater sampling is taken as part of any geotechnical ground investigation work. The samples should be sent to an accredited and approved laboratory for assessment to identify if there are any contaminants present with potential to harm human health and / or the environment, An appropriate remedial strategy will be designed and implemented should any contamination be identified. Appropriate construction methods (e.g. piling methods and design) to be chosen based on the results of the intrusive environmental investigation to ensure potential pathways for contamination to reach sensitive environmental receptors are not created. Management procedures and working practices to be developed to mitigate against the risks of encountering unknown contamination. This should include provisions for the training of construction workers in the identification of any potential contaminants. Where contamination is suspected samples of suspect materials are to be sent for laboratory assessment. Work is to be stopped until it is shown that the construction area is free from contamination. Workers should wear appropriate personal protective equipment (PPE) at all times throughout construction work.	EPC contractor Decommissioning contactor (s)	FMEnv and IFC requirements. Site inspection records. Soil physicochemical and microbiological characteristics.	Site inspection and reporting to be undertaken during construction phase. Sampling and analysis of soils and groundwater if contamination is suspected.
Air Emission and Ambient Air Quality Management (Mitigation Measures from section 9.1.1 of the ESIA)					

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Construction and decommissioning	Fugitive dust generation through disturbance of ground / wind blow from stockpiles.	Concrete batch plant and equipment shall be designed and used in a manner which minimises dust generation: Access roads shall be tarred to limit additional dust rising during construction trucks and other vehicles passage; Project roads and areas between stockpiles will be covered or treated to with water or other environmentally benign dust-suppressant material to the extent feasible; Dust from stockpiles will be controlled by covering or by treating with water or some other environmentally benign dust-suppressant material; Careful location, grading and management of stockpiles of soil and similar materials will be undertaken to prevent wind-blow; Sealing and / or re-vegetation of completed earthworks will be undertaken as soon as reasonably practicable; Open-bodied vehicles transporting materials will be covered with a tarp or water or treat materials as appropriate to reduce emissions; Spills of batching materials (e.g., fly ash, sand, aggregate, or additives) would be cleaned up or controlled to minimize dust; To the extent practicable, the batch plants would be located downwind of the site and away from the local community; All dry material transfer points will be ducted through an appropriate filter unless there are no visible emissions from the transfer point; All transfer points will be equipped with a wet suppression system to control fugitive particulate emissions unless there are no visible emissions; All bulk storage silos including auxiliary bulk storage trailers would be equipped with appropriate type filter; The dust collection system employed will be capable of controlling particulates using the best technology available. All conveyors will be covered unless the material being transferred results in no visible emissions.	EPC contractor Decommissioning contactor(s)	Complaints from workers / neighbouring communities.	Compliance monitoring to be undertaken during construction and decommissioning. Obtain verbal and documented feedback from construction workers and neighbouring communities.
Construction and decommissioning	Generation of exhaust fumes and fugitive dusts from construction / operational vehicles and traffic.	Impose speed limits for vehicles. Procurement of reputable construction vehicles which use modern technology to minimise exhaust emissions. Diesel powered construction equipment and vehicles will be well maintained to minimise exhaust emissions; and Use of wheel washers on entering and leaving site and between site areas as appropriate to prevent transfer of mud on site and onto public roads. Trucks will not be allowed to track concrete or other construction material from the Project site onto public roads. Open-bodied vehicles transporting materials will be covered with a tarp, or materials	EPC contractor Decommissioning contactor (s)	Complaints from workers / neighbouring communities.	Compliance monitoring to be undertaken during construction. Obtain verbal and documented feedback from construction workers and neighbouring communities.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		otherwise treated as appropriate, to reduce emissions. Exposed construction roads to be moisturized during the dry season to reduce fugitive dust. Use of clean fuel will be prioritised. Vehicles to be maintained regularly. Measures to be put in place to minimize diesel usage and emissions during construction activities, which will include idling reduction awareness activities for onsite diesel powered equipment and mobile vehicles. Engines to be switched off when vehicles are not in use, and idling reduction awareness training to be undertaken by operatives of onsite diesel powered equipment and mobile vehicles. Access roads tarred to limit dust rising during construction as a result of trucks and other vehicles' passage			
Ambient Noise Management (Mitigation Measures from 9.1.2 of the ESIA)					
Construction and Decommissioning	Generation of noise/ vibration though construction activities (particularly during piling and excavation works).	Construction contractor to use good international industry practice in terms of working practices and working hours to minimise impacts to workers. The use of personal protective equipment will be enforced at worksite, to be detailed in the ESMS. All noise-emitting equipment shall be properly maintained to minimize the noise impact on the area and shall be compliant with the applicable World Bank standards. The roadworthiness of trucks shall be ensured to minimize the noise impact. Movement of vehicles shall be restricted to day time; and Noise complaints shall be logged and kept onsite by the construction contractor.	EPC contractor, Decommissioning contactor (s)	FMEnv and IFC requirements.	Verbal and documented feedback from construction workers and neighbouring communities.
Wastewater Discharge Management and Groundwater Protection (Mitigation Measures from section 9.1.3 of the ESIA)					
Construction and decommissioning	Contamination of groundwater and surface waters due to accidental spillages.	Chemicals that will react together if brought into contact will be located in segregated storage and bunded areas. Areas where spills or leaks of hazardous materials could occur will be constructed in low permeability hardstanding to minimise potential for infiltration of contaminants to ground. Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses. Stormwater / surface water run-off will be channelled to oil separators / interceptors and silt traps prior to disposal to outfalls. All tank filling points will be situated within bunds so that any accidental spillage is contained.	Design engineer, EPC Contractor	FMEnv and IFC requirements. Site inspection records.	N/A
Construction and	Contamination of groundwater and	Workers will be trained in the handling, storing and disposal of hazardous and non-	EPC contractor	FMEnv and IFC	Site inspection and reporting

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
decommissioning	surface waters due to accidental spillages.	hazardous materials. In the event of an accidental release of hazardous materials, emergency procedures and management plans will be in place so that any spills or leaks can be contained immediately and cleaned and disposed appropriately. Storage of potentially hazardous construction materials will take place on hard surfacing and within appropriate containers. Where necessary, these would be covered and incorporate spill or leak containment measures. Chemicals that would react together if brought into contact will be located in segregated storage areas. Emergency spill containment material and clean up equipment will be readily available. To mitigate against creation of preferential pollution pathways in construction all drilling and construction techniques will be in line with GIIP (i.e. full impermeable grouting of borehole casing to prevent a rapid contaminant source-receptor pathway) Regarding water use, despite the low likelihood of any noticeable effect on water availability at the community supply boreholes, these will be monitored during drilling and test pumping of the remaining production wells. The boreholes will also be monitored during commissioning of the plant (specifically commissioning of the boreholes). Site inspection and reporting shall be undertaken by a designated person during the construction phase to ensure that good work practice is being adhered to. In the event that significant geology, hydrogeology and hydrology impacts are observed, a stop work order would be given and maintained until an appropriate investigation into the issue has been completed and addressed to the satisfaction of the project, the community and lenders.	Decommissioning contactor (s)	requirements. Site inspection records.	to be undertaken during construction phase. Soils and groundwater to be sampled and analysed following a spillage.
Construction	Unidentified contamination	It is recommended that any geotechnical intrusive investigation work undertaken prior to construction incorporates environmental soil and groundwater sampling to determine if there are any contaminants present. If the results indicate contamination is present then a remedial strategy should be developed and implemented to remove or ensure contaminants are reduced to safe levels prior to construction. Following environmental sampling and any remedial works required, there is the residual risk of encountering 'hotspots' of unknown soil and groundwater contamination during the construction phase. All workers should be trained in the identification of potential contamination and, if contamination is suspected, then work should be stopped immediately and samples of suspected contaminated materials sent for laboratory analysis. Work should not resume until the results have been received and appropriate mitigation measures implemented. Workers should wear appropriate PPE at all times throughout construction work.	EPC contractor	FMEnv and IFC requirements.	Monitoring of community supply boreholes during test pumping of new boreholes. Monitoring of community boreholes water quality regularly.
Ecology Management (Mitigation Measures from section 9.1.4 of the ESIA)					
Construction	Loss, degradation, or fragmentation of wildlife habitat	The limits of clearing will be delineated on appropriate site maps and then flagged to minimize the loss of natural vegetation. Trees and shrubs that are to be retained will be marked with flagging and compaction	EPC Contractor(s).	FFMENV and IFC requirements.	Site inspection to be undertaken twice yearly and site inspection reports produced.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		of the adjacent soils (where possible) will be avoided. Local, native plant species will be used in areas to be landscaped where feasible. Native species are best adapted to the local conditions, more likely to become established, require minimal maintenance, and are less likely to cause problems from the introduction of non-native species (due to competition with native species). Salvaged and stockpiled topsoil will be used to the extent possible in re-vegetation efforts, erosion control, and landscaping. Use of temporary fencing to prevent inadvertent damage to habitats adjacent to the construction area. Ensure the way-leave area width is at its minimum for least removal of vegetation. Siting of temporary works areas is to be within land to be developed subsequently.			
Construction and decommissioning	Introduction of non-native species into the terrestrial environment.	Implementation of procedures requiring the cleaning and visual inspection of machinery/ equipment entering and leaving the area. Materials and construction / decommissioning equipment to be sourced locally where possible.	EPC contractor(s). OPGCL	FMEnv and IFC requirements.	Visual inspection.
Construction and decommissioning.	Direct impacts on habitats and species	Limit the use of lighting at night time Minimise noise and vibration as far as practicable (see mitigation measures for noise impacts). Education of workers on the protection of threatened species with implementation of strict penalties for poaching of threatened species.	EPC contractor(s). Decommissioning contractor(s)	FMEnv and IFC requirements.	N/A
Construction and decommissioning.	Release of contaminants causing damage to sensitive ecological receptors.	As per provisions for maintaining land quality.	EPC contractor(s). Decommissioning contractor(s).	FMEnv and IFC requirements. .	Monitoring as per provisions for maintaining land quality.
Labour, Workforce, Community, Health, Safety and Security (Mitigation Measures from sections 9.2 -9.3 of the ESIA)					
Construction and decommissioning	General occupational health and safety impacts	Modification, substitution, or elimination of hazardous conditions where possible; Provide personnel with a Health and Safety orientation prior to early site preparation activities that addresses the safe operating and work execution plan; Enforce the use of appropriate PPE at work site; Specific identification of potential hazards to workers, particularly those that may be life-threatening; Documentation and reporting of occupational accidents, diseases, and incidents; Substances and task-specific training of personnel; and Emergency prevention, preparedness, and response arrangements, including those for risks of fire and explosion.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Implementation and monitoring or an appropriate workers grievance mechanism. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Construction and	Discrimination within the workplace	Identify migrant workers and ensure that they are engaged on substantially equivalent	EPC contractor(s).	Requirements of IFC	Implementation and

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
decommissioning	(based on gender, culture, age etc.).	terms and conditions to non-migrant workers. Make employment decisions related to inherent job characteristics and not on the basis of personal characteristics. Employment relationship to be based on equal opportunity and fair treatment. There shall be no discrimination with respect to any aspects of the employment relationship, such as recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, job assignment, promotion, termination of employment or retirement, and disciplinary practices. Comply with national law on non-discrimination and employ requirements of IFC Performance Standard 2 without contravening national law.	Decommissioning contractor(s).	Performance Standard 2.	monitoring or an appropriate workers grievance mechanism. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Construction and decommissioning	Exploitation of workers and contractors.	Comply with national law regarding workers' rights to join organisations for workers of their choosing and to allow workers to elect representatives. Measures to be taken to prevent and address any harassment, intimidation and exploitation in the workplace. Provision of a grievance mechanism for workers to raise workplace concerns. Ensure there is no forced labour. Ensure contractors have access to a grievance mechanism. Implement policies on the quality and management of the accommodation offered to workers.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and document details of all workers and contractors. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken. Implementation and monitoring or an appropriate workers grievance mechanism.
Construction and decommissioning	Exploitation of workforce by contractors.	Implement procedures to ensure contractors are legitimate enterprises with appropriate Environmental and Social Management Strategies. Management procedures to be established for managing and monitoring the performance of contractors.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Construction and decommissioning	Use of in appropriate child labour and exploitation of children.	Applicable national laws in child labour to be adhered to. Identify the presence of all persons under the age of 18. Children under the age of 18 are not to be employed in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. Appropriate risk assessment and regular monitoring of health, working conditions, and hours of work for all children under the age of 18 to be undertaken.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and documentation of staff recruitment and details of staff employment terms and conditions. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Construction and decommissioning	Unfair dismissal of workers.	Ensure that all workers receive notice of dismissal and timely severance payments mandated by law and any outstanding back pay and social security benefits and pension contributions	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and documentation of dismissals

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		Carry out an analysis of alternatives to retrenchment prior to implementing any dismissals. Where there are no alternatives to retrenchment, development and implementation of a retrenchment plan to be undertaken. The plan is to be based on the principle of non-discrimination and will follow consultation with workers, their organizations, and, where appropriate, the government. It is to be compliant with collective bargaining agreements, legal and contractual requirements related to notification of public authorities, and provision of information to, and consultation with workers and their organizations			and their circumstances.
Construction and decommissioning	Workers exposed to unsafe working conditions.	Specific potential hazards to be identified, particularly those that may be life-threatening, and provision of appropriate management and mitigation measures to be made. Preventative and protective measures to be implemented where necessary. Workers to have access to appropriate PPE at all times.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2.	Continued monitoring, reporting and documentation of any incidents.
Construction and decommissioning	Injury or harm to site workers / communities as a result of badly designed plant and construction / decommissioning management.	The designing, construction, operation, and decommissioning of the structural elements or components of the project to be in accordance with industry best practice. Use of competent personnel in design and construction. Design and construction to consider safety risks to third parties or Affected Communities as well as to project workers.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents.
Construction and decommissioning	Injury/death/asset damage from work place accidents/ incidents	Occupational health standards and use of appropriate PPE will be implemented in accordance with best industry practices including FMEnv regulatory requirements, IFC PS2 and IFC HSE Guidelines. Project Safety Plan to be developed to address site clearing, tree felling, grading and equipment operations, to ensure that these activities are executed in a safe manner. Personnel to be provided with a Health and Safety orientation prior to early site preparation activities that address the safe operating procedures presented or referenced in the Project Safety Plan. Relevant personnel to be trained on equipment handling procedures, and given substance and task-specific training as required for their role. Daily HSE briefings/tool box meetings are carried out before commencement of work. The power station site shall be block walled and secured to prevent trespass by unwanted persons or animals. Equipment (cranes, forklifts) maintenance programme to be developed and adhered to PPE to be supplied to work personnel as appropriate to the task (e.g. hard hats, overalls, safety boots, gloves) together with instruction in correct use. Correct use of appropriate PPE to be enforced.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2, IFC HSE Guidelines.	Weekly through HSE reports
Construction and decommissioning	Injury/death/assets damage due to road traffic accidents and interference with other road users	The final ESMP will include appropriate measures regarding community health and safety in line with IFC PS4 and HSE Guidelines. These will be updated and reviewed over the life of the project.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents. Reports documenting incidents and

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
	(market/commercial activities)	The EPC will carry out a pre and post-assessment of the roads that will be used during the project and develop a process that ensures overall safety, particularly along roads near communities. The main access road to the plant will be upgraded / tarred which will have a positive effect on local traffic Temporary traffic control and diversion arrangements to be provided at strategic points on local roads, where necessary. Effective journey management schedule, including materials management system for safe transportation of equipment and materials to/from site be maintained to reduce the risk of accidents. The use of appropriate and adequate signs shall be ensured. Drivers and equipment operators shall be educated on safe driving and operation strategies. All vehicles to be certified road-worthy (including fuelling) before being allowed to transport equipment, materials and personnel. Vehicle drivers to be certified competent before vehicle movement is permitted. Road load and speed limits to be observed.			site inspection will be produced.
Construction and decommissioning	Community unrest and conflicts with influx of workers from different communities and backgrounds	An induction and education programme outlining expected behaviour standards for all site workers. project The EPC contractors shall also be required to develop a project-specific health plan for project management's approval that will be implemented as part of the project ESMS.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents. No complaints received. Implementation of effective grievance mechanism.
Construction and decommissioning	Exposure of workers and communities to hazardous materials.	The potential for workers and communities to be exposed to hazardous materials or conditions to be modified, substituted, or eliminated. Deliveries and transportation of hazardous materials to be effectively managed to minimise exposure to workers and communities. Appropriate and legitimate waste disposal contractors to be used (see wastes management).	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 2 and 4.	See section on waste.
Construction and decommissioning	Risks to plant operations workers and communities from security personnel.	All security personnel to be fully trained and competent and not implicated in past abuses. Due diligence of security staff to be undertaken. Involve external stakeholders (i.e. police or local authorities) in any on or offsite security incidents and ensure that the appropriate incident response procedures are followed.	EPC contractor(s). Decommissioning contractor(s).	Requirements of IFC Performance Standard 4.	Continued monitoring, reporting and documentation of any incidents.
Construction and decommissioning	Gender equality	Long-term education and training programs for women and youth. Education assistance has been identified as a priority in the social investment strategy. Further long-term education programs targeting youth and women should be developed to increase employment opportunities in the community.	EPC Contractor Decommissioning contractor(s).	Requirements of IFC Performance Standard 4.	Continued community investment

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Construction and decommissioning	Local recruitment and job opportunities	Follow a transparent hiring process to help the community understand strategic staffing decisions and avoid conflict over hiring with the local communities. Develop a training and skills programme to impart best practice in the skilling of local people for construction and operational jobs. Encourage contractors to provide apprenticeship opportunities to local people, and encourage supply chain partners to recruit local people. Establish a local job readiness programme and encourage the construction supply chain to continue to invest in workers. Establish a local employment brokerage that will publicize publicise job vacancies and put in place initiatives to ensure employment opportunities for hard to reach groups.	EPC contractor(s). Decommissioning contractor(s).	IFC PS 2 and 4	Measure local recruitment numbers by the Project.
Construction and decommissioning	Awareness and prevention of spread of HIV/AIDS and other communicable diseases	OPGCL will develop an HIV / AIDS and other communicable disease management plan. This will be implemented to provide the community with tools and education materials to reduce the spread of HIV/AIDS. Worker health screening will be an important aspect of minimising the spread of communicable diseases within the community, particularly as many workers will be local people. The programme shall be developed and implemented during the peak construction period, or at any time when workers on site number more than 100. Sex education shall be promoted among workers and communities of the project area. The EPC contractors will also develop a project-specific health plan for project management's approval.	EPC contractor Decommissioning contractor(s).	IFC PS 4	Monthly through site inspection report.
Construction and decommissioning	Support to local welfare facilities	Provide capacity-building to applicable service providers to support community health clinics, traffic safety, and emergency response, e.g. ambulance, trauma centre/care facilities etc. First Aid and Safety training will be provided to workers and Community Emergency Response Plans will be developed and tested including workers and nearby residents in the vicinity of Project-related traffic. These will include emergency response related to traffic accidents and potential releases of chemicals and other hazardous materials.	EPC contractor(s). Decommissioning contractor(s).	IFC PS 4	Good levels of welfare facilities and emergency response teams.
Construction and decommissioning	Community consultation and handling of community grievances	Appropriate workers and community grievance mechanisms should be implemented during all phases of the Project. The mechanisms should be disclosed to all parties appropriately and grievance logged in a suitable manner.	EPC contractor(s). Decommissioning contractor(s).	IFC PS 2 and 4	Grievance logs are monitored for appropriate responses and mitigation measures.
Construction and decommissioning	Appropriate workers accommodation	Workers accommodation shall be developed in line with the European Bank for Reconstruction and Development (EBRD) / IFC workers accommodation guidance. Workers camps will be constructed in compliance with good international industry practice including IFC guidance notes in respect of space provided per worker, numbers of washing and sanitary facilities provided, security etc., and a worker management plan will be produced.	EPC contractor(s). Decommissioning contractor(s).	IFC PS 2	Audit of workers accommodation during construction activities demonstrates compliance with the guidelines.
General Waste Management (Mitigation Measures from section 9.1.6 of the ESIA)					
Construction and decommissioning	Pollution of the surrounding environment through improper management and disposal of wastes.	For the construction phase a Construction Waste Management Plan (CWMP) is to be developed by the EPC contractor. The plan shall include an inventory of identified waste streams and treatment, management, temporary management and final disposal procedures. The plan will focus on a hierarchy of waste minimisation, reuse	EPC contractor(s) Decommissioning contractor(s).	FMEnv and IFC requirements.	Visual inspection. Inspection and reporting to be undertaken during the construction phase and twice

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		and then disposal. The plan will include measures as follows: • Identification of suitable waste contractors and waste disposal sites. Provisions for regular auditing of facilities and contractors by an independent body to ensure they comply with national and international standards. • Measures for the appropriate treatment and disposal of contaminated and hazardous materials. • Waste metals: All waste metals generated on site during the construction Phase should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination, where available. "Clean" waste metals can be recycled within the community. • Building rubble: Wherever possible, uncontaminated building rubble will be utilised within the site for hardcore or other land reclamation purposes. Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism. Mitigation must be taken to prevent run-off from the stockpiles of building rubble on site. • Top soils and excavation wastes. Wherever possible these materials will be utilised for land reclamation purposes within the site. There is no history of any previous contamination of the site and therefore the top soils and excavation wastes can be re-used for landscaping, screening and filling purposes without prior treatment. Mitigation must be taken to prevent run-off from the stockpiles of top-soil and excavation materials on site. • Waste oils, lubricants, paints and solvents: Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container which has a bund wall built into it. The container itself will be located in a bunded area of hard standing, to prevent leaks and spillages from entering the ground and the groundwater. The waste oil, lubricants and containers will be taken from site and disposed of at the nearest suitable recycling facility. • Waste wood: Wherever possible, waste wood can be recycled in the community. However, where disposal is required, waste wood that is not contaminated by, or has not been treated with, halogenated organic compounds or heavy metals can be recovered for use as fuel. • Electrical cabling and electrical components including batteries: Electrical cabling and components could be recycled informally in the community. Spent batteries will need to be stored in a suitable storage facility on site prior to transport to a suitable disposal facility. • Sewage effluent: During the construction Phase, until suitable facilities are constructed, portaloos and portable showers should be used. The portaloos should be emptied by suitably licensed operators who will dispose of the effluent to a suitable treatment facility. Alternatively temporary facilities with a cesspit/ septic tank shall be constructed. Shower and wash facilities should drain to a cesspit/ septic tank until suitable treatment facilities are provided on site. Once available, permanent washing and toilet facilities shall be utilised and shall drain to a cesspit/ septic tank and thence to a package treatment facility capable of			yearly thereafter.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		meeting IFC standards prior to discharge to the watercourses. • Biodegradable food wastes: Wherever possible these shall be composted on site. • Oxygen and acetylene tanks (or other such tanks for welding and cutting gases): Gas cylinders used for welding and cutting gases shall be returned to the provider of the gases for reuse.			
Construction and decommissioning	Potential to harm human health and environment through uncontrolled disposal of wastes.	Waste streams to be kept segregated (hazardous, inert, industrial and domestic). Adequate provision of waste disposal containers at strategic locations around the site. Training of workers in waste management and safe handling of wastes. Solid waste handling and housekeeping to be monitored through regular inspection during construction and operation. Monitoring to be undertaken at waste storage and transfer sites. Chemicals that would react together if brought into contact will be located in segregated storage areas	EPC contractor(s) (s). Decommissioning contractor(s). EPC contractor responsible for monitoring and reporting of waste management during construction.	FMEnv and IFC requirements.	
Construction and decommissioning	Odour from wastes.	All wastes to be contained where possible. Regular uplift of normal domestic and inert wastes via municipal arrangements where appropriate.	EPC contractor(s). . Decommissioning contractor(s).	FMEnv and IFC requirements.	
Hazardous Waste Management (Mitigation Measures from section 9.1.6 of the ESIA)					
Construction and decommissioning	Harm to human health and the environment through improper management and disposal of hazardous wastes.	Hazardous materials to be stored, handled and used during construction shall be assessed to enable hazardous materials management priorities to be established. Management procedures are to be included in the CWMP. Waste streams to be kept segregated (hazardous, inert, industrial and domestic). All wastes in transit shall be tracked by waste consignment note and documented. All wastes shall be disposed at approved dump sites which meet FMEnv and IFC requirements. Workers to be trained in the handling, storing, and disposal of hazardous materials. Where required, engineering controls, spill containment and clean up provisions will be put in place to minimize the risk of an impact due to accidental release. A Spill Prevention and Response Plan shall be developed for safe transportation, storage and distribution of hydrocarbon and chemicals on site.	EPC contractor(s). Decommissioning contractor(s).	FMEnv and IFC requirements.	Regular inspections of waste storage and transfer sites and reporting during construction
Traffic Management (Mitigation Measures from section 9.2.2 of the ESIA)					
Construction and decommissioning	Risk of accidents and congestion.	The main access road to plant will be upgraded / tarred which will have a positive effect on local traffic. Temporary traffic control and diversion arrangements shall be provided at strategic points on local roads, where necessary.	EPC contractor(s). Decommissioning contractor(s).	FMEnv and IFC requirements.	Site inspections during construction

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		An effective journey management schedule shall be maintained to reduce the risk of accidents. A transportation and materials management system for safe transportation of equipment and materials to site shall be developed and implemented, to be included within the ESMS.			
Construction and decommissioning	Pollution of the environment associated with air emissions.	Mitigation as outlined within air quality management.	EPC contractor(s). Decommissioning contractor(s).	FMEnv and IFC requirements.	Site inspections during construction
Construction and decommissioning	Transport of contaminated soils on vehicles during construction and decommissioning activities.	Mitigation measures and outlined within land contamination management	EPC contractor(s). Decommissioning contractor(s).	FMEnv and IFC requirements.	Soil sampling and environmental monitoring as required (for example if contamination is suspected).
Greenhouse Gas Emissions (Mitigation Measures from section 9.4.2 of the ESIA)					
Construction	Energy Efficiency – CO2 emissions reduction	Mitigation measure to consider throughout the construction include: • Pumps/motors – use of high efficiency motors, variable speed drives or multi speed motors (depending on circumstances) and motor load sensing for start/stop control. • Lighting - use high efficiency lights (e.g. LEDs) where appropriate, use motion and photo sensors, use as much natural light as possible. • Waste – encourage reduction of waste through prevention and re-use. Where waste arises, opt to recycle before considering other disposal routes. • Water – encourage reduction in water use by staff, mend any water leaks, treat blow down water for re-use.	OPGCL	IFC PS3 Requirements	
Landscape and Visual Management					
Construction	Visual amenity	Landscaping of the site upon completion of construction works. This will both mitigate visual impact and reduce erosion from surface waters during heavy rains and flood periods. Soils excavated during construction may be used for landscaping if suitable.	EPC contractor	N/A	Visual inspection
Cultural Heritage Management					
Construction and decommissioning	Impacts / disturbance to unforeseen cultural heritage through project activities.	Procedures shall be developed in the event that cultural heritage is subsequently discovered during the project construction or operation.	EPC contractor Decommissioning contractor(s).	FM Env IFC PS1 and PS7	Visual inspection

Table 10-4 : ESMP for OMA Power Generation Project – Operational and Actions

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Geology, Hydrogeology and Hydrology (Mitigation Measures from section 9.4.6 of the ESIA)					
Operation	Contamination of soils following	Chemicals to be stored at suitable location (preferably on hard surfacing to minimise	OPGCL	FMEnv and IFC	Site inspection and

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
	spills, leaks of chemicals used.	potential for infiltration) and secondary containment to be provided where possible. Workers to be trained in the handling, storing, and disposal of hazardous materials and emergency procedures in place for action following accidental release of hazardous materials. Vessels and pans that prevent spillages to be used during refuelling. Emergency spill containment material and clean up equipment to be available to construction workers. Soil sampling and analysis to be undertaken in the event of any accidental spills. Drainage design and management to ensure that potentially contaminated surface run-off does not flow directly into watercourses without treatment, including any areas where cement or wet concrete is processed or stored. To prevent creation of preferential pollution pathways in construction all drilling and construction techniques will be in line with gross gas initially in place (GIIP) (i.e. full impermeable grouting of borehole casing to prevent a rapid contaminant source-receptor pathway)		requirements. Site inspection records. Soil physicochemical and microbiological characteristics.	reporting.
Air Emission and Ambient Air Quality Management (Mitigation Measures from section 9.4.1 of the ESIA)					
Operation	Generation of NOx emissions.	Monitoring of NOx emissions during operation to ensure they are within prescribed limits and there are no adverse effects to sensitive receptors. A detailed monitoring plan is to be developed and implemented by OPGCL. Two types of emissions monitoring are required: • Ambient air monitoring at nearby receptors • Stack emissions monitoring Should monitoring indicate exceedance of limit values appropriate mitigation measures will be implemented. General monitoring requirements are as follows: • Ambient air quality monitoring will be carried out at, or close to, the location(s) of receptors predicted to experience the highest increment in long term NO2 concentrations. The air emissions modelling has identified two receptors at which monitoring will be required. • The specific monitoring location(s) will be agreed with the FMEnv prior to the commencement of the monitoring survey. A suitable background monitoring location will also be included in the survey. • In addition to ambient air quality monitoring, a CEMS shall be integrated within the plant, and used to assess if NOx concentrations (measured as NO2) meet the project commitment not to exceed 25 ppm at the stack. Appropriate maintenance and / or operating changes will be implemented, if necessary, to maintain design parameters. Regular review of current and potential air emission sources to be undertaken.	Monitoring programme to be developed and implemented by OPGCL HSE department.	Nigerian FMEnv, IFC air emission guidelines for power plants.	Ambient air quality monitoring at nearby sensitive receptors. Stack emissions monitoring. Disclosure of monitoring results to IFC.
Ambient Noise Management (Mitigation Measures from section 9.4.3 of the ESIA)					

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Operation	Exceedance of night time noise emissions limits	As a result, a Noise Management Plan shall be developed for the project. It is recommended that noise monitoring be undertaken at site boundaries and sensitive environmental receptors throughout the project lifetime. Monitoring requirements should comply with IFC guidelines which recommend a 48 hour monitoring period. A noise monitoring programme will need to be developed for the project and this is included as an action in the ESMP.	OPGCL	FMEnv and IFC requirements.	Monitoring in operation phase to ensure compliance with modelling results and IFC standards.
Wastewater Discharge Management and Groundwater Protection (Mitigation Measures from section 9.4.4 of the ESIA)					
Operation	Contamination of groundwater and surface waters due to accidental spillages.	Workers will be trained in the handling, storing, and disposal of hazardous materials. In the event of an accidental release, emergency procedures and management plans will be in place so that the spill can be contained immediately and cleaned and disposed appropriately. Storage of potentially hazardous construction materials will take place on hard surfacing and within appropriate containers. Where necessary, these would be covered and incorporate spill or leak containment measures. Chemicals that would react together if brought into contact will be located in segregated storage areas. OPGCL will have emergency response plans and procedures in place should there be any loss of containment. Emergency spill response and clean up procedures will be in line with international standards. Emergency spill containment material and clean up equipment will be readily available. Emergency spill containment materials and clean up equipment will be readily available. OPGCL will maintain an inventory of the chemicals needed for the operation of the power plant, such as dosing and treatment chemicals and lubricants. Details of locations and quantities on site, and their usage will be strictly logged and tracked, and stored in a separate storage building at site. Drainage design and management will ensure that potentially contaminated surface run-off does not flow directly into watercourses. Stormwater / surface water run-off will be channelled to oil separators / interceptors and silt traps prior to disposal to outfalls. Periodic site inspection and reporting is to be undertaken by a designated person to ensure that good work practice is being adhered to.	OPGCL	FMEnv and IFC requirements.	Monitoring of community supply boreholes during test pumping of new boreholes. Monitoring of community boreholes water quality regularly. Soils and groundwater to be sampled and analysed following a spillage.
Ecology Management (Mitigation Measures from section 9.4.5 of the ESIA)					

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
Operation	Direct impacts on habitats and species	Limit the use of lighting at night time Minimise noise and vibration as far as practicable (see mitigation measures for noise impacts). Education of workers on the protection of threatened species with implementation of strict penalties for poaching of threatened species.	OPGCL	FMEnv and IFC requirements.	N/A
Operation	Release of contaminants causing damage to sensitive ecological receptors.	As per provisions for maintaining land quality.	OPGCL	FMEnv and IFC requirements. .	Monitoring as per provisions for maintaining land quality.
Labour, Workforce, Community, Health, Safety and Security (Mitigation Measures from sections 9.2 -9.3 of the ESIA					
Operation	General occupational health and safety impacts	Modification, substitution, or elimination of hazardous conditions where possible; Provide personnel with a Health and Safety orientation prior to early site preparation activities that addresses the safe operating and work execution plan; Enforce the use of appropriate PPE at work site; Specific identification of potential hazards to workers, particularly those that may be life-threatening; Documentation and reporting of occupational accidents, diseases, and incidents; Substances and task-specific training of personnel; and Emergency prevention, preparedness, and response arrangements including those for risks of fire and explosion.	OPGCL	Requirements of IFC Performance Standard 2.	Implementation and monitoring or an appropriate workers grievance mechanism. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Operation	Discrimination within the workplace (based on gender, culture, age etc.).	Identify migrant workers and ensure that they are engaged on substantially equivalent terms and conditions to non-migrant workers. Make employment decisions related to inherent job characteristics and not on the basis of personal characteristics. Employment relationship to be based on equal opportunity and fair treatment. There shall be no discrimination with respect to any aspects of the employment relationship, such as recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, job assignment, promotion, termination of employment or retirement, and disciplinary practices. Comply with national law on non-discrimination and employ requirements of IFC Performance Standard 2 without contravening national law.	OPGCL	Requirements of IFC Performance Standard 2.	Implementation and monitoring or an appropriate workers grievance mechanism. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Operation	Exploitation of workers and contractors.	Comply with national law regarding workers' rights to join organisations for workers of their choosing and to allow workers to elect representatives. Measures to be taken to prevent and address any harassment, intimidation and exploitation in the workplace. Provision of a grievance mechanism for workers to raise workplace concerns. Ensure there is no forced labour.	OPGCL	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and document details of all workers and contractors. Reporting of any incidents to be documented and monitored to enable

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		Ensure contractors have access to a grievance mechanism. Implement policies on the quality and management of the accommodation offered to workers.			appropriate action to be taken. Implementation and monitoring or an appropriate workers grievance mechanism.
Operation	Exploitation of workforce by contractors.	Implement procedures to ensure contractors are legitimate enterprises with appropriate Environmental and Social Management Strategies. Management procedures to be established for managing and monitoring the performance of contractors.	OPGCL	Requirements of IFC Performance Standard 2.	Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Operation	Use of in appropriate child labour and exploitation of children.	Applicable national laws in child labour to be adhered to. Identify the presence of all persons under the age of 18. Children under the age of 18 are not to be employed in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. Appropriate risk assessment and regular monitoring of health, working conditions, and hours of work for all children under the age of 18 to be undertaken.	OPGCL	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and documentation of staff recruitment and details of staff employment terms and conditions. Reporting of any incidents to be documented and monitored to enable appropriate action to be taken.
Operation	Unfair dismissal of workers.	Ensure that all workers receive notice of dismissal and timely severance payments mandated by law and any outstanding back pay and social security benefits and pension contributions Carry out an analysis of alternatives to retrenchment prior to implementing any dismissals. Where there are no alternatives to retrenchment, development and implementation of a retrenchment plan to be undertaken. The plan is to be based on the principle of non-discrimination and will follow consultation with workers, their organizations, and, where appropriate, the government. It is to be compliant with collective bargaining agreements, legal and contractual requirements related to notification of public authorities, and provision of information to, and consultation with workers and their organizations	OPGCL	Requirements of IFC Performance Standard 2.	Human Resources (HR) management systems to include the monitoring and documentation of dismissals and their circumstances.
Operation	Workers exposed to unsafe working conditions.	Specific potential hazards to be identified, particularly those that may be life-threatening, and provision of appropriate management and mitigation measures to be made. Preventative and protective measures to be implemented where necessary. Workers to have access to appropriate PPE at all times.	OPGCL	Requirements of IFC Performance Standard 2.	Continued monitoring, reporting and documentation of any incidents.
Operation	Injury or harm to site workers / communities as a result of badly designed plant and construction / decommissioning management.	The designing, construction, operation, and decommissioning of the structural elements or components of the project to be in accordance with industry best practice. Use of competent personnel in design and construction. Design and construction to consider safety risks to third parties or Affected	OPGCL	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		Communities as well as to project workers.			
Operation	Injury/death/asset damage from work place accidents/ incidents	Occupational health standards and use of appropriate PPE will be implemented in accordance with best industry practices including FMEnv regulatory requirements, IFC PS2 and IFC HSE Guidelines. Project Safety Plan to be developed to address site clearing, tree felling, grading and equipment operations, to ensure that these activities are executed in a safe manner. Personnel to be provided with a Health and Safety orientation prior to early site preparation activities that addresses the safe operating procedures presented or referenced in the Project Safety Plan. Relevant personnel to be trained on equipment handling procedures, and given substance and task-specific training as required for their role. Daily HSE briefings/tool box meetings are carried out before commencement of work. The power station site shall be block walled and secured to prevent trespass by unwanted persons or animals. Equipment (cranes, forklifts) maintenance programme to be developed and adhered to PPE to be supplied to work personnel as appropriate to the task (e.g. hard hats, overalls, safety boots, gloves) together with instruction in correct use. Correct use of appropriate PPE to be enforced.	OPGCL	Requirements of IFC Performance Standard 2, IFC HSE Guidelines.	Weekly through HSE reports
Operation	Injury/death/assets damage due to road traffic accidents and interference with other road users (market/commercial activities)	The final ESMP will include appropriate measures regarding community health and safety in line with IFC PS4 and HSE Guidelines. These will be updated and reviewed over the life of the project. The EPC will carry out a pre and post-assessment of the roads that will be used during the project and develop a process that ensures overall safety, particularly along roads near communities. The main access road to the plant will be upgraded / tarred which will have a positive effect on local traffic Temporary traffic control and diversion arrangements to be provided at strategic points on local roads, where necessary. Effective journey management schedule, including materials management system for safe transportation of equipment and materials to/from site be maintained to reduce the risk of accidents. The use of appropriate and adequate signs shall be ensured. Drivers and equipment operators shall be educated on safe driving and operation strategies. All vehicles to be certified road-worthy (including fuelling) before being allowed to transport equipment, materials and personnel.	OPGCL	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents. Reports documenting incidents and site inspection will be produced.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		Vehicle drivers to be certified competent before vehicle movement is permitted. Road load and speed limits to be observed.			
Operation	Community unrest and conflicts with influx of workers from different communities and backgrounds	An induction and education programme outlining expected behaviour standards for all site workers. The EPC contractors shall also be required to develop a project-specific health plan for project management's approval that will be implemented as part of the project ESMS.	OPGCL	Requirements of IFC Performance Standard 2 and 4.	Continued monitoring, reporting and documentation of any incidents. No complaints received. Implementation of effective grievance mechanism.
Operation	Exposure of workers and communities to hazardous materials.	The potential for workers and communities to be exposed to hazardous materials or conditions to be modified, substituted, or eliminated. Deliveries and transportation of hazardous materials to be effectively managed to minimise exposure to workers and communities. Appropriate and legitimate waste disposal contractors to be used (see wastes management).	OPGCL	Requirements of IFC Performance Standard 2 and 4.	See section on waste.
Operation	Risks to plant operations workers and communities from security personnel.	All security personnel to be fully trained and competent and not implicated in past abuses. Due diligence of security staff to be undertaken. Involve external stakeholders (i.e. police or local authorities) in any on or offsite security incidents and ensure that the appropriate incident response procedures are followed.	OPGCL	Requirements of IFC Performance Standard 4.	Continued monitoring, reporting and documentation of any incidents.
Operation	Gender equality	Long-term education and training programs for women and youth. Education assistance has been identified as a priority in the social investment strategy. Further long-term education programs targeting youth and women should be developed to increase employment opportunities in the community.	OPGCL	Requirements of IFC Performance Standard 4.	Continued community investment
Operation	Local recruitment and job opportunities	Follow a transparent hiring process to help the community understand strategic staffing decisions and avoid conflict over hiring with the local communities. Develop a training and skills programme to impart best practice in the skilling of local people for construction and operational jobs. Encourage contractors to provide apprenticeship opportunities to local people, and encourage supply chain partners to recruit local people. Establish a local job readiness programme and encourage the construction supply chain to continue to invest in workers. Establish a local employment brokerage that will publicize publicise job vacancies and put in place initiatives to ensure employment opportunities for hard to reach groups.	OPGCL	IFC PS 2 and 4	Measure local recruitment numbers by the Project.
Operation	Support to local welfare facilities	Provide capacity-building to applicable service providers to support community health clinics, traffic safety, and emergency response, e.g. ambulance, trauma centre/care facilities etc. First Aid and Safety training will be provided to workers and Community Emergency Response Plans will be developed and tested including workers and nearby residents in the vicinity of Project-related traffic. These will include emergency response related to traffic accidents and potential releases of chemicals and other hazardous materials.	OPGCL	IFC PS 4	Good levels of welfare facilities and emergency response teams.
Operation	Community consultation and handling	Appropriate workers and community grievance mechanisms should be implemented	OPGCL	IFC PS 2 and 4	Grievance logs are

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
	of community grievances	during all phases of the Project. The mechanisms should be disclosed to all parties appropriately and grievance logged in a suitable manner.			monitored for appropriate responses and mitigation measures.
Operation	Appropriate workers accommodation	Workers accommodation shall be developed in line with the EBRD / IFC workers accommodation guidance. Workers camps will be constructed in compliance with good international industry practice including IFC guidance notes in respect of space provided per worker, numbers of washing and sanitary facilities provided, security etc., and a worker management plan will be produced.	OPGCL	IFC PS 2	Audit of workers accommodation during construction activities demonstrates compliance with the guidelines.
General Waste Management (Mitigation Measures from section 9.4.7 of the ESIA)					
Operation	Pollution of the surrounding environment through improper management and disposal of wastes.	OPGCL will produce a Waste Management Plan for the operational phase. The plan shall include an inventory of identified waste streams and treatment, management, temporary management and final disposal procedures. The plan will focus on a hierarchy of waste minimisation, reuse and then disposal. The plan will include measures as follows: • Identification of suitable waste contractors and waste disposal sites. Provisions for regular auditing of facilities and contractors by an independent body to ensure they comply with national and international standards. • Measures for the appropriate treatment and disposal of contaminated and hazardous materials. • Waste metals: All waste metals generated on site during the construction Phase should be collected separately and stored in a suitable, secure location prior to disposal. Contaminated waste metals will require recovery by a suitable waste contractor for decontamination, where available. “Clean” waste metals can be recycled within the community. • Building rubble: Wherever possible, uncontaminated building rubble will be utilised within the site for hardcore or other land reclamation purposes. Contaminated building rubble will be sent off site to a suitable disposal facility capable of treating or disposing of the material without the loss of contamination at the disposal site, either by leaching or other mechanism. Mitigation must be taken to prevent run-off from the stockpiles of building rubble on site. • Top soils and excavation wastes. Wherever possible these materials will be utilised for land reclamation purposes within the site. There is no history of any previous contamination of the site and therefore the top soils and excavation wastes can be re-used for landscaping, screening and filling purposes without prior treatment. Mitigation must be taken to prevent run-off from the stockpiles of top-soil and excavation materials on site. • Waste oils, lubricants, paints and solvents: Waste oils and lubricants will be temporarily stored in oil drums placed in a sealed container which has a bund wall built into it. The container itself will be located in a bunded area of hard standing, to prevent leaks and spillages from entering the ground and the groundwater. The waste oil, lubricants and containers will be taken from site and disposed of at the nearest suitable recycling facility. • Waste wood: Wherever possible, waste wood can be recycled in the community. However, where disposal is required, waste wood that is not contaminated by, or	OPGCL	FMEnv and IFC requirements.	Visual inspection. Inspection and reporting to be undertaken twice yearly r.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		has not been treated with, halogenated organic compounds or heavy metals can be recovered for use as fuel. • Electrical cabling and electrical components including batteries: Electrical cabling and components could be recycled informally in the community. Spent batteries will need to be stored in a suitable storage facility on site prior to transport to a suitable disposal facility. • Sewage effluent: During the construction Phase, until suitable facilities are constructed, portaloos and portable showers should be used. The portaloos should be emptied by suitably licensed operators who will dispose of the effluent to a suitable treatment facility. Alternatively temporary facilities with a cesspit/ septic tank shall be constructed. Shower and wash facilities should drain to a cesspit/ septic tank until suitable treatment facilities are provided on site. Once available, permanent washing and toilet facilities shall be utilised and shall drain to a cesspit/ septic tank and thence to a package treatment facility capable of meeting IFC standards prior to discharge to the watercourses. • Biodegradable food wastes: Wherever possible these shall be composted on site. • Oxygen and acetylene tanks (or other such tanks for welding and cutting gases): Gas cylinders used for welding and cutting gases shall be returned to the provider of the gases for reuse.			
Operation	Potential to harm human health and environment through uncontrolled disposal of wastes.	Waste streams to be kept segregated (hazardous, inert, industrial and domestic). Adequate provision of waste disposal containers at strategic locations around the site. Training of workers in waste management and safe handling of wastes. Solid waste handling and housekeeping to be monitored through regular inspection during construction and operation. Monitoring to be undertaken at waste storage and transfer sites. Chemicals that would react together if brought into contact will be located in segregated storage areas	OPGCL HSE department are responsible for monitoring, inspection and reporting of solid waste management and handling during operation.	FMEnv and IFC requirements.	Regular inspections of waste storage and transfer sites and reporting to be undertaken during operation. Twice yearly site inspections and reporting to be undertaken during operation.
Operation	Odour from wastes.	All wastes to be contained where possible. Regular uplift of normal domestic and inert wastes via municipal arrangements where appropriate.	OPGCL.	FMEnv and IFC requirements.	Twice yearly inspections and reporting to be undertaken during operation.
Hazardous Waste Management (Mitigation Measures from section 9.4.7 of the ESIA)					
Operation	Harm to human health and the environment through improper management and disposal of hazardous wastes.	Management procedures are to be included in the WMP. Waste streams to be kept segregated (hazardous, inert, industrial and domestic). All wastes in transit shall be tracked by waste consignment note and documented. All wastes shall be disposed at approved dump sites which meet FMEnv and IFC requirements. Workers to be trained in the handling, storing, and disposal of hazardous materials. Where required, engineering controls, spill containment and clean up provisions will	OPGCL	FMEnv and IFC requirements.	Regular inspections of waste storage and transfer sites and reporting during operation.

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		be put in place to minimize the risk of an impact due to accidental release. A Spill Prevention and Response Plan shall be developed for safe transportation, storage and distribution of hydrocarbon and chemicals on site.			
Traffic Management (Mitigation Measures from section 9.2.2 of the ESIA)					
Operation	Risk of accidents and congestion.	Temporary traffic control and diversion arrangements shall be provided at strategic points on local roads, where necessary. An effective journey management schedule shall be maintained to reduce the risk of accidents. A transportation and materials management system for safe transportation of equipment and materials to site shall be developed and implemented, to be included within the ESMS.	OPGCL	FMEnv and IFC requirements.	Site inspections
Operation	Pollution of the environment associated with air emissions.	Mitigation as outlined within air quality management.	OPGCL	FMEnv and IFC requirements.	Site inspections
Greenhouse Gas Emissions (Mitigation Measures from section 9.4.2 of the ESIA)					
Operation	Energy Efficiency – CO2 emissions reduction	Mitigation measure to consider throughout the design and management of operations include: • Pumps/motors – use of high efficiency motors, variable speed drives or multi speed motors (depending on circumstances) and motor load sensing for start/stop control. • Lighting - use high efficiency lights (e.g. LEDs) where appropriate, use motion and photo sensors, use as much natural light as possible. • Waste – encourage reduction of waste through prevention and re-use. Where waste arises, opt to recycle before considering other disposal routes. • Water – encourage reduction in water use by staff, mend any water leaks, treat blow down water for re-use. Given the location and nature of the project, it is also recommended that the project: • Monitor, Calculate and Disclosure GHG Emissions Annually For projects that are expected to produce more than 25,000 tonnes of CO2e annually, the project is required to quantify direct emissions from the facilities owned or controlled within the physical boundary as well as indirect emissions associated with the offsite production of electricity used by the project. The project will quantify and disclose these carbon emissions annually in annual reports, as part of the project's commitment to meeting the requirements of IFC Performance Standard 3. In order to quantify and manage GHG emissions the following will be undertaken: - An Emissions Inventory to be maintained throughout all phases of the project. This should be a live document, to ensure all emissions sources are up to date. - Quantity of GHG emissions from fixed sources to be monitored.	OPGCL	IFC PS3 Requirements	

Project phase	Environmental aspect and identified impacts	Action / mitigation measures	Responsible party	Applicable standard(s) / recommended basis of assessment/ Key Performance Indicator (KPI)	Monitoring requirement(s) / recommended monitoring
		- Emissions and sources of emissions to be monitored throughout the life of the project with a focus on sensitive receptors as identified in the EIA. • Develop GHG Targets for Environmental Management System: IFC Performance Standard (PS) 1 requires the establishment of effective environmental and social management systems and PS3 requires the reduction of project GHG emissions. It is recommended that (a) the project's environmental management system include a target of reducing GHG emissions on an absolute and intensity basis; (b) GHG emissions be determined on an annual basis using the methodology described within IFC PS 3.			
Cultural Heritage Management					
Operation	Impacts / disturbance to unforeseen cultural heritage through project activities.	Procedures shall be developed in the event that cultural heritage is subsequently discovered during the project construction or operation.	OPGCL	FM Env IFC PS1 and PS7	Visual inspection

11. Stakeholder Consultation

11.1 Introduction

11.1.1 Overview

Engagement with interested and affected parties through the consultation process is a fundamental component of the ESIA process. It allows relevant persons and organisations to be involved in the planning and development of the project, and enables the developer to gather information about the understanding and possible impacts and can be useful in determining community and individual preferences and selecting alternatives. It also allows enhancement of project design and can promote greater project sustainability. This section presents the consultation conducted for the project to date.

11.1.2 Objectives

The main objectives of public consultation for this project were to:

- Inform stakeholders of the details of the proposed project and the likely implications of its development;
- Understand stakeholders' concerns, ideas and expectations in respect of the project (including anticipated positive and negative impacts) and consider how the development can address these; and
- In conjunction with the stakeholders, identify possible and agreeable mitigation measures.

11.2 Consultation undertaken

In line with the scope of the socio-economic assessment outlined in Appendix IV, consultation undertaken to date has included both formal and informal consultation with the local community and key stakeholders, and was conducted through the following means:

- Meetings with key LGA stakeholders (political leaders / traditional rulers / civic leaders) to share project information, and to secure permission and co-operation for the project and ESIA studies;
- Discussions with identified non-governmental stakeholders and community groups in consultative meetings to obtain useful knowledge of the project area and local communities;
- A formal public forum event held on 19th July 2013;
- Community meetings held in Obehie, Orgwu (Ogwe), Ihie-Iyi, Obiga, Ngwaiyiekwe, Obuzongwa, Owo-ala, and Umuaka in 2015;
- A meeting held at the Ogwe Autonomous Community Town Hall on 27th February 2014; and
- Ongoing informal consultation with local stakeholders by the project team throughout the project.

Table 11-1 shows the communities in which Focus Group Discussions were undertaken in 2015. Meeting minutes for these meetings are provided in Appendix IX.

Table 11-2 sets out the consultation undertaken between 2012 and 2014, and

Table 11-3 provides further details of topics discussed during consultation activities undertaken during 2013. Consultation was conducted by the local consultant, BGI, and the responses provided were given by BGI on behalf of Oma and not by Jacobs.

Table 11-1 : Focus Group Discussion (FGD) locations, 2015

Community	Focus Group Discussion (FGD) Venue	Date
Obehie	Eze's Palace, Obehie	August 17, 2015
Ngwaiyiekwe	Eze's Palace, Ngwaiyikwe	August 17, 2015
Obuzongwa	Eze's Palace, Obuzongwa	August 18, 2015
Obiga	Civic Town Hall, Obiga	August 18, 2015
Orgwu (Ogwe)	Elder Council Chief Place, Orgwu (Ogwe)	August 19, 2015
Owo-ala	Civic Town Hall, Owo-ala	August 19, 2015
Umuaka	Civic Town Hall, Umuaka	August 20, 2015
Ihie-iyi	Eze's Palace, Ihie-Iyi	August 30, 2015

Table 11-2 : Consultation undertaken in 2012-2014, show by group

Group	Dates	Venue	Key issues/concerns raised during consultations	Approach and responses to issues raised
Political leaders, traditional and civic leaders	11/10/2012 13/03/2013 24/10/2013	Ihie-Iyi Ogwe	Concerns that there will be increased social tension in the community due to the anticipated loss of livelihood.	The project land was acquired by prevailing fair market value, with consideration for the original owners of the land. It is anticipated that during the construction and operation phases, positive impacts will be gained by the local community through employment opportunities at the proposed plant. Employment prospects will exist for skilled and unskilled labour. Where possible, appropriately qualified personnel will be drawn from the local community in line with Oma Power's employment policies which will meet the requirements of Nigerian legislation and IFC PS2. Local sources of labour should be utilized where possible. There also will be a community liaison officer employed to, amongst other things, engage with host communities regarding their needs and opportunities the project may offer.
			It is hoped that the project proponent would agree a Memorandum of Understanding (MoU) or similar document with communities outlining what the Project would do for the communities, before commencement of the proposed project.	An MoU is being negotiated with the communities and this will be executed with responsibilities from both the project sponsors and the communities. The Project will play corporate social responsibility (CSR) roles (including provision of community facilities such as health centre, scholarships / trainings, pipe borne water, and employment / opportunities) in the host communities as negotiated in the MOU during operational period, and would encourage contractors to engage members of the host communities, as much as possible.
			All potentially negative long term effects, especially arising from technical operations of the plant should be clearly identified.	A mitigation plan for all identified negative impacts will be put in place by OMA Power.
			Employment of community residents should be a primary concern of Oma Power when it begins operations on the projects, and employment of residents should be at all levels including management, skilled and unskilled.	As above, the project will utilize appropriately skilled local labour where possible. Oma Power will also consider skills training and scholarships as part of its CSR programme activities.
			Concern that all the electricity generated at the proposed plant would be transmitted to the national grid and used up in other parts of Nigeria without providing adequately for the host community.	The electricity though generated by the power plant in Aba will be evacuated to the National Grid and distributed by the transmission company of Nigeria. Decisions regarding the distribution of electricity produced are with the Federal Government of Nigeria and not within the control of the project.

			Renovation of the public education facilities and incorporation of well-equipped modern laboratories and libraries. Also adequate staffing and provision of utilities in the schools.	OMA Power Management to engage in social responsibility projects for the communities and would form the basis for the MOU.
			Provision of functional public water scheme that would deliver safe potable water to households in the communities.	
			Provision of well-equipped and adequately manned public health facilities in the communities.	
Landlord families	22/10/2012 03/02/2013		Loss of livelihoods by families and households due to land acquisition for the project. The proposed project site is farmland belonging to groups of extended families in the area.	Landowners were duly compensated for the land acquired. The land was paid for at the going rate of similarly located lands in the area. There was no government intervention in the process to influence either of the parties.
Men's and youth groups	14/02/2013 24/10/2013	Ogwe	Concerns that there could be accidents like gas and electric leakages and fires at the plant considering the extensive use of natural gas and the generation of electricity.	There will be an emergency response and HAZOP plans in place to contain and rapidly respond to such events
			The discharge of chemical by-products from construction and production activities. If wastes are discharged into the environment, especially if untreated, it would cause considerable harm to residents.	OMA Power will put in place a Waste Management Plan and abide by pollution prevention guidelines. Untreated waste will not be discharged to the environment. An appropriate certified third party waste disposal company will be engaged to handle waste.
			Scope of the environmental studies should not be limited to the project site but should cover the entire community because the project would use natural gas which could be widely dispersed, with very negative effects, if there is a leak.	The study areas for each discipline within the Environmental and Social Impact Assessment have been informed by technical expertise, previous experience and standard practice, and where appropriate extend beyond the project boundary.
			Cost of living will increase in the community because of large numbers of workers, camp followers and others who will come into the community for one form of related business or another	It is expected that the local economy will benefits from the project development. Additionally, the host communities are not located too far from the commercial / Industrial city of Aba, where many members of the host communities live, own properties and carry out business activities.

			Concerns that mitigation measures will not be properly implemented	The ESMP will be the mechanism by which mitigation measures are implemented and adhered to by the project. This will be reviewed by and agreed with the FmENV and international lenders. The Department of Petroleum Resources also strictly monitor the O&M regime of the gas pipeline, which will be managed by the gas supplier. Oma Power is not constructing or managing any gas pipeline.
			Employment of community members and residents during all phases of the project from mobilization and construction to commissioning and decommissioning.	OMA Power will, within legal and practical limits, endeavour to ensure substantial number of community members are engaged in the construction and operation of the power plant
			Training of artisans from the communities to enhance their chances of employment on the project	Youths with the desire to learn will be considered for trainings and scholarship programmes, if these are part of the ultimately agreed community development activities.
Women's groups	14/02/2013 24/10/2013	Ogwe	What opportunities exist for women in the project?	The ESIA process has considered gender issues and involving women's groups was part of this. The community development activities will be appropriately designed to reflect the findings of the assessment in this respect. The types of support outlined here will be considered as part of consultations to agree the final community development activities.
			Specific empowerment programmes should be developed for the benefit of women who are resident in the communities	
			Award of scholarships. Women particularly canvassed for scholarships to enable girls in the communities pursue further education.	
			Introduction of a microcredit scheme in the communities	
			Concerns that the project could introduce activities of commercial sex workers in the communities	An occupational health and safety sensitization program will be implemented by OMA Power to manage this potential impact. Prostitution is unlawful in Nigeria and OMA Power will, where necessary, partner with local law enforcement agencies to prevent such unlawful activity.
Public forum	19/07/2013	Ihie-Iyi, Ugwunagbo LGA	How does the company plan to cross the Imo River considering the nuisance it will cause for the local fishermen there?	A belly bridge will be constructed to allow low-bed trailers cross the side of the Imo River. This would not stop the flow of water. The pipeline process is part of a separate ESIA process.
			How does the company intend to help the communities considering the fact that they are predominantly farmers?	An MoU with the communities will be developed, in which communities' requests will be considered. Community development activities will be designed to consider benefits to the community which are aligned with the communities' own objectives.
			What are the guarantees of actual jobs for the locals?	A MoU is being negotiated with the communities and this will be executed with responsibilities from both the project sponsors and the communities. See above response regarding employment policies for local community population.

			How does the company intend to harmonize the issues of inter community squabbles in terms of socio economic responsibilities and benefits to be received by each community?	Every affected community is considered in the consultations via their representatives and none is sidelined from the process.
			How far has the company gone with the owners of the lands the pipelines run through in terms of settlements?	OMA Power has already secured the land for the power plant site. OMA Power is not constructing any pipeline. The pipeline spur to the project site is the responsibility of the gas supplier and as such is part of a separate ESIA process being conducted by the gas supplier.
			When will the MoU be signed as a guarantee of the social-economic responsibilities?	The MoU will be signed once consultations with the community and negotiations with company are complete, but prior to the commencement of operation of the plant.
			Clarification on the issue of job creation; it is important that members of the community don't get left with the menial jobs as they also qualify as jobs	Please see above responses regarding employment policies and potential training opportunities.
			What commitments will the company make to nearby communities i.e. those not directly affected by the project, e.g. neighbouring villages?	Neighbouring communities within an appropriate zone of influence from the project site have been considered as part of the consultations.
			What will the company do the community with respect to the noise pollution caused by the plant?	A noise impact assessment and modelling exercise has been undertaken to identify potentially adversely affected receptors. Mitigation measures have been recommended where appropriate to ensure noise levels are below Nigerian limits and IFC EHS guideline values.
Community Town Hall meeting	27/02/2014	Ogwe Autonomous Community Town Hall	What the women stand to benefit from the project since the men get all the contracts and employment opportunities.	Please see above response regarding gender considerations.
			Elders called for an MoU between OMA Power management and the communities. The document will feature the projects to be executed for the communities by OMA Power management being "corporate responsibilities". They specifically requested for establishment of hospitals, better managed schools and other community development projects.	OMA Power to engage in corporate social responsibility projects for the communities and will confirm the final agreements in a MoU.
			The Ezes and community leaders raised the absence of modern market places and rural electrification works that would match the existence of OMA Power Plant	
			The youth leaders of the community requested that the youths be included in the development of the project, in order to prevent them causing trouble for the project.	Youth leaders of the community have been engaged with as part of the consultation process. This will continue throughout subsequent phases.

Table 11-3 : Consultation undertaken in 2013

Group / individual	Date	Issues Discussed
Ezeoha 1; the Eze (traditional ruler) of Ihie-Iyi community	13/03/2013	Traditional governance, community development needs and thrust, conflict management and security. Concerns about the proposed project's potential impact including human rights issues with respect to economic, social and cultural rights, suggestions about impact mitigation and enhancement measures.
Community members (men)	14/02/2013	Traditional governance, belief systems, social structures, developmental roles of women and the youth, conflict management procedures, migration pattern and oral traditions of origin, infrastructural network, livelihoods, household income levels and expenditure pattern, environmental problems and community efforts at solving them, perceptions and concerns about the proposed project including human rights issues with respect to economic, social and cultural rights, suggested mitigation and enhancement measures, community, needs and development prospects.
Community members (women)	14/02/2013	Traditional belief systems, social structures, traditional governance and the developmental roles of women and the youth, teenage pregnancy, social vices, conflict management procedures, infrastructural network, livelihood activities and income levels, household expenditure pattern, quality of housing, water supply for household use, sanitation, perceptions and concerns about the proposed project including human rights issues with respect to economic, social and cultural rights, suggested mitigation and enhancement measures, community, needs and development prospects.
Health Worker at Health Centre in Ihie Etiti	14/02/2013	Provision of health care services, functional status of public health facilities, immunization services and coverage, disease prevalence and mortality. Adequacy of health facility and staffing, nutrition and sanitation.
Medical Director, Joint Hospital (a private health facility at Ihie Ukwu)	13/02/2013	Maternal and child health, teenage pregnancy, disease prevalence and mortality. Nutrition and sanitation. General access to orthodox health care by household members in the community.
Principal of the Community Comprehensive Senior Secondary School, Ihie.	15/02/2013	Adequacy of public education facilities and services in the community, student enrolment, student teacher ratio, school dropout rate, children out of school and adult literacy. Social vices and miscreant behaviour.
Eze (traditional ruler) of Ogwe Autonomous Community	24/10/2013	Traditional governance, community development needs and thrust, conflict management and security. Concerns about the proposed project's potential impact including human rights issues with respect to economic, social and cultural rights, suggestions about impact mitigation and enhancement measures.
Leader of the Women in Ogwe Autonomous Community	24/10/2013	Traditional belief systems, social structures, developmental roles of women and the youth, teenage pregnancy, social vices, conflict management procedures, livelihood activities and income levels, household expenditure pattern, quality of housing, water supply for household use, sanitation, perceptions and concerns about the

		proposed project including human rights issues with respect to economic, social and cultural rights, suggested mitigation and enhancement measures.
Community Chairman, Chairman, Ogwe Town Union/Head Teacher, Owe Central School (Primary)	24/10/2013	Traditional governance, belief systems, social structures, developmental roles of women and the youth, conflict management procedures, migration pattern and oral traditions of origin, infrastructural network, livelihoods, household income levels and expenditure pattern, environmental problems and community efforts at solving them, perceptions and concerns about the proposed project including human rights issues with respect to economic, social and cultural rights, suggested mitigation and enhancement measures, community, needs and development prospects.
Youth Leader, President of Ogwe Youth Group	24/10/2013	Social structures, developmental roles of the youth, conflict management procedures, infrastructural network, livelihoods, household income levels and expenditure pattern, employment in households, environmental problems and community efforts at solving them, perceptions and concerns about the proposed project including human rights issues with respect to economic, social and cultural rights, suggested mitigation and enhancement measures, community, needs and development prospects.
Community Health Workers, Ogwe Health Centre	24/10/2013	Provision of health care services, functional status of public health facilities, immunization services and coverage, disease prevalence and mortality. Adequacy of health facility and staffing, nutrition and sanitation.

11.3 Future consultation and public engagement

Consultation is an ongoing process which will continue as the project develops. A Stakeholder Engagement Plan (SEP) will therefore be developed by Oma to facilitate this process and ensure the needs and opinions of those affected by the project are considered, and accommodated as far as possible.