DRAFT
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT

For

THE PROPOSED GAS PROCESSING FACILITY WITH LIQUIFIED NATURAL GAS (LNG) PLANT BY VTT LNG WEST AFRICA LIMITED IN GILLI-GILLI FIELD, OVIA NORTH EAST LGA, EDO STATE

Submitted To

FEDERAL MINISTRY OF ENVIRONMENT

Environment House, Mabushi, FCT, Abuja

By

VTT LNG WEST AFRICA LIMITED

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LIST OF ABBREVIATIONS AND ACRONYMS

ALARP	-	As Low as Reasonably Practicable
APHA	-	American Public Health Association
API	-	American Petroleum Institute
As	-	Arsenic
ASTM	-	American Society for Testing and Materials
Ba	-	Barium
BATNEEC	-	Best Available Technology Not Entailing Excessive Cost
BOD	-	Biochemical Oxygen Demand
BTEX	-	Benzene, Toluene, Ethylbenzene and Xylene
C	-	Simpson's Dominance Index
Ca	-	Calcium
CCR	-	Central Control Room
CCS	-	Convention on the Continental Shelf
Cd	-	Cadmium
CEC	-	Cation Exchange Capacity
cfu	-	Coliform Forming Unit
CFC	-	Chloroflorocarbons
CH_4	-	Methane
CHARM	-	Chemical Hazard Assessment and Risk Management
Cl^-	-	Chloride Ion
CLC	-	Convention on Civil Liability for Oil Pollution Damage
CNA	-	Clean Nigeria Associates
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
COD	-	Chemical Oxygen Demand
COLREG	-	Convention on the International Regulations for Preventing Collisions at Sea
Cr	-	Chromium
CTD	-	Conductivity Temperature Density Profiling
Cu	-	Copper
dBA	-	Decibels
Deg	-	Degree
DGPS	-	Differential Geographical Positioning System
DO	-	Dissolved Oxygen
DPR	-	Department of Petroleum Resources
EA	-	Environmental Assessment
EAL	-	Enviroafrica Limited

EEZ	-	Exclusive Economic Zone
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EHSS	-	Environmental Health and Safety Standards
EIA	-	Environmental Impact Assessment
EIS	-	Environmental Impact Statement
EMP	-	Environmental Management Plan
EMS	-	Environment Management System
EPA	-	Environmental Protection Agency
ESA	-	Environmentally Sensitive Areas
ESI	-	Environmental Sensitivity Index
ESP	-	Exchange Sodium Potential
ESIA	-	Environmental and Social Impact Assessment
ESMP	-	Environmental and Social Management Plan
E&P	-	Exploration and Production
Fe	-	Iron
FEPA	-	Federal Environmental Protection Agency
FID	-	Final Investment Decision
FMEnv	-	Federal Ministry of Environment
GPS	-	Global Positioning System
H_2S	-	Hydrogen Sulphide
HAZID	-	Hazard Identification Study
HAZOP	-	Hazard and Operability Study
HC	-	Hydrocarbon
HCFC	-	Hydro chlorofluorocarbons
HCO_3^-	-	Bicarbonate Ion
Hg	-	Mercury
HP	-	High Pressure
Hs	-	Shannon-Wiener Index
HSE	-	Health Safety and Environment
HSE-MS	-	Health Safety and Environment Management System
HSSE	-	Health, Safety, Security and Environment
HUB	-	Hydrocarbon Utilizing Bacteria
HUF	-	Hydrocarbon Utilizing Fungi
IFC	-	International Finance Corporation
IMO	-	International Maritime Organization
IMS	-	Integrated Management System
IOPC	-	International Oil Pollution Compensation Funds
ISO	-	International Organization for Standardization
ITCZ	-	Inter-Tropical Convergence Zone

j	-	Equitability Index
JV	-	Joint Venture
K	-	Potassium
Lat	-	Latitude
LP	-	Low Pressure
LRA	-	Lav-radioactive avleiringer
LSA	-	Low Specific Activity
Long	-	Longitude
MAP	-	Mutual Assistance Plan
MARPOL	-	Marine Pollution
Mg	-	Magnesium
MSL	-	Mean Sea Level
N	-	Nermetea
N	-	North
N	-	Total Species Abundance
NAG	-	Natural Gas Association
NESREA	-	National Environmental Standard and Regulation Enforcement Agency
NGC*	-	Nigeria Gas Company
NGC	-	Natural Gas Compressor
NH_4^+	-	Ammonium
Ni	-	Nickel
NNPC	-	Nigerian National Petroleum Corporation
NORM	-	Naturally Occurring Radioactive Materials
NO_2	-	Nitrogen Dioxide
NO_3	-	Nitrate
NO_3^-	-	Nitrate Ion
NO_x	-	Mono-Nitrogen Oxides
NORM	-	Naturally Occurring Radioactive Materials
NOSDRA	-	National Oil Spill Detection and Response Agency
NTU	-	Nephelometric Turbidity Unit
NW	-	North West
N_2O	-	Nitrous Oxide
OBM	-	Oil-Based Mud
OH	-	Open Hole
OILPOL	-	Convention for the Prevention of Pollution of the Sea by Oil
OML	-	Oil Mining License
OPL	-	Oil Prospecting License
OPRC	-	International Convention on Oil Pollution

		Preparedness, Response & Co-operation
OSPAR	-	Oslo/ Paris Convention for the Protection of the Marine Environment of the North East Atlantic
OSRL	-	Oil Spill Response Limited
PAH	-	Polynuclear Aromatic Hydrocarbons
Pb	-	Lead
pH	-	Hydrogen ion concentration
ESIA	-	Environmental and Social Impact Assessment Report
Plc	-	Public Limited Company
PPL	-	Platform Petroleum Limited
PM	-	Particulate Matter
POB	-	Persons on Board
PPE	-	Personal Protective Equipment
PSU	-	Practical Salinity Units
Pt-Co Units	-	Platinum-Cobalt Standard
SBM	-	Synthetic Based Mud
SEPA	-	State Environmental Protection Agency
SO_4	-	Sulphate
SO_x	-	Sulphur Oxides
SOW	-	Scope of Work
Sp	-	Species
SPM	-	Suspended Particulate Matter
SSW	-	South South-West
STCW	-	Standards of Training Certification and Watch-Keeping for Seafarer
TAH	-	Total Aliphatic Hydrocarbon
TDS	-	Total Dissolved Solids
TDU	-	Thermal Desorption Unit
THB	-	Total Heterotrophic Bacteria
THC	-	Total Hydrocarbon Content
THF	-	Total Heterotrophic Fungi
TOC	-	Total Organic Content
ToR	-	Terms of Reference
TPH	-	Total Petroleum Hydrocarbon
TSS	-	Total Suspended Solids
UNCLOS	-	United Nations Conference on the Law of the Sea
UNEP	-	United Nations Environment Programme
USEPA	-	United States Environmental Protection Agency
UTM	-	Universal Transverse Mercator

V	-	Vanadium
V	-	Volts
VOC	-	Volatile Organic Carbon
W	-	West
WBM	-	Water-based mud
WHO	-	World Health Organization
WMP	-	Waste Management Plan
Zn	-	Zinc

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Declaration

VTT LNG West Africa Limited, the proponent, identifies and accepts responsibility for all statements and judgments made in this report entitled '*Environmental and Social Impact Assessment Report for Proposed Gas Processing Facility with an LNG Plant in Gill-Gilli Field, Edo State'*

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EXECUTIVE SUMMARY

E.S.1 Background Information

VTT LNG West Africa Limited, a natural gas production and distribution Company located in Lagos State, wishes to carry Environmental Social Impact Assessment (ESIA) study for the development and operation of the Proposed Gas Processing Facility in Gilli-Gilli Field, OML 96, Edo State in Nigeria.

The gas development shall consist of VTT Gas Processing Facility with an LNG Plant (herein referred to as project) that will process and liquefy natural gas from the Dubri field which will contribute to the reduction of gas flaring and transported via virtual pipelines to support power plants that are off grid. Consequently, the gas processing facility shall be designed to achieve a maximum processing potential of gas from the Dubri flow station.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) and *Part VIII.A Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002, revised in 2018)* of Department of Petroleum Resources (DPR), as well as complying with the company's Environment, Health, safety and Security policies, VTT LNG West Africa Limited through her consultant, Afruitful Environment Limited (AFEL) accredited by Department of Petroleum Resources (DPR), Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out a Environmental and Social Impact Assessment Report (ESIA) of the proposed Gas Processing Facility with an LNG Plant and prepared this Environmental and Social Impact Assessment Report (ESIA). The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts

Objectives of the ESIA

The aim of the ESIA is to proactively evaluate the types and extents of potentially significant and adverse environmental impacts that may arise from the modular gas processing/LNG plant. The study therefore will:

- Determine the baseline (biophysical, social and health) conditions of proposed project environment;

- Assess the potential impacts of the planned development on biophysical, social and health components of the environment;
- Determine and document the sources of impact from the proposed development/project activities and identify the environmental, social and health components of the environment that can be potentially impacted;
- Identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural heritages, properties, social infrastructures and natural resources;
- Proffer appropriate mitigation measures for negative impacts and make recommendations aimed at sustaining the beneficial impacts of the projects on the environment;
- Aid early selection of best available techniques (including technology and method of operation) that can help in realizing the project environmental objectives;
- Develop and establish an appropriate Environmental and Social Management Plan (ESMP) as well as provide recommendations for monitoring and mitigation activities.

The ESIA Methodology includes:

i. Preliminary Activities
ii. Desktop/Literature Survey
iii. Stakeholders' Consultation
iv. Field Sampling and Laboratory Analysis
v. Impact Identification
vi. Impact Mitigation and Environmental and Social Management Plan
vii. Reporting and Review

The proposed project is affected by a number of national, state and international legislation which have been considered by the ESIA. A review of relevant legislation was done and briefed.

- National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)
- The Draft National Gas Policy, 2004
- Petroleum Act 1969
- Environmental Impact Assessment (EIA) Act No 86 of 1992
- Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002).
- Petroleum Products and Distribution Act, CAP P12, LFN 2004

National Environmental Protection (Effluent Limitations) Regulations, S.I.8

National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991

National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991

- Land Use Act L5 LFN 2004
- Forestry Law CAP 55, 1994
- Endangered Species Act (Cap 108), 1990
- Edo State Ministry of Environment and Public Utility Policy
- Edo State Ministry of Lands and Survey Policy
- Edo State Waste Management Board Policy
- Edo State Industrial Policy
- Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1987)
- Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)
- United Nations Framework Convention on Climate Change (1992)
- World Bank Guidelines on Environmental Assessment
- United Nations Guiding Principles on the Human Environment
- The Rio Declaration on Environment and Development
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990
-

E.S.2 Project Justification and Alternative

VTT LNG West Africa Limited intends to gather and distribute gas and electricity to customers in industrial clusters who are currently stranded from the gas pipeline network and also to customers who require gas as a back-up/storage solution. In this chapter, the justification and appraisal of possible project options and alternatives for the proposed LNG Plant is discussed.

Despite its abundant natural gas reserves (largest in Africa in proven reserves and ninth largest in the world), Nigeria still struggles to meet its energy requirements and has low domestic gas utilization. This is due to multiple reasons, with a key one being a deficit of gas transportation and distribution infrastructure. Given the role that natural gas plays as a fuel for electricity generation in Nigeria, the issues around limited supply of gas have a significant knock-on effect for industrial, commercial and residential users.

The benefit of the project includes:

- Reduced Cost
- Environmentally Friendly
- No Pilferage
- Reduction of Gas Flaring and conversion of waste gas to wealth
- Meeting the increasing demand for gas by customers
- Increase production cost competiveness and return on investment
- Reduced health risks and positive contribution to safety of the environment
- Global Warming Reduction
- Provision of Employment

The anticipated cost of the proposed project will be in the region of $60,000,000. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government.

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic and environmental sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Economic Sustainability:** VTT LNG West Africa Limited shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security.
- ✓ **Technical Sustainability:** The proposed project will be technically sustainable, utilising modern practices and techniques in the plant design and adhering to international and national

engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development.

- ✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because VTT LNG West Africa Limited's activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs.
- ✓ **Social Sustainability:** To ensure social sustainability of the project, VTT LNG West Africa Limited will ensure:
  1. Robust stakeholder engagement
  2. Establish a grievance mechanism

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go-ahead option.
- Project alternatives: Alternative location/site and Alternative technology.

Option Three: Go-Ahead Option

This project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. Therefore, the proposed mini LNG Plant shall be executed as planned.

Alternative Location

The Gilli-Gilli location was selected over other sites for the following reasons: The Gilli-Gilli location is closer to the tie-in point into the gas supply pipeline than other fields. This indicates a shorter trenching distance and less perturbation across the habitats in the area. Moreover, farmlands are more readily avoided with the shorter distance.

Alternative Technology

Preferred alternative: The expansion system, specifically nitrogen expansion technology was selected as the preferred option. Due to the fact that nitrogen can be produced from air and does not need to be imported, the ease of operation of the nitrogen expansion technology is a significant consideration. In addition, there are existing suppliers of nitrogen in Nigeria.

Transportation Method of Gas to the Plant

Preferred alternative: The Dubri pipeline as it is a more cost-effective option as the pipeline is currently operational and in good state.

Transportation Method of Gas out of the Plant

Preferred alternative: Virtual Pipeline is suited to a variety of transport modes and market segments including off-grids factories, power plants, communities etc, No adverse environmental impact from transporting through trucks

Product Storage Type

Preferred alternative: The selected option is an above-ground (pressurized cylindrical or bullet), full containment, flat-bottom storage tank as the storage concept for the LNG Facility. This is considered safest and most cost-effective as in-ground tanks are more difficult and more expensive to construct than above-ground tanks.

From the foregoing, it is evident that there is no better alternative to the proposed LNG Plant that favours environment, social and economy except as planned. Due to the advantages that the Go-Ahead Option has over other options considered, the proposed project is considered viable and should be executed as planned. The proposed project also considered environmental and social sustainability; therefore, it should be executed as planned.

E.S.3 Project and Process Description

The proposed facility is situated on coordinate of 5.35732N and 6.15518E in Gilli-Gilli Field, Ovia North East Local Government Area of Edo State, Nigeria (see admin maps in Figures 1.1 to 1.3). Situated about 45km southwest of Benin City, the field covers an area 221 sq. km.

The field is situated within the low-lying freshwater forest of Edo state. The natural vegetation is in different stage of disturbances. The topography is a low lying and relatively flat terrain drained by the Osse River. The rainfall pattern in the area determines the two characteristic seasons in the year, the wet and dry seasons. Rainfall occurs throughout the year with its peak in July and September, while the drier periods of the year are from November to February. Within the field, there are cultivated farmlands and forests. The plant can be accessible by road, water and rail infrastructure. This provide VTT, the uniqueness of easier reach to the south west industrial nerves of Nigeria.

VTT's proposed gas project is to produce Liquefied Natural Gas to support captive/embedded industries and domestic users who are off the pipeline grid. The plants are modularized skid mounted and would be developed in two Phases with a total daily production capacity of 30MMSCF (600TONS).

LNG takes up about 1/600th of the volume of natural gas in gaseous state and this makes it easy to transport to locations as far as 1200km away from the source (liquefaction facility). This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in Northern Nigeria who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. The LNG will be re-gasified back to gaseous form at the customer location before being used by their equipment.

The first phase of the LNG project will cater for 10MMSCFD while the 2nd phase will cater for 20MMSCFD while the entire project entails the development of a small-scale liquefied natural gas

(LNG) facility with a production capacity of 30MMSCF (600TONS) **per day**. The produced gas would be transported in special Cryogenic tanks to off takers, this method of moving gas by truck is known as Virtual Pipeline Transportation.

The gas processing starts with the wet in-let gas piped from Dubri Oil Company Ltd., into our metering Substation at a temperature of 80.6ºF and Pressure of 92psig. The fed in gas is pretreated through a cleanup process to remove acid gases, impurities and a dehydrating system to rid it of all moisture. The gas stream goes through a distillation process to separate the higher C_3^+ hydrocarbon gases and higher chain liquids, which are stored as LPG, Propane and Natural Gasoline (Condensate).

The unique blend of Methane and Ethane lean gas is further cooled through LNG Heat Exchanger Cold Box to a further temperature of -262°F and at a pressure of 0.5psig to and stored in large cryogenic tanks

The project activities will broadly cover the following areas:

- **Pre-construction activities include**
  - site preparation,
  - engineering design,
  - materials delivery etc.
- **Construction activities include**
  - installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.)
  - civil works.

- **Operational activities include**
  - operation of the LNG plant,
  - loading of LNG and
  - supply of same to customer locations etc.
- **The decommissioning activities include**
  - Removal of pipelines, plant components for relocation or sale

Process Description

- Natural Gas Pretreatment Unit
    - Amine Wash Unit
    - Dehydration and Mercury Removal Units
- Liquefier
    - Natural Gas Circuit
    - Cold Box
    - Liquefaction Cycle
- LNG Storage and Send-Out Unit

Sources and Characteristics of Wastes

The different waste streams – classified as gaseous, liquid and solid waste – will be generated by the proposed refinery. Anticipated waste include:

Construction Waste

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.
- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction.
- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment.

Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.

- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.
- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.
- Combustible office waste shall be collected and transported off-site for disposal.

Air Emissions

There shall be emissions of air pollutants from various sources during the operations of the plant and these include emissions from: Combustion engines, Pilot flare, Vents, Heating oil furnaces, LNG loading vapours and tank vents.

Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the r plant operations. Effluents generated will include backwash effluent from pressure filters, regeneration effluent from the demineralisation plant as well as other chemical laboratory wastes, battery waste water, gas turbine compressor wash water and sludge.

All these wastes shall be handled in line with the FMEnv and DPR regulations

The project is scheduled to reach completion in 2 years. On approval of the project ESIA by FMEnv, hopefully in the third quarter 2020, site preparation will commence immediately. This will run concurrently with preparation for procurements. This will follow with excavation and foundation work for the plant. Installation of plant equipment will follow and conclude with the commissioning of the plant which is envisaged to be in the fourth quarter 2021.

E.S.4 Baseline Social and Environmental Characteristics of the Project Area

The field work was carried out at both wet and dry season between 15th November – 17th November 2019 (3 days) and 4th February – 6th February 2020 (3 days) respectively. The Sampling radius for water, soil, vegetation and Air Quality for the ESIA study was 1km from the perimeter boundary of the proposed site. A total of Twenty (20) geo-referenced sampling stations and additional two (2) control points were established in line with the ESIA Terms of Reference (ToR) for Soil, Air Quality, Noise and Vegetation Study while two (2) sampling locations and one control for Groundwater within 2km spatial boundary and three (3) sampling locations and 1 control for surface water and sediment. The samples location distribution is attached in *Appendices 4.1a-c*.

Reconnaissance Survey and Delineation: The reconnaissance survey of the study areas was carried out, with objectives of setting boundaries of the study areas. Visual observation within the project sites were made to determine resources, population, land form features, ecological characteristics, drainage, and human communities within and around the project areas.

The baseline condition was stabled for the following components of the environment:

1) Weather and climate
2) Air quality and Noise
3) Surface water
4) Groundwater
5) Soil
6) Plankton and benthos
7) Sediment
8) Vegetation and wildlife

Although the microclimatic data was acquired via field measurement, macroclimatic data (long term data) was acquired from the database of the Nigerian Meteorological Agency (NIMET) and World Meteorological Organization (WMO). The purpose of the climatic and meteorological study is to establish meteorological conditions in-and-around the study area through microclimate and macroclimate data acquisition. The climatic characteristics of the study area relating to the following were extracted from historical and field sampling data.

The following data were collected:

- Temperature
- Rainfall
- Relative humidity

- Wind patterns (speed and direction)
- Sunshine (hours and intensity)
- Visibility Level

The samples collected from the field were preserved in an ice-cooled container and transported to the laboratory for analysis. All analysis was carried out in the Jacio Environmental Services Laboratory, Warri, Delta State.

When the gaseous pollutants (SO_X, VOCs, NOx, H_2S, CO and CO_2) were extrapolated to 24-hour averaging period concentration in the (Table 3.3) for the purpose of impact assessment. The daily equivalents of the measured SO_X were 0.00-0.25 ppm with an average of 0.039 ppm. The measured VOC_S became 76.4-361.4 ppm with an average of 123.68 ppm, while NO_X daily equivalents was measured to be 0.023-0.568 ppm with an average of 0.079 ppm. The measured daily was equivalent for H_2S was 0.000-0.083 ppm with an average of 0.013 ppm while that of CO was quantified to be 0.00-1.66 ppm with an average of 0.125 ppm. The daily averaging period concentration for CO_2 was measured to be 0.00-0.06 ppm with an average of 0.024 ppm.

The extrapolated 24- hour averaging for (SO_X, VOCs, NOx, H_2S, CO and CO_2) for the impact assessment study. The daily equivalents of the measured SO_X, was measured to be 0.00 ppm with an average of 0.00 ppm. The VOC_S daily concentration became 158.5-297.9 ppm with an average of 230.44 ppm while NO_X daily concentration was estimated to be 0.000-0.012 ppm with an average of 0.003 ppm, H_2S daily concentration was estimated to be 0.00-0.58 ppm with an average of 2.804 ppm while that of CO was estimated to be 0.00 ppm. The daily averaging period of CO_2 was estimated to be 0.014-0.034 ppm with an average of 0.037 ppm.

The daily concentration of SPM_{10} in the wet season were measured to be 8.5-11.93 $\mu g/m^3$ with an average of 9.65 $\mu g/m^3$ while $SPM_{2.5}$ values were measured to be 26.7-8.69 $\mu g/m^3$ with an average of 11.811 $\mu g/m^3$ Table 3.6 showed that the daily concentrations of SPM_{10} in the dry season were measured to be 32.07-66.51 $\mu g/m^3$ with an average of 44.5 $\mu g/m^3$ while that of $SMP_{2.5}$ were measured to be 29.44-42.79$c.$ $\mu g/m^3$ with an average of 33.97 ppm

Noise Level

The average minimum and maximum noise levels recorded at the project area during wet season was 40.48 dB and 51.64 dB respectively while during the dry season the average minimum and maximum noise level was 44.88 dB and 74.99 dB respectively. A large proportion of background noise in the area is due to human activities and noise from engine of the boat around the project area. In spite of this, the mean values recorded for both seasons are still below the FMEnv and DPR limit of 90dB (A) for 8 hours exposure respectively.

Surface water

During the dry season the values of pH ranged from 6.8 to 7.6 while the values ranged from 6.62 to 7 during wet season. These values show that surface water around the project area were slightly acidic and also were within FMENV and WHO limit of 6.5 – 8.5 for drinkable water.

The surface water temperature for dry season ranged from 27.2 – 27.9 ^{O}C while it ranged from 26.2 to 26.8 ^{O}C during the wet season. The water Turbidity ranged from 3.1 to 3.6 NTU during the dry season while the values ranged from 3 to 4.1 NTU during the wet season. Total Suspended Solids in both dry and wet season ranged from 1.68 to 2.31 mg/l and 1.26 to 2.21 mg/L respectively. Electrical conductivity varied between 38 and 48 µS/cm in dry while the values ranged from 133 and 138 µS/cm in wet season. Total Alkalinity ranged from 20 to 50 mg/L in dry season while the parameter has a value ranging from 8 to 20 mg/L during wet season.

The surface water Dissolved Oxygen (DO) recorded for dry season was between 6.7 and 8.9 mg/L while the values ranged from 8.6 to 9.5 during the wet season. The surface water Chemical Oxygen Demand (COD) values as an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were generally low. The values ranged from 30.93 mg/l to 42.67 mg/l for dry season while the values ranged from 15.6 to 26.26 mg/L in wet season. The surface water Biological Oxygen Demand (BOD^5) as the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 6.18 mg/L in dry season while it has a mean value of 4.15 mg/L in wet season.

Groundwater

During the dry season the values of pH ranged from 6.34 to 6.84 while the values ranged from 5.7 to 7.2 during wet season. These values show that groundwater around the project area were slightly acidic and also were within FMENV and WHO limit of 6.5 – 8.5 for drinkable water.

The water temperature for dry season ranged from 25.4 – 26 ^{O}C while it ranged from 27.2 to 33.2 ^{O}C during the wet season. The water Turbidity ranged from 11.4 to 13.9 NTU during the dry season while the values ranged from 5.2 to 7.6 NTU during the wet season. Total Suspended Solids in both dry and wet season ranged from 0.86 to 7.48 mg/l and 1.03 to 8.77 mg/l. Electrical conductivity varied between 45 and 346 µS/cm in dry while the values ranged from 44 and 192 µS/cm in wet.

The groundwater Dissolved Oxygen (DO) recorded for dry season was between 8.3 and 10.6 mg/L while the values ranged from 5.7 to 6.8 during the wet season. The groundwater Chemical Oxygen Demand (COD) values as an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were generally low. The values ranged from 2.41 mg/l to 6.01 mg/l for dry season while the values ranged from 29.87 to 51.2 mg/L in wet season. The groundwater Biological Oxygen Demand (BOD^5) as the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 1.4 mg/L in dry season while it has a mean value of 7.14 mg/L in wet season.

Soil

The soils in the entire area were mainly acidic with pH ranging from 2.9 to 5.1 in the dry season and 6.8 to 7.3 in the wet season indicating slightly acidic to neutral pH. The soil texture manifested properties of sand and loamy sand in the dry season. Mean sand amount of 83.9%, clay (11.78%) and silt (4.2%) were determined in the fractions. These varied from the means levels found in the wet season: clay (30.3%), silt (20.1%) and sand (19.5%). High precipitation especially during the rainy season accompanied by inundation may be responsible for the change in the textural properties in the two seasons.

The soils exhibited wide variability in terms of total organic carbon content. TOC ranged from 0.70% to 6.44%, with a mean value of 2.55% in the dry season and mean level of 1.55% in the wet season. The production, accumulation and degradation of organic matter are greatly dependent on climate. Temperature, soil moisture and topography are the major factors affecting the accumulation of organic matter in soils.

Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature (Buol, 1990) or excess moisture which results in anaerobic conditions (Trofimov et al 2008). Conversely, excessive rain and high temperatures of tropical climates as in the present assessment enables rapid decomposition of organic matter and leaching of plant nutrients. Excessive slope may encourage the erosion of the top layer of soil which holds most of the raw organic material that would otherwise eventually become humus.

In view of the observations during the field studies, the present variability in total organic carbon content of the soils could be attributed to its high accumulation around the densely vegetated and unhampered secondary forest portion of the area. The other areas possess less dense vegetation cover leading to reduced rate of plant residue returns and accumulation with inherent high decomposition rate on the sandy, loamy sand texture soil.

The mean levels of these anions (dry season) were generally low as follows; Sulphate (3.33mg/kg); Chloride (8.88mg/kg) and Phosphate (0.17mg/kg) respectively. In the wet season, the values were: sulphate (119.59mg/kg), phosphate (13.69mg/kg). These values are consistent with the relatively low CEC determined in the soils. In soil, iron and aluminum hydroxide clays are able to exchange their hydroxide anions (OH^+) for other anions. The order reflecting the strength of anion adhesion is as follows; $H_2PO_4^{2-}$ replaces SO_4^{2-} replaces Cl^-.

The E.C. of the soils varied between 21.00 to 235.0061µS/cm with a mean value of 59.61µS/cm (dry season) and range from 6.25 to 980.00µS/cm in the wet season with a mean value of 641.90µS/cm. The THC of the soils ranged from 1.94mg/kg to 16.08mg/kg with a mean value of 7.36mg/kg.

The mean concentration of the heavy metals in the dry season and related soil micronutrient elements were as follows; Iron (2222.15mg/kg), Zinc(4.83mg/kg), Chromium (0.02mg/kg), Lead (3.92mg/kg), Copper (2.95mg/kg), Cadmium(0.18mg/kg), Nickel(1.94mg/kg), Barium(0.19mg/kg). However, in the wet season, the mean values were iron (1503.66mg/kg), zinc (44.85mg/kg), chromium (1.87mg/kg), Lead (85.92mg/kg), Copper (7.30mg/kg), Cadmium (1.54mg/kg). These values are consistent with levels of these metals as found in non-contaminated or none anthropogenically impacted soils, except for lead in the wet season.

Fisheries

Fish catch in this area, according to response from the fishermen are on the average, though gradually declining, when compared to the past years. Fishing activity was very low in the project area. Only few fishermen were seen in fishing canoes checking their overnight fish traps and nets for catch. Women fish mainly using basket traps but sometimes they use long lines, set gill nets and lift nets. The fishermen operate different types of gears such as cast nets, gill nets, beach seines, filter nets, long lines and encircling nets in near and distant waters.

Only few members of the communities are involved in aquacultural practices, using monoculture fishponds constructed near homes, for the rearing of catfishes.

Thirty eight species in 18 families of fish were recovered from the study area. The families Characidae, Bagridae and Cyprinidae appeared extensively in the catches. The bagrid species included *Chrysichthys nigrodigitatus,* and *Clarotes macrocephalus*.
The average catch per unit effort was low. Interview with fishermen indicates that sometimes, the day's effort can be fruitless without any catch. Because of the low catch from the castnet gear, the locals resort mainly to the use of fenced seine nets and traps and hooks for littoral bank edge fishes like *Clarias* and *Gymnarchus*, which ensures more yield.

No observable physical deformities were examined in the fishes. The laboratory results of tissue analysis indicate that all heavy metals associated with crude oil such as V, Hg, Cd, As, Cr and Ba were below detection limit. Trace metals like Zn and Fe were high in fish tissue, slightly above WHO limits but below FAO limits. In general, the toxic heavy metal concentrations in the tissue of fish were within the recommended acceptable limits and in most cases not detectable.

A total of 58 species belonging to 32 families were identified as making up the taxonomic diversity in the forests of the study area. Diversity at the rank of family is in the following order: Euphorbiaceae (9) > Fabaceae (6) > Meliaceae (4) > Asteraceae, Rubiaceae, Poaceae (3). Twenty (20) Families were represented by single species. Species composition is fairly consistent with disturbed areas of rainforest ecosystem. A few incidences of invasive species (*Mimosa pudica*) were observed at VG 15 and C1.

Dominant economically important undersized timber species present in this tropical low land rain forest canopy include: *Lophira alata, Alstonia boonei, Fleroya ledermanii, Ceiba pentandra, Ricinodendron heudelotii, Musanga cercropioides, Albizia zygia, Parkia bicolor, Ficus mucoso, Khaya ivorensis, Irvingia gabonensis, Pycnanthus angolensis, Cleistopholis patens, Lovoa trichilioides, Nauclea diderrichii, Terminalia superba, Terminalia ivorensis, Caesalpinia bonduct, Vitex grandifolia, Elaeis guineensis, Ficus exasperata, Funtumia elastica, Trycoscypha arborea.*

Information from native hunters and observations of key indicators of animal presence show that the project area harbors at least 23 Species of animals belonging to 17 Families; whichcut across three classes in the phylum chordata.The three classes identified include: Mammalia, Reptilia and Aves. The diversity within these classes in decreasing order is Mammalia (13 species) > Reptilia (5 species) > Aves (5 species). The absence of Amphibia reflects the rain forest ecological conditions. However the possibility of Crocodiles wandering into the portion of the river is limited because of the volume of activity on the main river course even though they are present in the nearby Ughoton Stream.

The identified host community for the proposed gas plant project is Gelegele-gbene community and adjoining riverine sub-communities namely, Owubuloba-gbene, Atunkpo-gbene, Ukulebor-gbene, Lanu-gbene, James-gbene, Cinima-gbene, Itilan-gbene, Agbada-gbene, Sanimo-gbene, Nene-gbene, Omaria-gbene, Apur-gbene, Ugbodudu I & II, Oje-gbene, Reme-gbene, Felicia-gbene, Danikoba I & II, Jimmy-gbene, Pukpaye-gbene, Zimmy-gbene and Ukponme-gbene. There are also impacted Gelegele-gbene upland sub-communities namely, Camp-1 Opuosuwo, Camp-2 Pere, Camp-3 Desmond, Camp-4 Lucky, Camp-5 Midwest, Camp-6 Benson and Camp-7 Richard-obey.

The host community is predominantly Christians by religion. Over 90% of the respondents across the surveyed community are Christians as against the few who practice the African Traditional Religion (ATR) and Islam. There are also shrine venerated in the community like Egbesu (Supreme god), Amaye, Masquerade, Mammy Water, Seibo (forbidden forest), and Opuaduell. The most popular among them is Egbesu (the supreme god of the Ijaw people). The aforementioned deities are mostly associated with festivals celebrated annually with fixed calendar dates while the dates of the other festivals are communicated by the Chief Priest as revealed by the deity. Once the date is revealed, the priest sends the message across to the community.

Resident status of Gelegele-gbene community according to survey analysis shows that significant proportion of the community respondents has spent a greater part of their life in the community. About 47.8% of the respondents have lived in the community their whole lives i.e. since birth, while about 19.6% have spent over 20 years in the community. Another 19.6% spent between 16 and 20 years in the community while 17.4% spent between 11 and 15 years in Gelegele. A further 15.1% have lived in the community for between 1 and 10 years. The implication of this is that most of the respondents are mainly natives of the community who have spent enough time within the immediate environment and as such have a thorough knowledge of the prevailing circumstances of the socio-economic environment with respect to the proposed VTT LNG project.

Survey analysis shows the following occupational distribution: farming 19.6%, fishing 26.2% and trading 13.1%. These make up the primary occupation of the people. Also, 10.6% of the population work as technicians/artisans.

While businessmen and contractors are not represented in the job distribution, unemployment stands at 15.2%. 4.3% of the sampled populations are civil servants, 8.6% are students/apprentice, industrial workers are unrepresented even as others take up 2.3%.

The 15.2% unemployment rate shows that employment issues are of serious concern in the host community of VTT LNG project.

Common and most frequent diseases include malaria, whooping cough, pneumonia, fever, typhoid, diarrhoea, and rheumatism. Measles, fever, sexually transmitted diseases, cholera, skin rashes and stomach ache occur occasionally. These diseases have been prevalent in the communities for the past six years. The community members attribute the cause of these diseases to the pollution of air and water, from oil development projects in the area (oil and gas exploration and exploitation). Health status of the indigenes of host and impact communities are satisfactory.

The focus group discussion revealed that the host community of the proposed VTT LNG project is made up of peace-loving people and they are not in any way opposed to the proposed project. They are friendly and are ready to welcome and work harmoniously with VTT LNG, the project proponent. They also have been yearning for development and see the proposed gas project and its subsequent operation as a real opportunity which they believe will attract more development to the area.

However, the various groups in the community like the elderly group, women group and youth group have numerous expectations numerous but prominent among them, in particular order, are:

1) Creating of employment opportunities
2) Construction of internal roads
3) Construction of landing jetty
4) Cottage hospital
5) Scholarship awards for the children and ward from secondary school to tertiary institutions

Other notable demands in no particular are:

- Skill acquisition/human capital development centre
- Farming implements e.g. a tractor
- Improved seedlings and fertilizer

The fulfilment of any promises and terms as may be contained in an MoU when entered into is regarded as very vital in improving the company's relations with the host community.

E.S. 5 Associated and Potential Impacts of the Project

The proposed projects will interact with the environment in various ways known as the *"development's aspects"* which could cause change or alteration in the baseline environmental condition, this change is known as *''impact''*. The identified environmental aspects of the proposed development that can cause impacts on the environment include:

Pre-Construction phase activities

- Mobilisation (transport) to site (equipment, personnel and construction modules).
- Energy requirements (provision of energy for pre-construction activities).
- Site Preparation and excavation of land area.
- Labour requirements.

Construction phase activities

- Transportation.
- Excavation.
- Piling.
- Construction of interconnecting spurline.
- Platform construction.
- Site fabrication (welding) and coating.
- Radiographic testing and Pressure testing.
- Backfilling.
- Interconnecting Pipeline commissioning.
- Demobilization

The operational phase activities are

- Liquified Natural Gas Plant Operations/ maintenance (normal)
- Liquified Natural Gas Plant Operations/maintenance (abnormal)

The decommissioning activities include

- Dismantling of the entire plant

- Removal of interconnecting pipeline, storage tanks, gantry equipment e.t.c, for relocation or sale

The overall intent of the ESIA study is to identify and characterizes all the associated and environmental impacts or effects that will be caused by **VTT LNG West Africa Limited's** proposed LNG project in Gilli-Gilli Field, Edo State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

Based on the method adopted, impacts ranging from low to severe significance were identified, qualified and quantified. Among the impacts that have high significance ranking include:

a) Injury and trapped impact to personnel from heavy lifting during construction
b) air pollution and climate change potential arising from gas flaring, venting and fugitive emissions arising from gas process operations
c) surface water contamination from wastewater and effluent discharges
d) explosion and fire from routine activities and accidental occurrences
e) workers' ill health from release of VOCs, H_2S and other chemically dangerous substances
f) noise pollution from process equipment
g) land and water pollution from potential oil spill incidents
h) toxic air condition within nearby communities from release of benzene from the facility
i) Traffic and transport impact from loading of finished products

E.S.6 Mitigation Measures

The actions and measures that **VTT LNG West Africa Limited** intends to take to reduce (or eliminate) negative impacts and promote positive environmental, social and health impacts of the proposed project are therefore presented in this chapter. In this mitigation measures, emphasis are placed on those negative impacts rated as significantly medium and high. These measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of the Health, Safety and Environment (HSE) policies put in place during the different phases of the project

Summary of Residual Impacts after Mitigation

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the mitigation measure implemented.

Overall, on balance, with the provision of the proposed mitigation measures outlined, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project.

Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

An overall mitigation measure is to undertake a Job Hazard Analysis, to enable each worker assess the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management for the project shall be carried out in line with **VTT LNG West Africa Limited** waste management policy and guidelines, as well as international best practices.

VTT LNG West Africa Limited shall take all practical and cost-effective measures to minimise the generation of wastes, by employing the four Rs (Reduce, Reuse, Recycle, and Recovery) through process of optimisation or redesign, efficient procedures and good housekeeping.

Waste shall be managed in the following ways:

- Inventorisation
- Classification

- Segregation
- Wastes quantification
- Wastes tracking; and
- Wastes disposal

E.S.7 Environmental and Social Management Plan (ESMP)

The ESMP shall be employed as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.

Environmental management activities of the proposed VTT LNG West Africa Limited project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

Management Commitments and Responsibility

The Management commitment and responsibility of VTT LNG West Africa Limited are detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of VTT LNG West Africa Limited states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of VTT LNG West Africa Limited contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of VTT LNG West Africa Limited host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;

- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve VTT LNG West Africa Limited's assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;
- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate VTT LNG West Africa Limited's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the VTT LNG West Africa Limited's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and
- adequately resource health, safety and environment functions throughout the business.

E.S.8 Site Decommissioning and Abandonment

Projects are usually designed with an expected lifespan and so, no matter how long the design life, all projects eventually close out. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. The longevity of any development project is primarily dependent on a number of factors including:

- Availability of equipment and the servicing parts
- Durability of equipment and machinery
- Profitability of the project
- Usefulness and acceptability of end-product

The gas plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. **VTT LNG West Africa Limited** would need to decommission the entire system when this situation arises. While this is not expected to occur within the **next thirty years**, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

E.S.9 Conclusion

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and ESMP that has been presented in earlier sections of this ESIA, it is therefore concluded that:

- The technology, equipment and facilities that is proposed to be employed in the proposed project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria;

- The comprehensive effluent and waste water treatment plants incorporated into the design of the Gas Plant system will ensure the complete treatment of effluent to regulatory requirements before discharging into the nearby stream or river.

- Apart from the buffer zone that shall be created in between the Gas Turbines and the other buildings, the engine rooms shall be adequately sound proofed to reduce noise in the office environment.

- The project will be attended with a number of positive impacts such as employment opportunities, increased power and gas supply and utilization, reduced cost of production, increase in income etc.

- A number of negative impacts have also been identified to be associated with the projects. Such impacts include, potential pollution of ambient air, water and soil, soil erosion, increase in noise, pressure on limited infrastructures, potential proliferation of STDs, potential etc. However, the mitigation measures recommended for this project if judiciously implemented will reduce some of the significant negative impacts to minor and negligible.

- The project will ensure more efficient utilization of natural gas, much of which is currently flared. Consequently, leading to reduction in health and environmental challenges associated with gas flaring.

- The ultimate success of this project and full actualization of improved power and gas supply to stakeholders around the project area and Nigeria in general is partly dependent on the desire to protect the power and gas supply facilities from possible vandals.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

VTT LNG West Africa Limited, a natural gas production and distribution Company located in Lagos State, wishes to carry Environmental Social Impact Assessment (ESIA) study for the development and operation of the Proposed Gas Processing Facility in Gilli-Gilli Field, OML 96, Edo State in Nigeria.

The gas development shall consist of VTT Gas Processing Facility with an LNG Plant (herein referred to as project) that will process and liquefy natural gas from the Dubri field which will contribute to the reduction of gas flaring and transported via virtual pipelines to support power plants that are off grid. Consequently, the gas processing facility shall be designed to achieve a maximum processing potential of gas from the Dubri flow station.

In compliance with the requirements of the *Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004* of Federal Ministry of Environment (FMEnv) and *Part VIII.A Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002 revised in 2018)* of Department of Petroleum Resources (DPR), as well as complying with the company's Environment, Health, safety and Security policies, VTT LNG West Africa Limited through her consultant, Afruitful Environment Limited (AFEL) accredited by Department of Petroleum Resources (DPR), Federal Ministry of Environment (FMEnv) and National Environmental Standards and Regulations Enforcement Agency (NESREA), wishes to carry out an Environmental and Social Impact Assessment of the proposed Gas Processing Facility with an LNG Plant. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts

1.2 Project Location

The proposed facility is situated on coordinate of 5.35732N and 6.15518E in Gilli-Gilli Field, Ovia North East Local Government Area of Edo State, Nigeria (see admin maps in Figures 1.1 to 1.3). Situated about 45km southwest of Benin City, the field covers an area 221 sq. km.

The field is situated within the low-lying freshwater forest of Edo state. The natural vegetation is in different stage of disturbances. The topography is a low lying and relatively flat terrain drained by the Osse River. The rainfall pattern in the area determines the two characteristic seasons in the year, the wet and dry seasons. Rainfall occurs throughout the year with its peak in July and September, while the drier periods of the year are from November to February. Within the field, there are cultivated farmlands and forests.

Gilli Gilli Community (Gelegele-gbene) is an ancient Olodiama Ijaw speaking Community founded by PA OLUGBO IKPITI several centuries ago. It is surrounded by other Ijaw communities in Olodiama clan, which are Ikoro, Inikorogha, Iboro, Igbeleuba, Kusangha {Ekenwan} with Ikoro as the Traditional head quarters. Gelegele is a border community between Bini communities and Ijaw communities on one hand and also is a boundary community of Olodiama clan and Egbema clan of Delta and Edo states. Some of the Bini communities near and around Gelegele are UGHOTON, IKPAKO, EGBETAN, ODUNA and UGBINE etc.

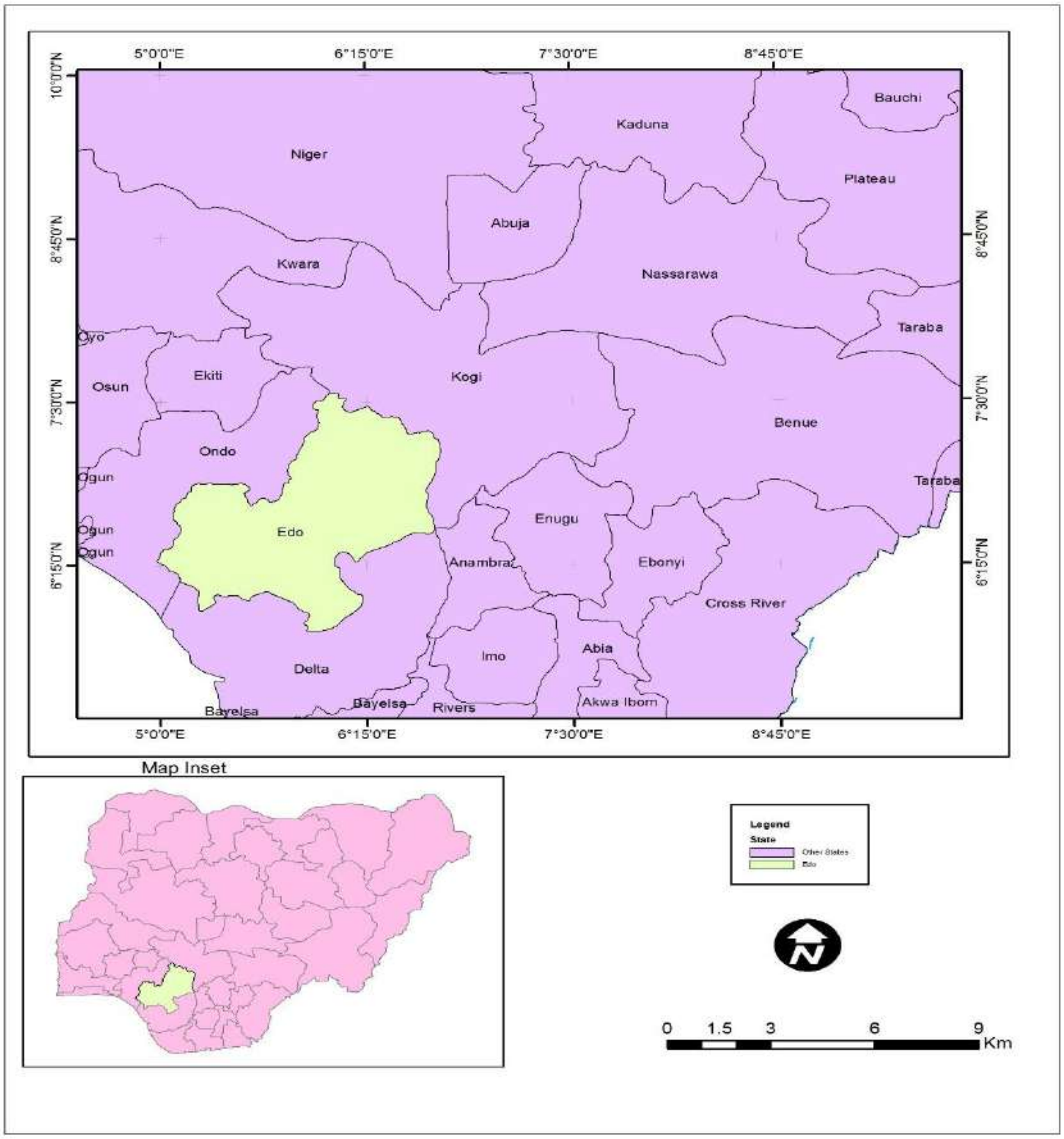

Figure 1.1: Map of Nigeria showing Edo State

Source: VTT LNG West Africa, 2019

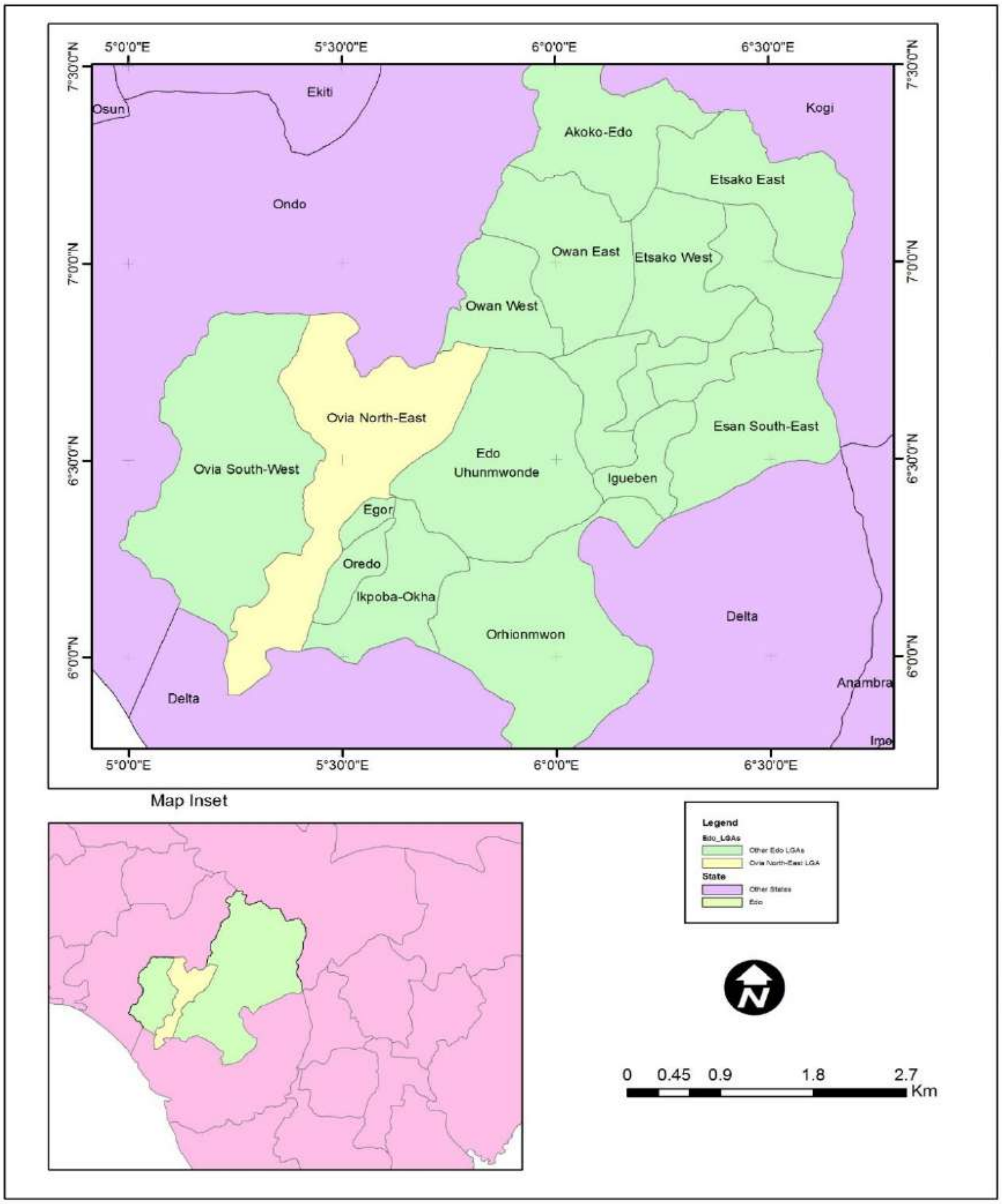

Figure 1.2: Administrative Map of Edo State showing Ovia North East LGA, Edo State, Nigeria, ***Source: VTT LNG West Africa, 2019***

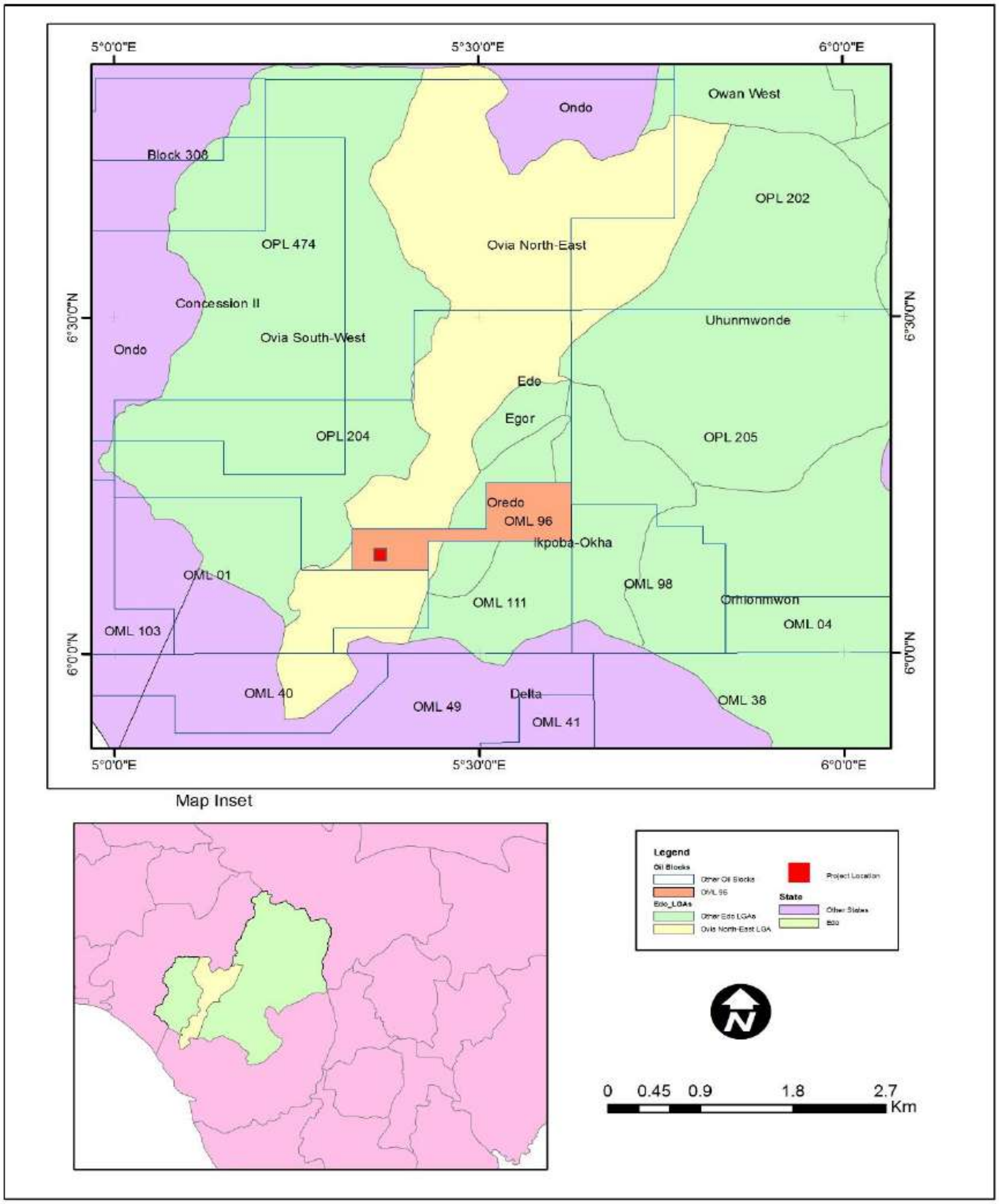

Figure 1.3: Administrative Map of Ovia NE LGA showing the Project Location within OML 96 ***Source: VTT LNG West Africa, 2019***

1.3 Objectives of the ESIA

The aim of the ESIA is to proactively evaluate the types and extents of potentially significant and adverse environmental impacts that may arise from the modular gas processing/LNG plant. The study therefore will:

- Determine the baseline (biophysical, social and health) conditions of proposed project environment;
- Assess the potential impacts of the planned development on biophysical, social and health components of the environment;
- Determine and document the sources of impact from the proposed development/project activities and identify the environmental, social and health components of the environment that can be potentially impacted;
- Identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural heritages, properties, social infrastructures and natural resources;
- Proffer appropriate mitigation measures for negative impacts and make recommendations aimed at sustaining the beneficial impacts of the projects on the environment;
- Aid early selection of best available techniques (including technology and method of operation) that can help in realizing the project environmental objectives;
- Develop and establish an appropriate Environmental and Social Management Plan (ESMP) as well as provide recommendations for monitoring and mitigation activities.

ESIA Scope

The ESIA scope of work include:

- Review of national and international environmental regulations, standards, codes and conventions relevant to the proposed project activities;
- Establish the baseline environmental condition of the project area through literature research;
- Laboratory analysis of samples collected during the field sampling/survey;
- Impact identification, prediction, interpretation and evaluation;
- Development of cost-effective mitigation measures, monitoring programmes and Environmental and Social Management Plan (ESMP) covering the project life span; and
- Preparation of detailed report to meet FMEnv and DPR permitting requirements.

1.4 ESIA Methodology

The EIA was carried out in line with procedures provided in the *EGASPIN (2002)* as summarized below:

i. Preliminary Activities

The EIA preliminary activities carried out include:

- Project scoping;
- Preparation of an environmental screening report for VTT project conceptual alternatives; and
- Site verification by officials of FMEnv.

ii. Desktop/Literature Survey

Literature survey, which involves consultation/desktop review of previous studies in the project area, was carried out for initial unravelling of local and regional environmental baseline condition of the project area. The information gathered from the literature review was used to compliment the results of actual field samplings.

iii. Stakeholders' Consultation

Consultation was instituted through the entire ESIA process. This involved information dissemination to and interaction/dialogues with stakeholders in the project to intimate them with the project and associated impacts, address their concerns, solicit their support and document their expectations on relevant environmental, social and health issues. The stakeholders consulted include:

- Federal Ministry of Environment (FMEnv)
- Department of Petroleum Resources (DPR);
- Delta State Ministry of Environment; and
- Stakeholder communities.

iv. Field Sampling and Laboratory Analysis

Field sampling was carried out to gather primary environmental and socio-economic data. The data collected were used to characterize the environment and establish the baseline condition of the proposed project area. Samples were subsequently analyzed at Jacio Environmental and Laboratory Services Limited, Warri. Jacio Environmental and Laboratory Services Limited is accredited by FMEnv and DPR. The following components of the environment were studied:

- ***Climate and Meteorology***

Description of regional climatic conditions including ten-year meteorological records on ambient temperature, rainfall, sunshine, wind speed, wind direction, seasonal variations and extremes were carried out and presented.

- ***Air Quality and Noise***

The up and down-wind in and around the study area was analysed for air quality. Parameters analysed include: Volatile Organic Compounds (VOCs), Nitrogen II Oxide (NO_2), Nitrogen (I) Oxide (NO), Sulphur IV Oxide (SO_2), Ammonia (NH_3), Methane (CH_4), Carbon Monoxide (CO), Hydrogen Sulphide (H_2S), Suspended Particulate Matters (SPM), and ambient Noise level. The values obtained in the study area were compared with statutory limits provided by FMEnv and DPR.

- ***Sediment and Benthic Investigation***

The samples of sediment collected from the surface water bodies were analysed for physico-chemical composition, heavy metals, hydrocarbons and microbial compositions. The benthic macro organisms were also studied.

- ***Surface Water Samples***

The surface water samples were collected, preserved and analysed for physico-chemical composition, heavy metals, hydrocarbons and microbial compositions.

- ***Hydrobiology***

The surface water plankton study was carried out to determine the abundance of organisms and their species composition.

- ***Ecological Studies***

The review of micro and macro benthic organism's species, diversity, abundance, occurrence frequency was carried out. A study of vegetation and wildlife composition of the study area was carried out via sampling, in situ observation and tissue analysis.

- ***Social/Health Impact Studies***

The socioeconomic and health status of the area was reviewed against the following:

- Description of settlements and man-made features
- Description of economic and historical sites
- Description of population distribution
- Description of income distribution
- Description of recreational facilities
- Description of social organizations and institutions
- Description of occupation and employment structure
- Description of cultural and religious practices
- Description of stakeholder community health status and facilities
- Description of community health needs and concerns of stakeholder communities

- Description of community structure, employment markets and labour supply, income distribution and consumption.
- Determination of the views of the affected populations through discussion with local communities.
- Determine the effects of crude oil exploration/production activities on cultural heritage/artifacts, and other historical/cultural patrimony of the affected communities.

v. Impact Identification

The potential and cumulative adverse and beneficial impacts of the project activities on the environment were identified by considering the interactions of the environmental aspects at the different phases of the project. The *EGASPIN, 2002 [Revised in 2018]*, and the conceptual engineering project description among other source references, were used in the process. Evaluation of the identified impacts were carried out using such criteria as legal/regulatory requirements in respect of the current activities, magnitude of impacts, risk posed by impacts, public perception and importance of affected environmental component. The results are documented in chapter five of this report.

vi. Impact Mitigation and Environmental and Social Management Plan

Mitigation measures were proffered for identified associated and potential impacts. In proffering mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the project, professional judgment (based on scientific deductions) project experience, knowledge of the ecosystem in which the project is located and consensus of opinions among experts were used as tools. Other resource materials consulted include the Federal Ministry of Environment (FMEnv) EIA Guidelines and the World Bank Environmental Source Book, EGASPIN (Revised 2002 and 2018) etc.

In addition, measures were proffered to enhance/optimize beneficial impacts of the project. Chapter six of this report documents the mitigation measures prescribed for identified significant impacts of the project (both adverse and beneficial). To ensure sustainable implementation of the mitigation measure recommended, an Environmental and Social Management Plan (ESMP) was also developed for the project, applicable for the project life span.

vii. Reporting and Review

The findings of the study are documented in this Report. The final version of the report shall be issued following regulators/stakeholders review meeting. The review shall address the stakeholders' concerns and incorporate any comments arising from the review meeting as shall be directed by FMenv. Also, in order to allow for on-going improvement of operational practices if those initially established prove inadequate, post auditing or monitoring has been designed into the Environmental and Social Management Plan (ESMP) developed for the project. The ESMP shall also enable a rapid rescue/response if an unforeseen social or environmental impact occurs from the proposed project.

1.5 Legal and Regulatory Framework

The project is affected by a number of federal, state and international legislation which have been considered. A review of relevant legislation was done and presented in this section.

1.5.1 National Legislation

➢ **National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)**

Nigeria enunciated a National Policy on the Environment to achieve sustainable development in Nigeria, and in particular to:

- Secure a quality of environment adequate for good health and well-being;
- Conserve and use the environment and natural resources for the benefit of present and future generations;
- Restore, maintain, and enhance the ecosystem and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
- Raise public awareness and promote understanding of the essential linkages between the environment, resources, and development, and encourage individual and community participation on environmental improvement efforts; and
- Co-operate in good faith with other countries' international organizations and agencies to achieve optimal use of Trans-boundary natural resources and effective prevention or abatement of Trans-boundary environmental degradation (Article 2.0).

➢ **National Gas Policy, 2017**

On Wednesday, June 28, 2017, the Federal Executive Council (FEC) at its monthly meeting approved the National Gas Policy, 2017 ("NGP"). The NGP, which was first released through the Ministry of Petroleum Resources ("MPR"), as a Consultation Draft in October

2016, is based on a fundamental review of the policy positions of the Government over the last ten (10) years in respect of Nigeria's gas resources.

Fundamentally, the NGP sets the goals, strategies and an implementation plan for establishing a framework that will drive the institutional, legal, regulatory and commercial reforms necessary for attracting investment into the gas sector. Key components of the NGP are highlighted hereunder:

Strategic Objectives of the NGP

The NGP envisions Nigeria as an attractive gas-based industrial nation, focused on satisfying local gas demand requirements, and developing a significant presence in international markets. The Policy aims to define and set the framework necessary to move Nigeria from being a crude oil export-based economy to becoming an attractive, oil and gas-based industrial economy.

The strategic objectives of the NGP include the following:

- ✓ Separation of the roles and responsibilities of government and the private sector, as it relates to the gas sector;
- ✓ Implementation of full legal separation of the upstream from the midstream;
- ✓ Implementation of full legal separation of gas infrastructure ownership and operations from gas trading;
- ✓ Establishment of a single independent petroleum regulatory authority;
- ✓ Optimisation of Liquefied Natural Gas ("LNG") international downstream value;
- ✓ Pursuit of a project-based approach rather than a centrally-planned model for domestic gas development;
- ✓ Identification of new gas resources from the Niger Delta, offshore, inland basins and at the same time, aiming to achieve a reduction in gas flaring;
- ✓ Creation of a conducive environment for investors through the introduction of an appropriate institutional, legal, regulatory and commercial framework for the gas sector;
- ✓ Establishment of strong linkages of the gas sector with the electric power, agriculture, transport and industrial sectors;

- ✓ Ensuring compliance with the requirements of the Nigerian Content Act.

The Gas Value Chain

The NGP separates and segments the gas value chain, for the following reasons:

- ✓ Separate fiscal treatment (extensively dealt with in the complementary Petroleum Fiscal Policy), as well as providing a basis for ending the practice of consolidating midstream costs and using same to offset upstream tax liabilities;
- ✓ Enabling market entry and access for new entrants and investors;
- ✓ Providing a level playing field between existing industry players and new entrants; and
- ✓ Ensuring clarity in the regulation of the midstream sector.

Goals of the NGP

- ✓ The strategic objectives of the NGP are described under broad heads to wit; Governance (establishment of requisite legal, regulatory and institutional framework);
- ✓ Industry Structure (provisions in respect of the roles of government-owned corporations, export gas ownership and tolling arrangements, wholesale domestic market, separation of transport and trading, domestic gas supply obligations ("DSO"), review of the gas aggregation policy ("GAP");
- ✓ Development of Gas Resources (including gas flare-out, gas field development & resource management plans); Infrastructure (development of a gas infrastructure blueprint & strategy necessary for the improvement of the whole supply chain);
- ✓ Building Gas Markets (strategies for financing and developing gas markets, LNG, Liquefied Petroleum Gas ("LPG") and pipeline projects domestically, regionally and internationally);
- ✓ Developing National Human Resources (for achieving local content and building in-country capacity); Communications (specifying models for internal & external communication within the MPR and government entities as well as consultations with industry stakeholders; necessary to properly explain the policy and changing

attitudes); and a Roadmap and Action Plan (setting timeline for the gas policy roadmap).

- ***Petroleum Act 1969***

Pollution control regulations in oil and gas operations are governed by the Principal legislation of Petroleum Act 1969. The regulations are made pursuant to section 8(i) b (iii) of the Petroleum Act 1969 that empowers the Minister of Petroleum Resources to make regulations for the prevention of pollution of water courses and the atmosphere. Some of the specific regulations include:

i. the Petroleum (Drilling and Production) Regulations 1969, Sections 25 and 36;
ii. the Mineral Oils (Safety) Regulation, 1963, Part III Section 7 and Part IV Sections 44 and 45;
iii. the Petroleum Regulations 1967; the Oil in Navigable Waters Decree NO.34/Regulations 1968;
iv. the Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipeline Act 1965, Section 17(3);
v. the Petroleum Refining Regulations 1974, Section 43;
vi. the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002, 2018 Revision)

The primary objective of the foregoing guidelines and standards is to regulate the environmental management practices in the production and discharge of produced formation waters, oily waste water, sludge and accidental spills of oils from oil and gas production installations within the territory and territorial waters of the Federal Republic of Nigeria.

- ***Environmental Impact Assessment (EIA) Act CAP E12, LFN 2004***

The EIA institutional framework is provided by *Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004*. Environmental Impact Assessment (EIA) is an assessment of the potential impacts whether positive or negative, of a proposed project on the natural environment. The E.I.A Act, as it is informally called, deals with the considerations of environmental impact in respect of public and private projects. Sections relevant to environmental emergency prevention under the EIA include:-

- Section 2 (1) requires an assessment of public or private projects likely to have a significant (negative) impact on the environment.
- Section 2 (4) requires an application in writing to the Agency before embarking on projects for their environmental assessment to determine approval.
- Section 13 establishes cases where an EIA is required and
- Section 60 creates a legal liability for contravention of any provision.

➢ ***Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002 and 2018).***

Part VIII A made preparation of EIA report mandatory for development activities. The EGASPIN is administered by Department of Petroleum Resources (DPR).

➢ ***Associated Gas Re-Injection Act, CAP 20, LFN 2004.***

The Associated Gas Re-Injection Act deals with the gas flaring activities of oil and gas companies in Nigeria. The following sections are relevant to pollution prevention: -

- Section 3 (1) prohibits, without lawful permission, any oil and gas company from flaring gas in Nigeria.
- Section 4 stipulates the penalty for breach of permit conditions.

➢ ***Petroleum Products and Distribution Act, CAP P12, LFN 2004***

Under Petroleum Products and Distribution Act, CAP P12, LFN 2004, the offence of sabotage which could result in environmental pollution is punishable with a death sentence or an imprisonment term not exceeding 21 years.

➢ ***National Environmental Protection (Effluent Limitations) Regulations, S.I.8 of 1991***

Official Gazette, Federal Republic of Nigeria No. 42, Vol.78, August 1991, which requires installation of anti-pollution equipment for detoxification of effluents and chemical discharges from the company's existing facilities.

- ***National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991*** Official Gazette, Federal Republic of Nigeria No. 42, Vol. 78, August 1991, which imposes restrictions on the release of hazardous or toxic substances into the air, water and land into Nigeria's ecosystems beyond the limits approved by FEPA.

- ***National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991*****:** Official Gazette, Federal Republic of Nigeria, No. 102, Vol. 78, 31st December, 1991; describes the requirements for Groundwater protection, surface impoundment, land treatment, waste piles, landfill, incinerators, etc.

- ***Land Use Act L5 LFN 2004***

The Land Use Act L5 LFN of 2004 protects the rights of all Nigerians to use and enjoy land in Nigeria which must be protected and preserved. Land acquisition must follow all the due process of law.

- ***Forestry Law CAP 55, 1994***

This Act provides for the preservation of forests and the setting up of forest reserves.

- Prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property in Nigeria.
- Prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria.

- ***Endangered Species Act (Cap 108), 1990***

The Endangered Species Act (Control of International Trade and Traffic) Cap.108 Law of Nigeria, 1990 prohibits the hunting, capture and trade of endangered species.

- ***Criminal Code***

The Nigerian Criminal Code makes it an offence punishable with up to 6-months 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 carry 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.

➢ ***Labour Act, 1999***

Nigeria has ratified all eight core International Labour Organization Conventions. The Labour Act (1999) is the primary law protecting the employment rights of individual workers. The Act covers protection of wages; contracts; employment terms and conditions; recruitment; and classifies workers and special worker types.

➢ ***Land Use Rights Act No. 6, 1978***

The Land Use Act No. 6 was enacted in 1978. The Act vests all land in the urban areas of each state under the control and management of the governor of the state. The governor of the state holds the land in trust for the people of the state and is solely responsible for the allocation of land in all urban areas to individuals who reside in the state and to organizations for residential, agricultural and commercial purposes. All other land in the state subject to conditions under the Land Use Act is under the control and management of the local government. The Act divests traditional owners of land and vests such land in the state governor for the benefit and use of all Nigerians. It provides the processes through which land maybe acquired by the federal government.

1.5.2. Edo State Legislation

➢ **Edo State Ministry of Environment and Public Utility**

The Edo State Government recently passed into Law the Environmental Guidelines for the Management and Protection of the Environment within the State. The custodian of this law is the Edo State Ministry of Environment and Public Utility. Section (8) of the law identifies the following as prohibitive activities.

- Carry on or run any manufacturing operation or business in any premises within the State except such waste generated in the process of such manufacturing operation or business is treated or purified to the satisfactory standards approved by the Ministry before discharge into the environment;

- Discharge or cause to be discharged, raw, untreated human waste into any public drain, water-course, gorge, storm water or into any land within the state;
- Discharge or cause to be discharged any form of oil, grease, spent oil including trade waste brought about in the course of any manufacturing operation or business into any public drain under course, water gorge and road verge;
- Discharge into the air any inadequately filtered and purified gaseous waste and this includes gas flaring from oil exploration;
- Burn, dump or bury or cause to be burnt, dumped or buried refuse of any type, bush, weeds, grass, tyres, cables, or waste of any description without a written permission from the Ministry.

Environmental Protection and Waste Management Agency Law

Environmental Protection and Waste Management Agency Law No. 8 of 2000 states that::

- No person shall discharge any form of oil, grease or spent oil produced in the course of any manufacturing operation or other type of business into any public drain, watercourse, water gorge or road verge. Any such waste which is to be discharged by the person generating it shall have been certified as having complied with set-down and approved standards by the Agency;

- No person shall discharge into the air inadequately filtered and purified industrial gaseous waste containing substances injurious to life and property, such as sulphur dioxide, oxides of nitrogen, hydrogen fluoride, sulphide, carbon monoxide, ammonia, chlorine, smoke and metallic dust, particulate and other injurious gases;

- No person shall dump or burn or cause or allow to be buried or dumped in any land or water any toxic, hazardous substance or harmful waste
  - No person shall establish petrol stations, gas plants or other petroleum related activities without adherence to approved environmental standards; and no

person shall engage in any form of petroleum exploration or production activities.

- **Edo State Ministry of Lands and Survey**

The Land Use Act of 1978 transferred authority over land from customary oversight into the control and management of State Governors. The Edo State Ministry of Lands and Survey is the authority that oversees land matters in Edo State.

- **Edo State Waste Management Board**

The Edo State Waste Management Board (EDSWMB) is an agency under the direct supervision of the Edo State Ministry of Environment and Public Utilities (EDSMEPU). The Board's functions include the collection, transport, processing, recycling or disposal and monitoring of waste materials. This includes solid, liquid and gaseous substances. Other responsibilities include the development of guidelines, standards and regulations for pollution control and waste management as well as inspection and compliance monitoring of industrial facilities.

- **Edo State Industrial Policy**

The current policy of the Edo State Government is to create an enabling environment for private entrepreneurship to thrive. In turn, this policy mirrors the recent political and trade liberalisation programmes at the Federal level. The State has the capacity to support major manufacturing and service industries such as power supply (Edo State Government, 2010). It helps to facilitate the establishment of industrial estates by allocating plots of land to private investors.

1.5.3. International Conventions Ratified by Nigeria

The proposed development will have impacts on local as wells as regional environment. The regional impact could result from emission of greenhouse gases (GHGs) via gas flaring which could have effect on global climate change. Therefore, the ESIA considered relevant international Conventions, Agreements and Protocols on climate change and other pertinent environmental issues relevant to Nigeria.

VTT LNG West Africa Limited committed to its environmental management by complying with relevant international legislation covering various environmental effects arising from the operation of VTT LNG West Africa Limited facilities, including noise, gaseous emission, particulate, liquid effluent and solid waste.

- **Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, 1989 (Nigeria signed the Basel Convention document on 15th march, 1990 and ratified it on 13th march, 1991. Nigeria also ratified the amendment to the Basel Convention on 24th may, 2004)**

The convention focuses attention on the hazards of the generation and disposal of hazardous wastes. The convention defines the wastes to the regulated and controls their trans-boundary movement to protect human and environmental health against their adverse effects. Some highlights of the convention include:

- The generator of hazardous waste should carry out duties with regard to the transport and disposal of such generated waste in a manner that is consistent with the protection of the environment, whatever the place of disposal,
- All should recognize that any State has the sovereign right to ban the entry or disposal of foreign hazardous wastes and other wastes in its territory,
- It should be recognized also that there is an increasing desire for the prohibition of trans boundary movements of hazardous wastes and their disposal in other States, especially developing countries,
- Hazardous wastes and other wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated,
- Trans boundary movements of such wastes from the State of their generation to any other State should be permitted only when conducted under conditions which do not endanger human health and the environment, and under conditions in conformity with the provisions of this Convention,

- Control of trans boundary movement of hazardous wastes and other wastes will act as an incentive for their environmentally sound management and for the reduction of the volume of such trans boundary movement,
- States should take measures for the proper exchange of information on and control of the trans boundary movement of hazardous wastes and other wastes from and to those States,

➢ **UNFCCC, Paris agreement of 2016 [The agreement was signed on 22 September, 2016 and ratified by Nigeria on 16th May, 2017]**

The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework

➢ **Agenda 21 – United Nations Conference on Environment and Development**– also called the **Earth Summit [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

Held in Rio de Janeiro, Brazil (1992), with recommendations from the WHO Commission, more than 150-member states adopted ***Agenda 21*** – an action plan to guide future strategies for health and environment activities on a national and international level which in fact provided the background for FEPA's EIA framework to ensure environmental sustainability of all types of activities in the oil and gas industry (FEPA, 1995).

- **United Nations Guiding Principles on the Human Environment [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

The United Nations (UN) published the concept of Guiding Principles on the Human Environment in 1972. 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 Rio Declaration on Environment and Development [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

The UN Conference on Environment and Development met at Rio de Janeiro in June 1992, at which time it reaffirmed the 1972 declaration on the Human Environment, and sought to build upon it. This was done with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among states, key sectors of societies and people. It was also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental development system, and recognize the integral and interdependent nature of the earth.

- **Polluters Pays Principle (Adopted by Nigeria in 1999)**

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organisation for Economic Co-operation and Development (OECD) and European Community (EC) countries.

The polluter pays principle underpins environmental policy such as an ecotax, which, if enacted by government, deters and essentially reduces greenhouse gas emissions. Some eco-taxes underpinned by the polluter pays principle include: the Gas Guzzler Tax, in US, Corporate Average Fuel Economy (CAFE) - a "polluter pays" fine. The U.S. Superfund law requires polluters to pay for clean-up of hazardous waste sites, when the polluters can be identified.

Polluter pays is also known as extended producer responsibility (EPR). This is a concept that was probably first described by Thomas Lindhqvist for the Swedish government in 1990. EPR seeks to shift the responsibility dealing with waste from governments (and thus, taxpayers and society at large) to the entities producing it. In effect, it internalised the cost of waste disposal into the cost of the product, theoretically meaning that the producers will improve the waste profile of their products, thus decreasing waste and increasing possibilities for reuse and recycling.

- ***Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)***

The Fund Convention was adopted to provide additional compensation for victims of oil pollution and to transfer some of the economic consequences to the owner of the oil cargo as well as the ship owner. Compensation payable under the Fund is limited to 450 million francs per incident and an aggregate of 450 million francs for pollution damage resulting from a natural phenomenon of an exceptional, inevitable, and irresistible character.

- ***United Nations Framework Convention on Climate Change (1992)***

The convention on climate change was signed in 1992 during the Earth summit in Rio de Janeiro. Its implementation did not come into force till 1994. In this declaration, developed countries and economies in transition were mandated to limit their emissions of greenhouse gases which cause global warming. However, no mandatory emission/restrictions were placed on developing countries. This is now being reviewed including binding higher emission reduction by developed countries.

- ***World Bank Guidelines on Environmental Assessment***

The World Bank requires an Environmental Impact Assessment (EIA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable in order to improve decision making. Additionally, the policy specifies that the Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EIA. The Bank classifies projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. Details of World Banks EIA procedures and guidelines are published in the banks EA Source Books Vols. i – iii of 1991. Potential issues considered for EIA in the oil and gas industry include:

- Biological Diversity
- Coastal and Marine Resource Management
- Hazardous and Toxic Materials
- Cultural Properties
- International Waterways

World Bank Operational and Safeguard Policies

The World Bank is committed to a number of operational and safeguard policies which aim to prevent and mitigate undue harm to people and their environment in any development initiative involving the bank. These policies provide guidelines for bank and borrower staff in the identification, preparation, and implementation of programs and projects. There are ten World Bank Environmental/Safeguard Policies. As discussed below not all these policies are triggered by the mini LNG Plant development.

The World Bank policies that have been triggered by the proposed mini LNG Plant project are:

- **Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (last updated February 2011)**.

  This is the umbrella policy for the Bank's environmental 'safeguard policies' which among others include: Natural Habitats (OP 4.04), Forests (OP 4.36) and Physical Cultural Resources (OP 4.11).
- **Operational Policy/Bank Procedure 4.04** - ***Natural Habitat*** - seeks to ensure that World Bank-supported infrastructure and other development projects take into

account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society.

- **Operational Policy/Bank Procedure 4.36 - *Forests.*** This policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.
- **Operational Policy 4.09 - *Pest Management* -** policy recognizes that pesticides can be persistent and harmful to the environment for a long time. If pesticides must be used, the policy requires that Pest Management Plan (PMP) be prepared by the borrower, either as a stand-alone document or as part of an Environmental Assessment.
- **Operational Policy /Bank Procedure 4.11 - *Physical Cultural Resources*** seeks to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

The Bank requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus improve decision making.

Such EA are carried out by the borrower to evaluate a project's potential environmental risks and impacts in its area of influence. The EA process analyzes project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts; and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. The Bank favours preventive measures over mitigatory or compensatory measures, whenever feasible.

EA looks at the interaction of the project with the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and where applicable, trans-boundary and global environmental aspects.

The World Bank has also issued a *Pollution Prevention and Abatement Handbook (1998)* which describes pollution prevention and abatement measures and emission levels that are normally acceptable to the Bank.

However, taking into account borrower country's legislation and local conditions, the Bank works with alternative emission levels and approaches to pollution prevention and abatement for projects. The EA report must provide full and detailed justification for the levels and approaches chosen for the particular project or site.

- **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 the 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 most relevant to the proposed project are summarized below.

- ***Principle Two***

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 Four***

Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperiled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.

- ***Principle Six***

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 of all countries against pollution should be supported.

- **International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990**

Parties to the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents.

- **Nagoya Protocol of 2010 (Ratified by Nigeria in 12 October 2014)**

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, also known as the Nagoya Protocol on Access and Benefit Sharing (ABS) is a 2010 supplementary agreement to the 1992 Convention on Biological Diversity (CBD). Its aim is the implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity. However, there are concerns that the added bureaucracy and legislation will, overall, be damaging to the monitoring and collection of biodiversity, to conservation, to the international response to infectious diseases, and to research.

- **Kyoto Protocol of 2004 (Ratified by Nigeria on 5th November, 2004)**

The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) it is extremely likely that human-made CO_2 emissions have predominantly caused it. The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005. There are currently 192 parties (Canada withdrew from the protocol, effective December 2012) to the Protocol.

The Kyoto Protocol implemented the objective of the UNFCCC to reduce the onset of global warming by reducing greenhouse gas concentrations in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2). The Kyoto Protocol applies to the six greenhouse gases listed in Annex A: Carbon dioxide (CO2), Methane (CH4), Nitrous oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6).

The Protocol is based on the principle of common but differentiated responsibilities: it acknowledges that individual countries have different capabilities in combating climate change, owing to economic development, and therefore puts the obligation to reduce current emissions on developed countries on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.

- **Stockholm Convention Against Persistent Organic Pollutants of 2004 (Signed on 23/05/2001, ratified by Nigeria on 24/05/2004 and came to force on 22/08/2004)**

Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). In 1995, the Governing Council of the United Nations Environment Programme (UNEP) called for global action to be taken on POPs, which it defined as “chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment".

Following this, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Program on Chemical Safety (IPCS) prepared an assessment of the 12 worst offenders, known as the *dirty dozen*. The INC met five times between June 1998 and December 2000 to elaborate the convention, and delegates adopted the Stockholm Convention on POPs at the Conference of the Plenipotentiaries convened from 22–23 May 2001 in Stockholm, Sweden.

The negotiations for the Convention were completed on 23 May 2001 in Stockholm. The convention entered into force on 17 May 2004 with ratification by an initial 128 parties and 151 signatories. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans.

Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and transboundary threat. The first set of new chemicals to be added to the Convention were agreed at a conference in Geneva on 8 May 2009.
As of June 2018, there are 182 parties to the Convention, (181 states and the European Union). Notable non-ratifying states include the United States, Israel, Malaysia, and Italy.
The Stockholm Convention was adopted to EU legislation in REGULATION (EC) No 850/2004.

- **Cartagena Protocol on Bio-safety of 2003 (Singed on May 24, 2000, ratified on Jul 15, 2003 and force into action on Oct 13, 2003)**

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement on biosafety as a supplement to the Convention on Biological Diversity effective since 2003. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology.

The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will for example let countries ban imports of genetically modified organisms if they feel there is not enough scientific evidence that the product is safe and requires exporters to label shipments containing genetically altered commodities such as corn or cotton.

- **Montreal Protocol on Substances that Deplete the Ozone Layer, 1988 (Ratified by Nigeria in 22/09/1988)**

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. It was agreed on 26 August 1987, and entered into force on 26 August 1989, followed by a first meeting in Helsinki, May 1989. Since then, it has undergone eight revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2016 (Kigali, adopted, but not in force). As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

The treaty is structured around several groups of halogenated hydrocarbons that deplete stratospheric ozone. All of the ozone depleting substances controlled by the Montreal Protocol contain either chlorine or bromine (substances containing only fluorine do not harm the ozone layer). Some ozone-depleting substances (ODSs) are not yet controlled by the Montreal Protocol, including nitrous oxide (N2O). For a table of ozone-depleting substances controlled by the Montreal Protocol see. For each group of ODSs, the treaty provides a timetable on which the production of those substances must be shot out and eventually eliminated. This included a 10-year phase-in for developing countries identified in Article 5 of the treaty.

The stated purpose of the treaty is that the signatory states: "Recognizing that worldwide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment. Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it with the ultimate objective of their elimination on the basis of developments in scientific knowledge"

1.5.4 International Best Practices

Other considerations of the ESIA include other international best practices. International institutions provide guidance on best practice for the ESIA process and place emphasis on achieving sustainable environmental, social and health outcomes. They also provide environmental standards and limits for emissions and discharges. A number of key project impact mitigation measures such as resettlement are also specified.

The overall project design and this ESIA will align with international best practices such guidelines published by the International Finance Corporation (IFC) and the World Bank. The following is a summary of the specific international requirements and standards that will be applied to this ESIA. It should be noted that, given the private-sector nature of the development, the IFC Performance Standards described below will be most directly applicable to the project in this case.

➢ **The IFC Performance Standards**

The IFC applies Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in the private sector. The IFC Performance Standards encompass eight topics:

✓ **Environmental and Social Assessment and Management System:** Commercial clients/investees are required to manage the environmental and social performance of their business activity, which should also involve communication between the client/investee, its workers and the local communities directly affected by the business activity. This requires the development of a good management system, appropriate to the size and nature of the business activity, to promote sound and sustainable environmental and social performance as well as lead to improved financial outcomes.

- ✓ **Labour and Working Conditions:** For any business, its workforce is a valuable asset and a sound worker-management relationship is a key component of the overall success of the enterprise. By protecting the basic rights of workers, treating workers fairly and providing them with safe and healthy working conditions, commercial clients/investees can enhance the efficiency and productivity of their operations and strengthen worker commitment and retention.

- ✓ **Pollution Prevention and Abatement:** Increased industrial activity and urbanization often generate increased levels of pollution to air, water and land that may threaten people and the environment at the local, regional and global level. Commercial clients/investees are required to integrate pollution prevention and control technologies and practices (as technically and financially feasible as well as cost-effective) into their business activities.

- ✓ **Community Health, Safety and Security:** Business activities can increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures and releases of hazardous materials as well as impacts on a community's natural resources, exposure to diseases and the use of security personnel. Commercial clients/investees are responsible for avoiding or minimizing the risks and impacts to community health, safety and security that may arise from their business activities.

- ✓ **Land Acquisition and Involuntary Resettlement:** Land acquisition due to the business activities of a commercial client/investees may result in the physical displacement (relocation or loss of shelter) and economic displacement (loss of access to resources necessary for income generation or as means of livelihood) of individuals or communities. Involuntary resettlement occurs when affected individuals or communities do not have the right to refuse land acquisition and are displaced, which may result to long-term hardship and impoverishment as well as environmental damage and social stress. Commercial clients/investees are required to avoid physical or economic displacement or minimize impacts on displaced individuals or communities through appropriate measures such as fair compensation and improving livelihoods and living conditions.

- ✓ **Biodiversity Conservation and Sustainable Natural Resource Management:** Protecting and conserving biodiversity (including genetic, species and ecosystem diversity) and its ability to change and evolve, is fundamental to sustainable development. Commercial clients/investees are required to avoid or mitigate threats to biodiversity arising from their business activities and to promote the use of renewable natural resources in their operations.

- ✓ **Indigenous Peoples:** Indigenous Peoples are recognized as social groups with identities that are distinct from other groups in national societies and are often among the marginalized and vulnerable. Their economic, social and legal status may limit their capacity to defend their interests and rights to lands and natural and cultural resources. Commercial clients/investees are required to ensure that their business activities respect the identity, culture and natural resource-based livelihoods of Indigenous Peoples and reduce exposure to impoverishment and disease.

- ✓ **Cultural Heritage:** Cultural heritage encompasses properties and sites of archaeological, historical, cultural, artistic and religious significance as well as unique environmental features and cultural knowledge, innovations and practices of communities embodying traditional lifestyles, which are protected for current and future generations. Commercial clients/investees are required to avoid significant damage to cultural heritage due to their business activities.

- **Environmental and Social Safeguards Policies (African Development Bank)**

The African Development Bank issued its Environmental Assessment Guidelines (EAG) in 1992, but since then, many changes have occurred in the Bank' structure and operations. The revised Environmental and Social Assessment Procedures (ESAP 2015) have therefore been updated to reflect the more integrated approach addressing all crosscutting themes as well as the new organizational structure.

The main purpose of the Environmental and Social Assessment Procedures (ESAP) is to improve decision-making and project results in order to ensure that Bank-financed projects, plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines. The ESAP apply to the Bank's public sector operations. Similar procedures were developed and approved for the Bank's private sector operations: AfDB Environmental Review Procedures for Private Sector Operations (2000). Other relevant AfDB policies are: AfDB Policy on the Environment (2004), AfDB Environmental Review Procedures for Private Sector Operations (2000), AfDB Gender Policy (2001), AfDB Policy on Poverty Reduction (2004) and AfDB Policy on Involuntary Resettlement (2003).

See ***Table 1.1*** below for the ten (10) IFC Equator Principles that considered by the ESIA to ensure its conformity with international standard.

Table 1.1: IFC Equator Principles

Code	Principle	Description
1	Review and categorization	Screening to determine the magnitude of the proposed project's potential environmental and social risks and impacts
2	Environmental and social assessment	Aimed at addressing the relevant environmental and social risks and impacts of the proposed Project, as well as, propose measures to minimise, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project

Code	Principle	Description
3	Applicable environmental and social standards	Ensure compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues
4	Environmental and Social Management System and Equator Principle Action Plan	Develop or maintain an Environmental and Social Management System (ESMS) to address issues raised in the assessment process
5	Stakeholder engagement	Ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process should be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.
6	Grievance mechanism	Establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of the ESMS
7	Independent review	An Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation
8	Covenants	Ensure compliance with all relevant host country environmental and social laws, regulations and permits in all material respects and during construction and operation
9	Independent monitoring and monitoring	Ensure the appointment of an Independent Environmental and Social Consultant, or /qualified and experienced external experts to verify monitoring information

Code	Principle	Description
10	Reporting and transparency	Ensure that, at a minimum, a summary of the ESIA is accessible and available online

1.5.5 *VTT LNG West Africa Limited Health, Safety, Security, Environment (HSSE) and Community Relations (CR) Policy*

VTT LNG West Africa Limited is committed to conducting its operations with utmost health, safety, security and environment (HSSE) and corporate social responsibility (CSR) standards internationally obtainable in the Oil and Gas industry. VTT LNG West Africa Limited HSSE and CSR policy which is a driver to environmental protection is stated thus, we will give utmost regards to safety, security of persons, preservation of operating environment and peaceful coexistence with host communities and the public. We believe that the achievement of this commitment is an integral part of efficient and profitable business management. To achieve this, we will be guided by the following:

- ***Health and Safety Policy***

We shall establish a safe work-permit system and conduct our operations in accordance with applicable statutory regulations and oilfield best practices. We will encourage Company and Contractor's employees to maintain a healthy work/life balance.

We shall provide appropriate Personnel Protective Equipment (PPE) for employees and enforce their use in accordance with the Policy. Contractors are similarly required to provide appropriate equipment and ensure use in compliance with the VTT LNG West Africa Limited PPE Policy. Compliance with VTT LNG West Africa Limited Health and Safety rules and regulations will be a condition of employment for both Company and Contractors employees.

We shall promptly report and investigate all incidents, including Near Misses to determine cause(s), and share lessons learnt, across the organization and contractors. We will establish contingency plans for foreseeable emergencies and regularly conduct exercises to train all on emergency response procedures.

- ***Environment***

We shall conduct all Company operations with due regard to the preservation of the environment and in compliance with applicable Local Regulations and Guidelines, and International codes of practice. We will develop Environmental Management Plans and monitor effectiveness of mitigating measures and review as necessary.

- ***Security***

We will partner with host Communities to secure lives and assets. We will apply non-confrontational security strategies in compliance with National and International Laws with respect to Human Rights.

- ***Community***

We regard our host communities as stakeholders and our primary objective in the partnership is to promote capacity building. We will pursue proactive engagements with communities and utilize the atmosphere of peaceful coexistence achieved to implement sustainable development programs for communities.

1.6 Structure of the Report

The ESIA is structured in accordance with *the EIA Sectoral and Procedural Guidelines, 1995* as presented below:

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CHAPTER TWO

PROJECT JUSTIFICATION AND ALTERNATIVE

2.1 Introduction

The general aim of any growing economy is to attain self-sufficiency in as many facets of its activities as possible. As such, the more self-sufficient an economy is, the more developed it is regarded to be. Nigeria is a developing economy, dependent almost exclusively on revenue from the oil and gas sector.

VTT LNG West Africa Limited intends to process, produce & distribute gas to embedded and industrial customers who are currently stranded from the gas pipeline network and also to customers who require gas as a back-up/storage solution. In this chapter, the justification and appraisal of possible project options and alternatives for the proposed gas plant is discussed.

2.2 Need for the Project

Despite its abundant natural gas reserves (largest in Africa in proven reserves and ninth largest in the world), Nigeria still struggles to meet its energy requirements and has low domestic gas utilization. This is due to multiple reasons, with a key one being a deficit of gas transportation and distribution infrastructure. Given the role that natural gas plays as a fuel for electricity generation in Nigeria, the issues around limited supply of gas have a significant knock-on effect for industrial, commercial and residential users. A further consequence is in the area of economic development. Natural gas is also used by industries as feedstock and to run boilers and furnaces.

A virtual pipeline such as Liquefied Natural Gas (LNG) project will help towards meeting the energy requirements of various customers, primarily industrial and commercial.

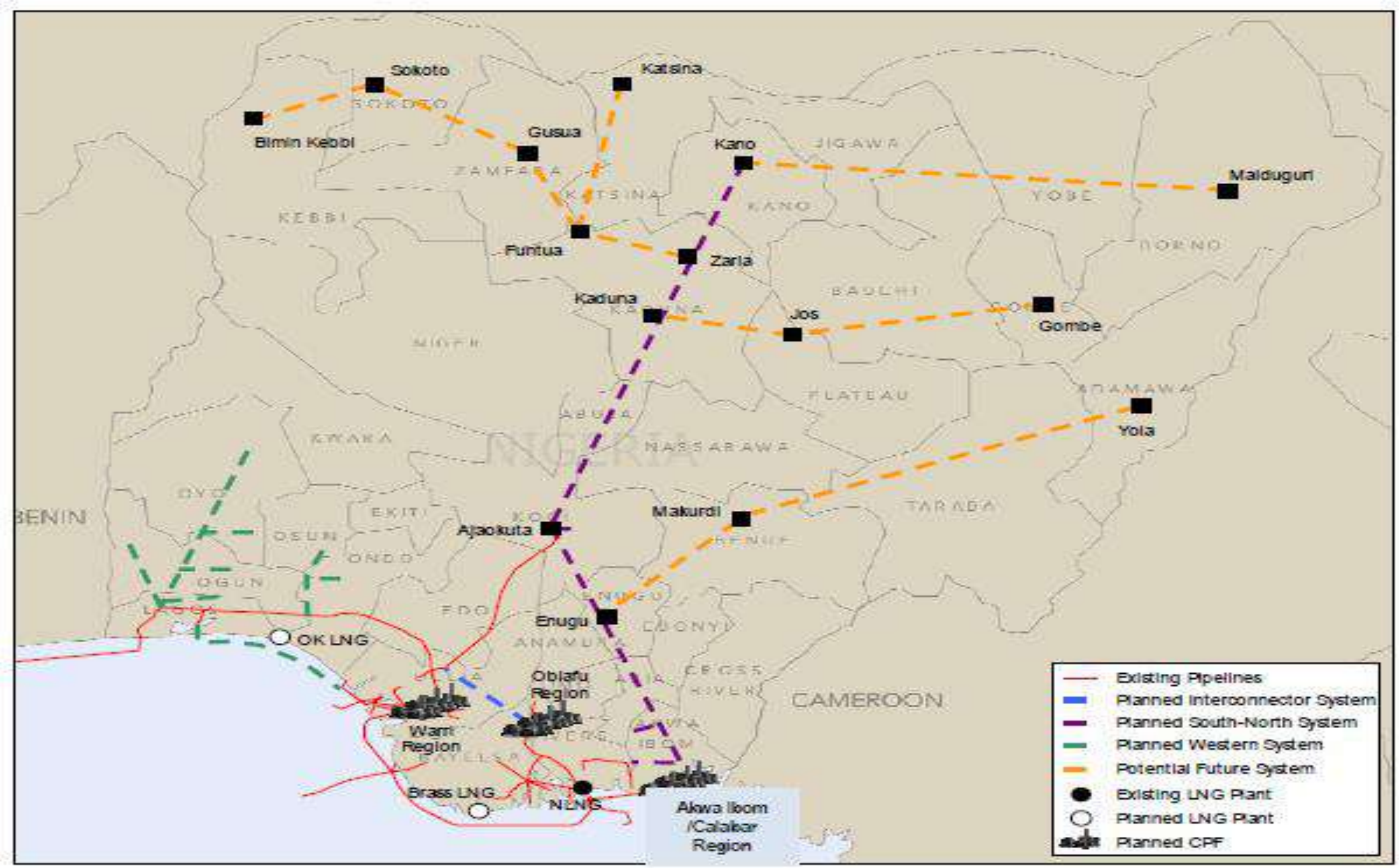


Figure 2. 1: Natural Gas Transmission Infrastructure (Source - NNPC)

2.3 Benefits of the Project

Reduced Cost

LNG offers up to 50% savings over diesel (in fuel cost alone). When incorporating the full lifecycle savings of operating gas generators instead of diesel, LPFO (Low-Pour Fuel Oil) or HFO (Heavy Fuel Oil) generators, the saving is significantly higher (70% or more) in terms of total energy costs. Moreover, the cost of gas is stable, whereas the diesel price fluctuates regularly.

Environmentally Friendly

Natural gas is the cleanest and quietest burning fossil fuel available, emitting significantly less carbon and nitrogen emissions than diesel or other fossil fuels – creating a safer and cleaner work environment.

No Pilferage

Diesel pilferage is a problem in Nigeria – industry experts estimate that at least 20% of diesel is pilfered or adulterated in Nigeria. As an alternative fuel, LNG is stored in cryogenic containers, eliminating the risk of pilferage.

Reduction of Gas Flaring and conversion of waste gas to wealth

Despite holding the world's ninth largest proven gas reserves of over 187 trillion cubic feet, Nigeria imports billions of dollars' worth of refined oil every year and still flares a large volume of natural gas. This is largely due to the inadequate national gas processing and pipeline infrastructure which can increase gas supply into the domestic market. The LNG facility will ensure markets are created, especially in Northern Nigeria where existing pipeline infrastructure is unavailable. This will encourage upstream producers to monetize gas produced from their fields by supplying the volumes to the LNG facility for utilization rather than flaring the gas.

Meeting the increasing demand for gas by customers:

This project will help to reduce the domestic gas supply gap by ensuring that the gas demand of industrial and commercial clusters is met. These customers currently require cost-effective, reliable fuel for use by their power plants and process facilities. Natural gas from the LNG facility will be used to bridge the gap and enhance domestic utilization of gas.

Increase production, cost competiveness and return on investment:

The project will ensure that its customers are able to operate their facilities with a cost-effective fuel, which offers at least a 30% discount to the alternative liquid fuels. This will enable firms optimize their cost of production and result into increased earnings for the company and revenue generation for the nation in general.

Reduced health risks and positive contribution to safety of the environment:

The extent of human damage attributable to gas flaring is unclear but doctors have found an unusually high incidence of asthma, bronchitis, and skin and breathing problems in communities in oil & gas-producing areas. Reduction in flaring by the proposed project if such flaring sites serve as the gas source will certainly help mitigate these effects. LNG fuel storage tanks are relatively stronger and safer than gasoline or diesel tanks, decreasing the likelihood of accidental release. Moreover, natural gas disperses quickly into the air instead of on ground, reducing the risk of fire or ground contamination. Natural gas also has a higher ignition temperature (628 degrees Celsius) than diesel (210 degrees Celsius), significantly reducing the chance of accidental ignition.

Global Warming Reduction:

Flaring is a global source of greenhouse gas emissions, contributing to global warming. The actualization of this project shall reduce, in some measure, the emission of greenhouse gases to the atmosphere.

Provision of Employment:

The project is in line with one of the Millennium Development Goals (MDGs) to eradicate poverty, through the creation of employment opportunities. The project is poised to improve overall economic activity for the Gilli-Gilli community. It is estimated that about 200 skilled and unskilled workers will directly or indirectly be engaged throughout the project lifecycle – pre-construction, construction, operations & maintenance and decommissioning phase.

a) **Pre-construction:** Workers from the community will be engaged to carry out pre-construction activities such as site clearance, excavation etc.

b) **Construction:** The project will provide short term local employment opportunities during the construction phase for community members in terms of loading and offloading materials and deliveries, drivers for the mobile site workforce etc. Other services include security, food vendors etc. Skilled labour required during this phase will include project managers, engineering consultants etc.

c) **Operations & Maintenance:** During the operational phase, jobs required will include site security/manning of the liquefaction facility, the general day to day operation and maintenance of the facility, cleaning etc. In addition, occasional opportunities such as vegetation clearance requiring unskilled labour will arise in the course of operations

d) **Decommissioning:** The facility is likely to remain in place for many years and therefore any decommissioning works would be a long time in the future. During this phase however, labour will be required for activities such as dismantling/demolishing, recycling, re-planting etc. This will largely be sourced from the local community.

In addition, a natural gas facility in Gilli-Gilli will attract new small and medium scale businesses to the community and immediate region because of the availability of cheaper alternative to alternative fuels like diesel. This could potentially lead to the creation of more employment opportunities.

Overall, business activity will be enhanced through activities such as resident staff patronizing local businesses, local sourcing of construction materials where these are locally available (e.g. cement, glass, bricks etc.) and so on.

***Other project benefits*:**

- Potentially enabling power generation thereby improving overall generation capacity in Nigeria;
- Enable greater utilization of indigenous natural gas reserves targeted at increasing domestic gas consumption, helping to develop national industrial and economic activity;

- Natural gas is a much cleaner fuel than diesel or petrol – reducing the risk of damage and extending the life of industrial equipment. Gas generators also have long service intervals (up to 30,000 hours), reducing maintenance and aftermarket costs; and
- Natural gas can replace several types of solid, liquid, and gaseous fuels in industrial processes (from steel to paper production) and is the most cost effective fuel for power generation in Nigeria, boosting productivity and competitiveness

2.4 Value of the Project

The anticipated cost of the proposed project will be up to $50,000,000. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government. Importantly, the site of the project was strategically selected with the intent to accomplish long term economic growth that will create local employment for various categories of indigenes in particular and Nigerian professionals in general.

2.5 Envisaged Sustainability

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic and environmental sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Economic Sustainability:** VTT LNG West Africa Limited shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security. Funds accruing from the sales of natural gas will continually enable VTT LNG West Africa Limited meet its production and investment costs, contribute additional revenue to Edo State and Federal Government of Nigeria from tax payments, create more jobs and meet its financial, socioeconomic and material obligations to the host communities. The favorable enabling environment ensures that the mini LNG facility will continue to exist for decades as a business venture and as an industry.

The economic sustainability of the proposed project is, therefore considered highly feasible given the following highlighted reasons:

- Natural gas, which is the major raw material is currently available in the project area and is in abundance as a natural resource in Nigeria;
- There is a ready and viable market for natural gas products from the plant;
- Envisaged revenue accruing to the mini LNG plant from the sale of natural gas product will be sufficient to meet production and investment costs;
- The plant will continuously support the government and host communities with respect to taxes, employment generation, and facility improvement among others.

- **Technical Sustainability:** The proposed project will be technically sustainable, utilising modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development e.g. e.g. NFPA 59A, EN 1473, EN 13645, ISO 16903, API 625, etc.

  The manufacturer of the gas process plant equipment is a world leader in the manufacturing and supplier of cryogenic equipment and products and covers areas including the following.

  - Equipment Supply.
  - Engineering Support.
  - Personnel Training.
  - Operations & Maintenance Support.

✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because VTT LNG West Africa Limited’s activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs. The proposed activities will also be carried out in compliance with standard industry and regulatory guidelines as set by Nigerian environmental laws for the petroleum industry. Incorporating the findings and recommendations of this ESIA and subsequent implementation of the Environmental and Social Management Plan (ESMP) for the project’s phases will ensure the desired environmental sustainability.

In addition, the project activities shall be guided by the VTT LNG West Africa Limited's HSE Policy. A standard Environmental and Social Management System (ESMS) which conforms with ISO 14001:2015 shall be developed for management of aspects and anticipated impacts of the plant. The environmental sustainability of the project is premised on the following:

- VTT LNG West Africa Limited shall ensure that all the plant is designed and installed in a manner that will keep all the potential adverse environment effects to the minimum and within the acceptable regulatory levels.
- A standard Waste Management Plan (WMP), aimed at pollution prevention strictly in line with regulator and best industry practice shall be developed for the plant.
- The principle of Best Available Technique (BAT) that prevents pollution shall be adopted.

The General Health, Safety and Environment (HSE) guidelines to be adopted by VTT LNG West Africa Limited addresses "Good International Industry Practices" in four focus areas in line with *World Bank Group Environmental, Health, and Safety Guidelines for Petroleum Refining (2016):*

- Environmental.
- Occupational Health and Safety.
- Community Health and Safety.
- Construction and Decommissioning.

✓ **Social Sustainability:** To ensure social sustainability of the project, VTT LNG West Africa Limited will ensure:

1. ***Robust stakeholder engagement****:* VTT LNG West Africa Limited will ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process will be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.

2. ***Establish a grievance mechanism:*** designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of its Environmental and Social Management System (ESMS). Sources of grievances could include community youths, militia groups, etc.

2.6 Project Options and Alternatives

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go ahead option.
- Project alternatives: Alternative location/site and Alternative technology.

2.6.1 Project Options

- ***Option One: No Project Option***

This option assumes that the proposed project will not take place which means that the plan to develop the modular gas processing plant will not take place. The No Project option will have a negative impact on the local and national economies. The significant socio-economic and industrial development benefits associated with the proposed development such as increased business opportunities, increased revenue to government, increased foreign exchange earnings, employment opportunities, etc. will be forfeited. As a result, the 'No Project option' was not considered to be a viable or acceptable option for the proposed project.

- ***Option Two: Delayed Project Option***

Due to some unfavorable conditions such as civil unrest or hostilities within the stakeholder communities, malicious public opinion, unfavorable government policies, prevailing bad economic conditions or any force majeure, implementation of a proposed project may be delayed. Considering this option implies that the development's activities would be stalled until conditions become conducive. Interestingly, none of the above mentioned or any related delaying factors currently exist against the proposed development, therefore the delayed project option was not considered a preferred option and thus was not selected.

- ***Option Three: Go-Ahead Option***

This project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. Therefore, the proposed mini LNG Plant shall be executed as planned.

2.6.2 Project Alternatives

During the formulation of the proposed project design, possible alternatives have been considered in compliance with the requirements of Nigeria's EIA procedures together with international best practice and the IFC Performance Standards. The project alternatives considered are as follow:

- ***Alternative Location***

The site/ location selection criteria included a wide range of engineering, environment, permitting and economic considerations. Other fields as alternative sites were considered.

The Gilli-Gilli location was selected over other sites for the following reasons:

- Less complex as the secured site is located within the same field where the tie-in flow station is located
- The site is free from encumbrance and located away from residential settlements. A gas receiving pipeline will be easily installed connecting existing flow station
- The preliminary soil analysis indicates that soils are adequate to support a gas processing facility.
- The cost of building an interconnecting pipeline from the flow station to the inlet flange of the LNG facility is reduced.

- Few communities are located close to the project site thus, there are minimal interface issues with the communities
- Land is already secured thus avoiding the need for lengthy discussions/negotiations with new land-owners.

- ***Alternative Plants***

Construction of a Compressed Natural Gas (CNG) Plant

This option was rejected due to the limited reach in terms of distance of a CNG solution. A CNG solution is typically used within a radius of 200-250km from the plant while an LNG solution can be deployed to distances of over 1000km from the plant. Given the need to ensure that gas is made available to as many industries in the region that currently have no access to gas, the CNG plant option would have a negative impact on this possibility.

In addition, LNG offers a unique advantage over CNG for more demanding high-horsepower applications by eliminating the need for a turbocharger. Because LNG boils at approximately -160C, using a simple heat exchanger a small amount of LNG can be converted to its gaseous form at extremely high pressure with the use of little or no mechanical energy. A properly designed high-horsepower engine can leverage this extremely high-pressure energy dense gaseous fuel source to create a higher energy density air-fuel mixture than can be efficiently created with a CNG powered engine. The end result when compared to CNG engines is more overall efficiency in high-horsepower engine applications when high-pressure direct injection technology is used.

- ***Alternative Technology***
  - ✓ The Nitrogen Expansion System: Requires the use of mainly nitrogen as a refrigerant, which can be produced from air and does not need to be imported. The ease of operation of the nitrogen expansion technology is a significant consideration.
  - ✓ The Cascade System: The complexity of control systems as well as the extensive piping work used in a cascade system makes it capital intensive and not suitable for small-scale liquefaction plants. This system also requires the importation of propane, ethylene and methane refrigerants which will require importation.
  - ✓ Mixed Refrigerant System: Requires the use of nitrogen, methane, ethane, propane and isopentane refrigerants.

Preferred alternative: The expansion system, specifically nitrogen expansion technology was selected as the preferred option. Due to the fact that nitrogen can be produced from air and does not need to be imported, the ease of operation of the nitrogen expansion technology is a significant consideration. In addition, there are existing suppliers of nitrogen in Nigeria.

Transportation Method of Gas to the Plant

- ✓ The Dubri flare Gas pipeline is currently operational and in good state. Also, Pipelines are the most cost-effective way of transporting gas.
- ✓ Through Barges/Vessel: Adverse environmental impact due to continuous logistics requirements and liquid fuels used for transportation. Also, it is more expensive to transport gas to the project site via the listed virtual means as additional compression/processing equipment and logistics (trucks/barges) will need to be procured.

***Preferred alternative**: The Dubri pipeline as it is a more cost-effective option as the pipeline is currently operational and in good state.*

- **Product Storage Type**
  - ✓ Above-Ground Storage Tanks: For above-ground storage tanks, visual checks for leaks can easily be performed, it can easily be repositioned, and It is less costly to install and maintain.
  - ✓ In-Ground Storage Tanks: For in-ground storage, it is difficult to maintain, difficulty in the detection of leakages, more complex interface with associated plant equipment, more expensive to install and maintain and higher environmental risk (especially where there are underwater reservoirs nearby.

Preferred alternative: The selected option is an above-ground (pressurized cylindrical or bullet), full containment, flat-bottom storage tank as the storage concept for the LNG Facility. This is considered safest and most cost-effective as in-ground tanks are more difficult and more expensive to construct than above-ground tanks.

From the foregoing, it is evident that there is no better alternative to the proposed LNG Plant that favors environment, social and economy except as planned. Due to the advantages that the Go-Ahead Option has over other options considered, the proposed project is considered viable and should be executed as planned. The proposed project also considered environmental and social sustainability; therefore, it should be executed as planned.

CHAPTER THREE
PROJECT AND PROCESS DESCRIPTION

3.1 Introduction

This chapter provides a description of the proposed LNG. It provides details of the proposed production process, the project location, project schedule and details of the plant's product. It also provides details on the project activities at each phase throughout the life cycle of the project namely: pre-construction/site preparation, construction, operation, maintenance and decommissioning.

Specifically, the chapter provides detailed information on the environmentally relevant processes of wastewater, waste, air emission, water consumption, and noise likely to arise from the project.

3.2 Project Location

The proposed facility is situated on coordinate of 5.35732N and 6.15518E in Gilli-Gilli Field, Ovia North East Local Government Area of Edo State, Nigeria (see Figures 1.1 to 1.3). Situated about 45km southwest of Benin City, the field covers an area 221 sq. km.

The field is situated within the low-lying freshwater forest of Edo state. The natural vegetation is in different stage of disturbances. The topography is a low lying and relatively flat terrain drained by the Osse River. The rainfall pattern in the area determines the two characteristic seasons in the year, the wet and dry seasons. Rainfall occurs throughout the year with its peak in July and September, while the drier periods of the year are from November to February. Within the field, there are cultivated farmlands and forests.

Gilli Gilli Community (Gelegele-gbene) is an ancient Olodiama Ijaw speaking Community founded by PA OLUGBO IKPITI several centuries ago. It is surrounded by other Ijaw communities in Olodiama clan, which are Ikoro, Inikorogha, Iboro, Igbeleuba, Kusangha {Ekenwan} with Ikoro as the Traditional headquarters. Gelegele is a border community between Bini communities and Ijaw communities on one hand and also is a boundary community of

Olodiama clan and Egbema clan of Delta and Edo states. Some of the Bini communities near and around Gelegele are UGHOTON, IKPAKO, EGBETAN, ODUNA and UGBINE etc.

3.3 The Project

VTT LNG West Africa Limited is developing a modular Gas Processing Facility. 'The Modular Gas Processing & Liquefaction Plant' will process and liquefy wet natural gas from the Dubri oil/gas facility – to contribute to the reduction of gas flaring and a virtual gas pipeline solution to enable the supply of natural gas to support power plants that are off grid. This will also help towards meeting the energy requirements of various customers, primarily industrial and commercial. We are developing skid mounted modular Mini-LNG Plants in 2 phases, inclusive of VIRTUAL PIPELINE TRANSPORTATION support capacity. VTT 's technology ensures, gas availability to captive industries and domestic users off the pipeline grid stimulating growth and industrialization.

Technical Partnership

- VTT LNG is in partnership with TM Llanos of USA both in the areas of technical and financial backing. Mechero energy which is a subsidiary of TM Llanos is providing 100% technical support for VTT LNG gas to liquid technology, while VTTLNG provides the virtual pipeline solution.

- Mechero Energy is a company focused on converting low cost, stranded and/or residual energy resources into higher value fuels and distributing them to energy-constrained markets.

- Mechero Energy engages in the Engineering, Procurement and Construction (EPC) and Operation and Maintenance (O&M) of its assets with a focus on 3 technologies:

  - Associated Gas Treatment Facilities with Condensates (NGL) recovery
  - Liquefied Natural Gas (LNG) production
  - Power Generation

- Mechero Energy engages in different activities along the energy downstream value chain. Jetties, fuel pipelines, transmission lines, transformation infrastructure, fuel treatment plants and fuel trading companies are part of the businesses in which Mechero holds positions.
- Mechero's shareholders have experiencing building more than 500 MW's of capacity in Latam and West Africa.

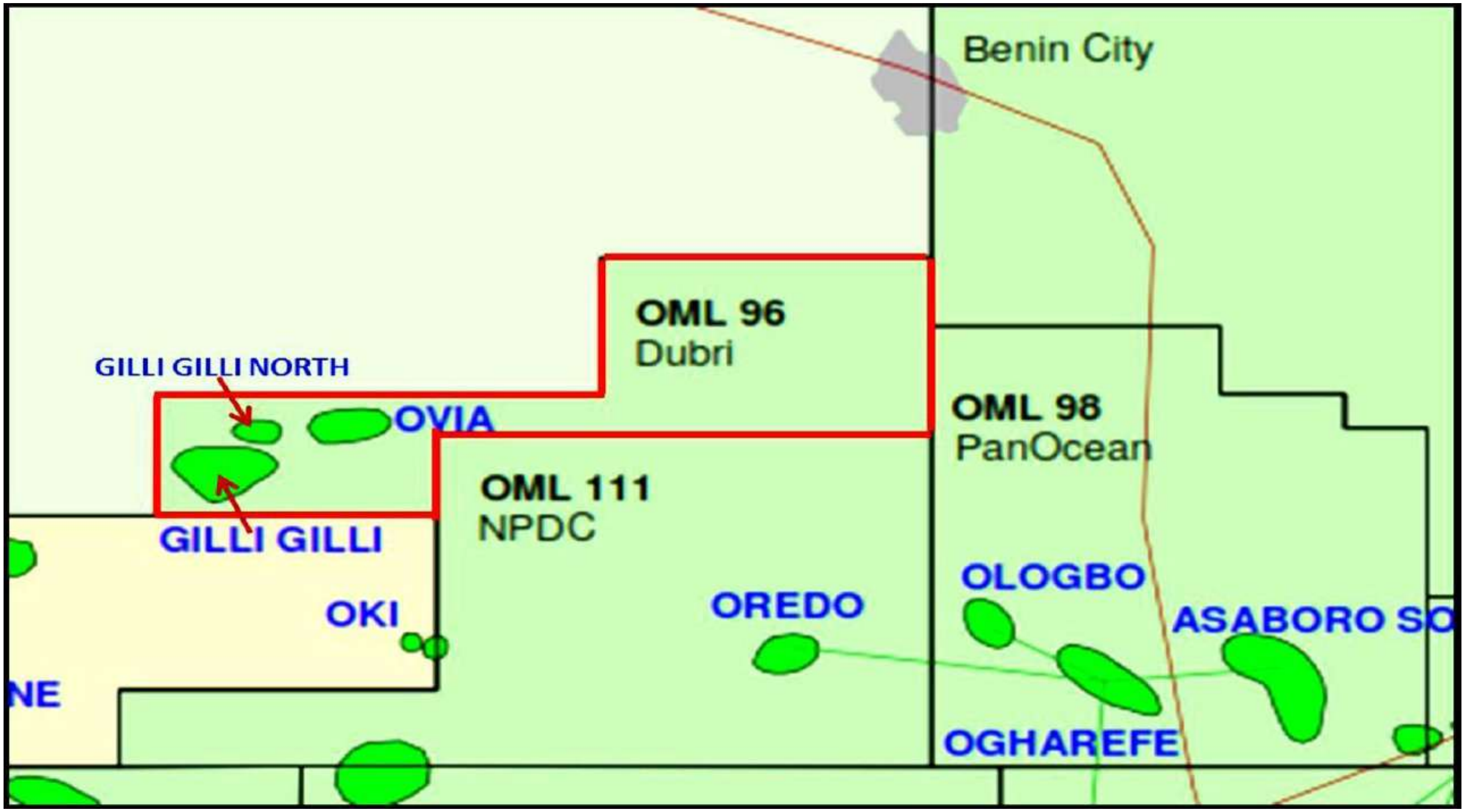


Figure 3.1: OML 96 Concession/ Boundary Map

Source: VTT LNG WEST AFRICA, 2019

Figure 3.2: Google Map of the Project Location

Source: VTT LNG West Africa, 2020

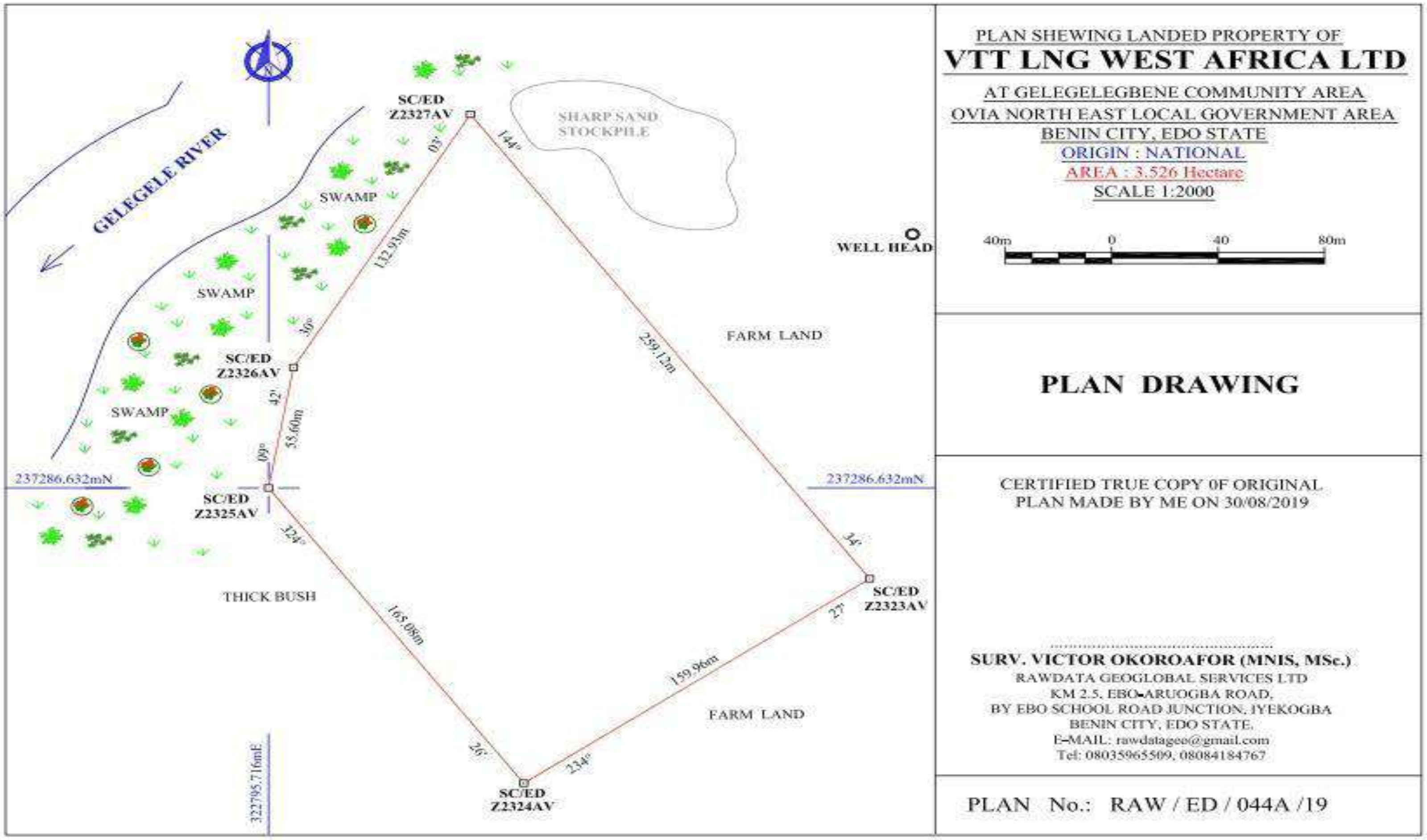


Figure 3.3: Survey Plan of the Project Location

Source: VTT LNG West Africa, 2020

3.4 Project Scope

The scope of the project is essentially design, engineering, procurement, installation/commission of the gas facility and activities shall include:

- Design and construction of a 6'' feed gas pipeline tie-in to existing Dubri flare gas pipeline;
- Acquisition of +/-1.5km new pipeline right of way (ROW) for the feed gas pipeline.
- Engineering design, fabrication of modular/mini gas processing/LNG units with inter-connection piping system.
- Site civil construction of modular/mini gas equipment foundation and support ancillary equipment.
- Installation of all factory prefabricated gas processing equipment; i.e. in-let gas metering station, feed gas pretreatment station, LNG coolbox, compressors.
- Construction of 6nos horizontal tanks to hold 5days production of total 50MMSCF, with each tank holding 10MMSCF of LNG.
- Construction of office building and staff accommodation and mess hall.

Other support infrastructure includes:

- A 5mw power generation system to support the gas processing plant and ancillary facilities.
- A mini fire station with gas firefighting equipment, i.e. fire/water system, foam, gas detectors and gas fire extinguishers
- A 5-system gantry for loading of tanks. Can load 1 ISO container (1mmscf) tank in less than 1hour.
- 40 – 50 ISO container tanks and 30 Side-Loader Trucks to support the supply chain structure for prompt delivery. (see Fig 3.10 for tank details)
- Systems controls Room
- Offices, Laboratory and Control Centre
- Accommodation for up to 20 – 30 plant engineers, Mess and Sick Bay

- Truck Park and Changing rooms to hold up to 50 - 60 trucks at a time

VTT's proposed gas project is to produce Liquefied Natural Gas to support captive/embedded industries and domestic users who are off the pipeline grid. The plants are modularized skid mounted and would be developed in two Phases with a total daily production capacity of 30MMSCF (600TONS).

LNG takes up about 1/600th of the volume of natural gas in gaseous state and this makes it easy to transport to locations as far as 1200km away from the source (liquefaction facility). This enables the servicing of the target market of the opportunity; industrial and commercial clusters located in Northern Nigeria who currently use alternative liquid fuels such as diesel because they do not have access to pipeline gas. The LNG will be re-gasified back to gaseous form at the customer location before being used by their equipment.

The first phase of the LNG project will cater for 10MMSCFD while the 2nd phase will cater for 20MMSCFD while the entire project entails the development of a small-scale liquefied natural gas (LNG) facility with a production capacity of 30MMSCF (600TONS) **per day**.

The produced gas would be transported in special Cryogenic tanks to off takers, this method of moving gas by truck is known as Virtual Pipeline Transportation.

The gas processing starts with the wet in-let gas piped from Dubri Oil Company Ltd., into our metering Substation at a temperature of 80.6^{0}F and Pressure of 92psig. The fed in gas is pretreated through a cleanup process to remove acid gases, impurities and a dehydrating system to rid it of all moisture. The gas stream goes through a distillation process to separate the higher C_3^+ hydrocarbon gases and higher chain liquids, which are stored as LPG, Propane and Natural Gasoline (Condensate).

The unique blend of Methane and Ethane lean gas is further cooled through LNG Heat Exchanger Cold Box to a further temperature of -262°F and at a pressure of 0.5psig to and stored in large cryogenic tanks. Some of the steps are detailed in the table below:

Table 3.1. Detailed Step for LNG Operation

S/N	Item	Description
	Natural Gas Supply	Natural gas to be liquefied is supplied from the transmission pipeline, at the required specification. The natural gas is available at medium pressure (approximately 30-50 bar), simplifying the liquefaction process.
	LNG Production and Storage	The natural gas is treated to reduce the level of impurities. The purified natural gas is liquefied through the LNG Production facility that is directly connected to the outlet flange of the pre-treatment facilities. A nitrogen-expansion compression system is used to cool the natural gas to cryogenic temperatures until it becomes liquid. Liquefied Natural Gas produced is then stored in cryogenic tanks which are able to retain the cold temperature of the gas. The produced LNG is store in large Cryogenic Storage Tanks with a holding of 50MMSCF (1000TONS)
S/N	Item	Description
		This storage will serve as buffer capacity to enable supply reliability during maintenance on the LNG production facility or other downtime period.

	LNG Distribution	LNG is off-loaded from the storage tanks into smaller cryogenic tanks that are retrofitted on truck heads. The filled-up cryogenic tanks are then transported by trucks to end-users. This virtual pipeline allows maximum flexibility to make natural gas available to off-grid end users. The LNG is transported at a medium pressure and remains at gas/liquid equilibrium. Therefore, the boil-off gas generated during transportation is extremely limited and the LNG contained in the trucks remains cold for a long duration.
	Off-grid Power and Process Utilization	Once delivered, the LNG is stored in storage tanks at the customer's site. The LNG is then vaporized via atmospheric vaporizers and burnt as fuel in gas engines/turbines to produce electrical power or used as a fuel for manufacturing applications.

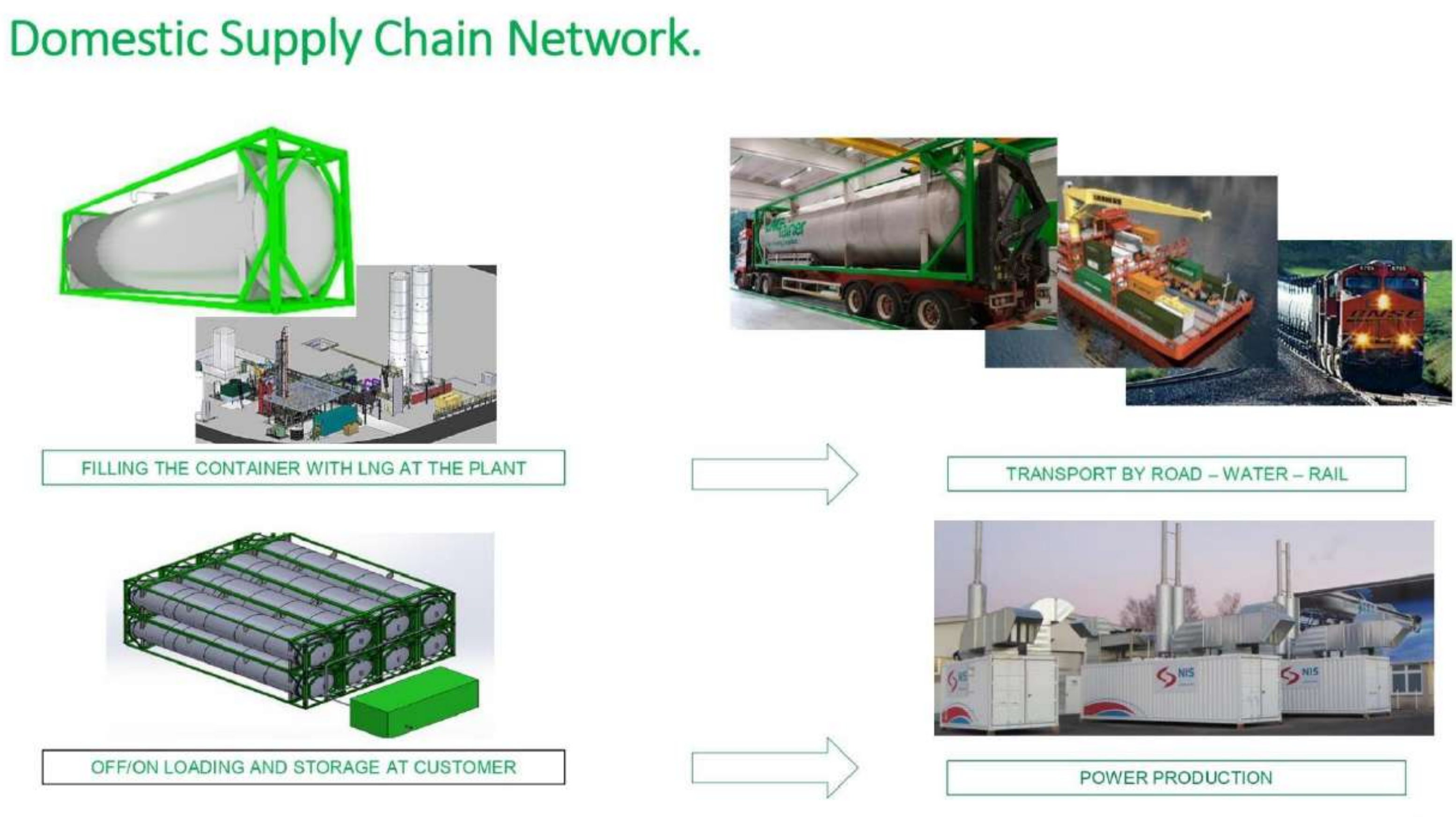

Domestic Supply Chain Network.
FILLING THE CONTAINER WITH LNG AT THE PLANT
TRANSPORT BY ROAD – WATER – RAIL
OFF/ON LOADING AND STORAGE AT CUSTOMER
POWER PRODUCTION

Figure 3.4: LNG Supply Value Chain

3.5 Liquefaction Process Description

3.5.1 Natural Gas Pretreatment Unit

Amine Wash Unit

Impurities such as CO_2 and H_2S need to be removed from the natural gas before entering the cold box. Amine wash units are a state-of-the-art solution for acid gas removal. In an amine wash unit, the natural gas enters an absorber column operating at high pressure and ambient temperature. As it circulates upwards, natural gas is washed against the amine solution circulating at counter current and absorbing CO_2 molecules present in the natural gas.

The rich amine is then sent to the regeneration section, where CO_2 is desorbed and the amine solution regenerated under low pressure and high temperature. The natural gas leaves at the top of the absorber column with CO2 specifications adjusted to cryogenics applications.

Dehydration and Mercury Removal Units

The treated gas leaving the amine wash unit is routed to a molecular sieve dehydration system for water removal. This system mainly consists of two molecular sieve beds working in parallel in a temperature swing adsorption mode (TSA). The system is designed for a mid-term adsorption cycle. The beds are regenerated using a slip-stream of dry natural gas, which is recompressed and heated via a natural gas fired heater. The wet regeneration gas leaving the vessels is cooled down, condensed water is withdrawn and the gas is sent back to the suction of the amine unit. The sweet and dry natural gas is filtered and routed into the mercury removal bed. The mercury removal guard bed consists of one single bed of non-regenerative activated carbon.

3.5.2. Liquefier

Natural Gas Circuit

The natural gas leaving the pre-treatment section enters the cold box, is cooled, liquefied and subcooled at high pressure. The LNG is then sent to the storage area where it is let-down at storage pressure. Heavy hydrocarbons which present a risk of freezing are removed from the process stream in the course of the liquefaction.

Cold Box

The cold box mainly consists of a brazed aluminum heat exchanger, very compact and efficient. These pieces of equipment are packaged within the cold which is insulated with perlite. The cold box is also continuously blanketed with nitrogen to avoid ice formation within the perlite-filled volume space.

The liquefaction process is based on Mixed Refrigeration Cycle. This cycle is simple, allows operation through a wide range of plant load factors, easy to operate (especially for start-up and turndown), reliable, cheap and readily available. The nitrogen circulates in a closed loop cycle and remains in its vapor phase during the entire cycle. The refrigerants exit the warm end of the heat exchanger at medium pressure and ambient temperature. It is first compressed by the recycle compressor.

The Refrigerant discharge are further compressed by two parallel boosters driven by cryogenic expanders. The high-pressure nitrogen from both boosters is cooled down again by aero coolers and goes to the warm end of the heat exchanger. The high-pressure nitrogen is then pre-cooled and split into two streams. The first one is sent to the “warm” expander and the second one is further cooled and sent to the “cold” expander. The resulting expansions provide the cold necessary to liquefy and sub-cool the natural gas while maximizing the heat exchange efficiency. Finally, both medium pressure refrigerants streams are mixed at the cold end of the heat exchanger and are warmed up by the condensing natural gas and high-pressure nitrogen streams. A small amount of refrigerants make-up is required to compensate for the seal gas losses.

LNG Storage and Send-Out Unit

The produced LNG is store in large Cryogenic Storage Tank with a holding of 50MMSCF (1000TONS) and then transported to several storage vacuum isolated tanks via a liquid header. A gaseous balancing line relying the storages ensure that the level is approximately the same in each storage. A small level difference can be observed to balance the pressure drops across the headers. The transfer of the LNG produced to the LNG storages is done using pressure difference between the cold box and the storage tanks, thus there may not be need for any transfer pump.

Figures 3.5 and 3.6 show process flow diagrams and pictures of typical gas processing and LNG plant.

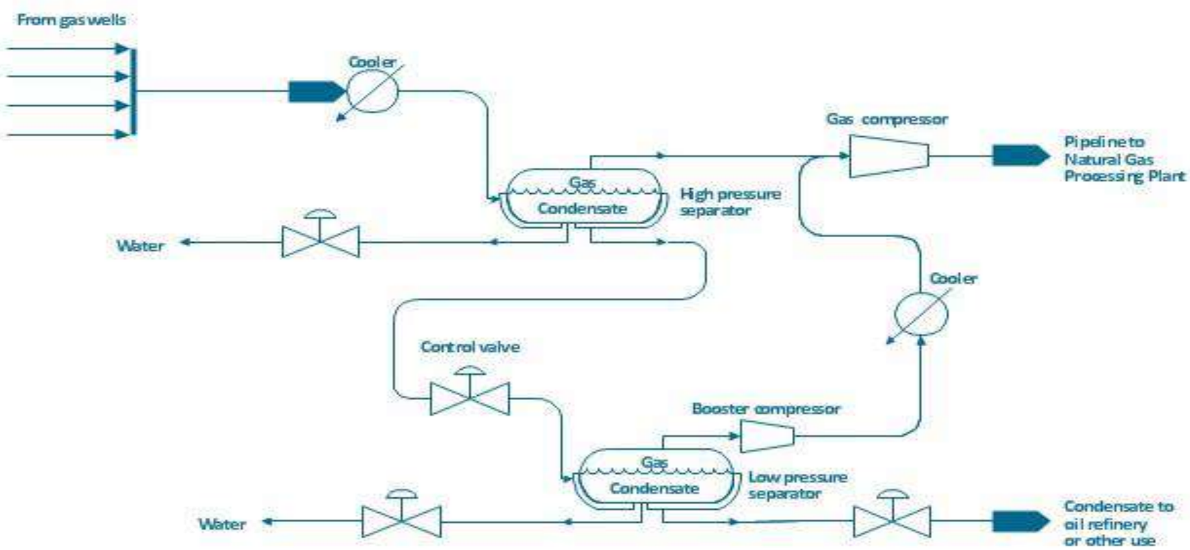


Figure 3.5: Layout of Gas Processing Plant **Source: VTT LNG WEST AFRICA, 2020**

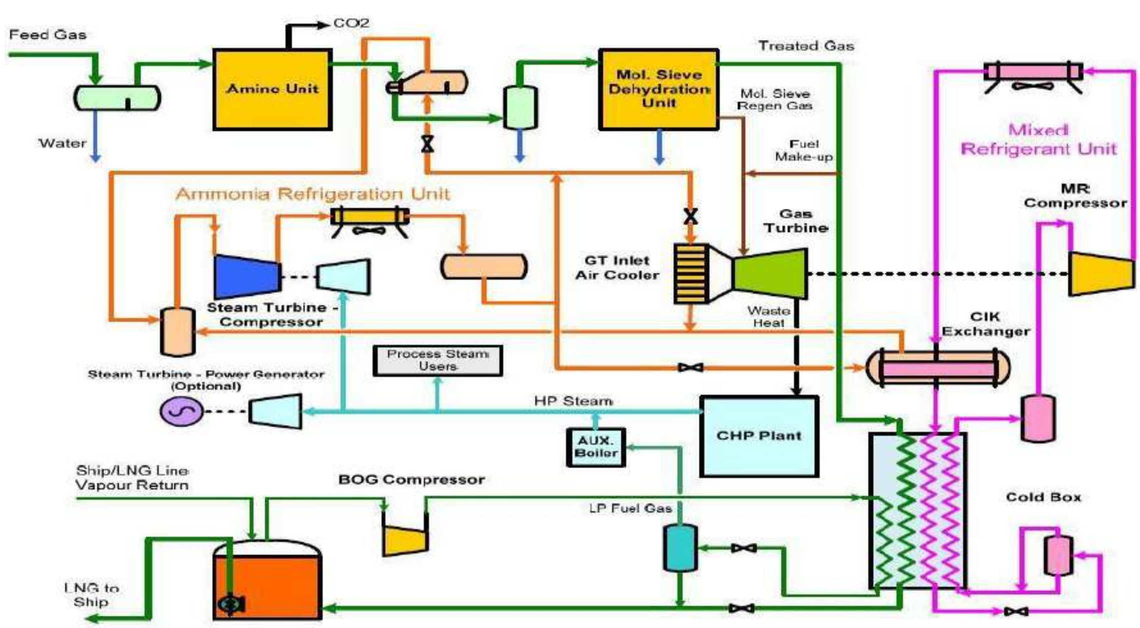


Figure 3.6: Process Flow Diagram of Gas Processing Plant Source: VTT LNG WEST AFRICA, 2019

LNGTainer data	
Maximum Allowable working Pressure :	5 bar(Gauge)/ Psi72.5
Product Service :	Methane Refrigerated Liquid
Water Capacity :	50 Cubic meter
Ma. Lading Weight :	30.48tons
Design Temp :	-196 C to 50 C
Length :	12192mm;40ft
Width :	2500mm; 8.2ft
Height :	2896mm; 9.5ft
Estimated Tare weight :	9.48 Tons
Evaporation Rate:	0.15

Figure 3.7: Virtual Pipeline Specification

Source: VTT LNG WEST AFRICA, 2019

3.5.3. LNG Storage and Send-Out Unit

The LNG produced is then transported to several storage vacuum isolated tanks (with a withholding capacity corresponding to a few days' worth of LNG production) via a liquid header. A gaseous balancing line relying the storages ensures that the level is approximately the same in each storage. A small level difference can be observed to balance the pressure drops across the headers. The transfer of the LNG produced to the LNG storages is done using pressure difference between the cold box and the storage tanks, thus there may not be need for any transfer pump.

3.6 The project activities

The project activities will broadly cover the following areas:

- Pre-construction activities include
  - site preparation,
  - engineering design,
  - materials delivery etc.

- **Construction activities include**
  - ➢ installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.) ➢ civil works.

- **Operational activities include**
  - operation of the LNG plant,
  - loading of LNG and
  - supply of same to customer locations etc.

- **The decommissioning activities include**
  - ➢ Removal of pipelines, plant components for relocation or sale

3.6.1 Site Preparation

The area in which the LNG will occupy shall be cleared of all vegetation, graded and compacted to ensure adequate strength to accommodate the plant. As part of the site preparation, the existing road that leads to the site will be reinforced to allow movement of heavier traffic. The engineering design for the proposed project shall be made which will be followed by movement of construction materials.

3.6.2 Construction

This shall involve construction and installation of various equipment (interconnecting pipeline, cold box, compressors, power generation equipment etc.). Also, the civil work of the plant shall also be done during this phase. Upon completion of various equipment installation, the plant shall be hooked up to gas supply [feed gas from the Dubri Flow Station]. The unit shall also be started up and tested.

3.6.3 Operation and Maintenance

Upon the completion of the plant, operation and maintenance of the plant follow. This shall include operation of the LNG plant, loading of LNG trucks and supply of same to customer locations etc. It also involves regular maintenance of the entire plant.

3.6.4 Plant Decommissioning

After the close-out of the proposed project, the plant shall be decommissioned in accordance with the developed decommissioning plan. This shall involve removal of interconnecting pipeline, plant components for relocation or sale, etc.

3.7 LNG Plant Facilities

- **Compressed Air System**: Two Screw Compressors, with each capacity of 950Nm^3/Hr.
- **Fuel Gas Station**: The fuel gas station (consists of pressure reducing valve & ambient air heater etc.) shall have capacity of 15,000SCFH. The Fuel Gas System shall work with Conditioning Skid of adequate capacity to meet the above requirement.
- **Blowdown and Flare System**: The flare system shall have a stack of 150,000 kg/hr.
- **Instrumentation System**: The Distributed Control System (DCS) has been considered to provide basic regulatory control of the process facilities; protective and emergency shutdown of the process facility; custody transfer and process data management. On-line analysis has been considered for monitoring plant performance and computation of

energy contents wherever needed for custody transfer. DCS will have interface with ERP system to provide plant operation data for integrated plant information management.

LNG Storage Tanks: There shall be 40 – 50 ISO container tanks and 30 Side Loader Trucks to support the supply chain structure for prompt delivery. The tanks considered are vacuum insulated horizontal tanks with liquid and vapor balancing lines. For this project, an above-ground, full containment design has been selected. The LNG shall be stored near atmospheric pressure and in full-containment tanks that typically consist of the following:

- Primary inside tank - made of a "cryogenic material" such as 9% Nickel steel, aluminum alloy or reinforced pre-stressed concrete; it is now common practice to use 9% Nickel steel for the inner tank in LNG service;
- Insulation - loose insulation material (such as perlite) surrounding the inner nickel steel tank (sides, floor and roof);
- Vapour barrier tank - made of carbon steel to contain the insulation system and vapour pressure of the primary tank;
- Tanks are horizontal cylinders supported on concrete stand.

The LNG tanks have a top entry point for both the loading and unloading operations. Submerged send-out pumps per tank shall be suspended from the top of the tank and pump the LNG out of the tanks. All tanks will be designed to simultaneously send out (to the vaporizer units) and to receive LNG (from unloading LNG carriers). The tanks shall be fitted with a low-pressure vent, which will provide storage tank overpressure protection if the tank pressure exceeds the maximum operating limit of the LNG storage tank design pressure.

- **LNG Composition Data:** The Terminal shall be designed considering the reference LNG composition given in the table below.

Table 3.2: LNG COMPOSITION

Particulars	Units	Design Case	Check Case NO1	Check Case NO2
Nitrogen	mol%	0.60	0.37	0.02
Oxygen	mol%	0.00	0.00	0.00
Carbon Dioxide	mol%	0.00	0.00	0.00
Methane	mol%	90.00	86.98	97.21
Ethane	mol%	6.24	9.08	2.49
Propane	mol%	2.19	2.53	0.14
i-Butane	mol%	0.58	0.42	0.09
n-Butane	mol%	0.39	0.62	0.02
i-Pentane	mol%	0.01	0.00	0.00
n-Pentane	mol%	0.00	0.00	0.03
Hexane and higher	mol%	0.00	0.00	0.00
Molecular Weight	Kg/kmol	18.02	18.51	16.50
HHV	MJ/kg	53.80	53.81	54.91
LHV	MJ/kg	48.97	49.02	49.85
WOBBE Index (WI)	MJ/kg	68.60	67.70	73.23
Boiling Temperature (BT) (@ 1 bara)	0C	-162.8	-161.7	-161.5
Liquid Density (@ 1 bara & BT)	Kg/m3	463.5	470.8	432.7

- **Vapour handling facilities**: The vapour handling facilities shall be designed for 10 MMTPA considering the following operating conditions:
  - The LNG tank boil-off rate is considered for LNG tanks;
  - The design LNG unloading rate is 12750m^3/h;

- A heat leak of insulating piping of 30 W/m^2 based on external surface of the insulation; and
- The truck loading facilities is fully operated.

- **Boil-off Gas (BOG) Header**: A boil-off gas header (low pressure vapour balance line) connects the vapour space of all the LNG storage tanks, the flare, the suction line of the boil-off compressors.

- **Boil –Off Gas (BOG) Compressors**: BOG compressors are designed considering the design LNG unloading rate (12750 m^3/h), the minimum send-out rate, installed storage tanks and the vapour returned from the LNG trucks at the loading station. The motors of the BOG compressors shall be sized on the densest boil-off gas. The common KO drum shall be located at the suction of the BOG compressors which shall be sized for the design BOG rate i.e. considering three compressors in operation.

  An in-line desuperheater is provided in the main suction line to maintain the compressors inlet temperature lower than minus 80°C; it shall be designed for three compressors in operation.

- **BOG Re-condenser:** Excess vapour generated during LNG unloading into the storage tanks and boil-off gas generated in normal operation are compressed by the boil-off compressors and condensed in sub cooled LNG delivered by the low-pressure LNG pumps.

  The BOG re-condenser has two sections

  - The upper section is a packed tower for mixing gas and LNG resulting in the gas to be condensed; and
  - The lower section is as buffer vessel for feeding LNG to the high-pressure LNG pumps with a net positive suction head (NPSH) above the minimum value required by the HP pump manufacturer.

The LNG required for condensing the vapour is delivered into the upper section of the BOG re-condenser while the balanced LNG send-out is flowing directly to the lower section of the BOG re-condenser; the LNG coming out from the BOG re-condenser is so sub-cooled and provides a medium suitable for being pumped by the high pressure LNG pumps (a safety margin of minimum 2°C below the saturation temperature of the BOG re-condenser out-coming LNG shall be considered).The BOG re-condenser shall be designed for the duty envisaged in different operating modes.

- **Low Pressure Pump**: The LP pumps are designed considering the peak send-out rates
  - 5 MMTPA: 685ton/h
  - 10 MMTPA: 1370ton/h

All the LP pumps are identical and shall be designed to comply with the above 10 MMTPA LNG flow rate.

- **High Pressure Pump**: Design of all the HP pumps shall be identical. Design of HP pumps will meet conditions given in Table 3.3

Table 3.3: Design of HP Pumps

Phase	Nominal Send-Out	Peak Send-Out (MTPA)
1	5.0	6.0
2	10.0	12.0

➢ **Shell and Tube Vaporizer:** LNG shall be vaporized in shell and tube type vaporizer (STV) with LNG on the tube side and an ethylene glycol water mixture on the shell side. STV flow rate shall be designed to meet conditions given in Table 3.4.

TABLE 3.4: STV FLOW RATE

Phase	Nominal Send-Out (MTPA)	Peak Send-Out (MTPA)
1	5.0	6.0
2	100 .	120 .

- An ethylene glycol water mixture shall be used as heating medium.
- The ethylene glycol water is heated with air fans. The atmospheric air conditions are:
- Air temperature: 15°C min. design and 40°C max. design
- Air humidity : 85% design 95% max. 0% min.

- **Metering Station**: The metering station, equipped with custody transfer meters, shall be implemented with several metering lines in parallel including, each one, one ultra-sonic type flow meter. A fiscal metering is required with a gas chromatograph on-line analysis of exported gas from each metering run. In 5 MMTPA, (2+1 spare) metering lines in parallel shall be implemented, each one being capable of 50% of the peak send- out (5+2% MTPA). In 10 MMTPA, (4+1 spare) metering lines in parallel shall be implemented, each one being capable of 5% of the peak send-out (10+2% MTPA).

- **Truck Loading Station**: This is provided to dispatch LNG by specially built cryogenic road tankers to various consumers which are not connected with gas pipeline. The facility is planned to accommodate three truck loading bay A truck loading station shall be implemented consisting in 3 truck loading bays having common weighbridge;
  - Each loading bay shall be designed to load 50 m3/h LNG; and
  - The total BOG from the LNG truck loading station (3 bays) shall be designed at 3,000 m^3 (n)/h.

- **Generator Specifications:** The Size of gas engine generator for utility power is a 1 X 5MW configuration with a terminal voltage of 15 kV, a rated voltage of 50 Hz and a rated speed of 3000 RPM. While the size of the turbine to drive the compressor for the cold box is about 9MW. The rated power factor will be 0.8 (lagging) and the generator efficiency between 98.5 to 98.8 percent depending on the unit load. Each generator will have automatic voltage regulator and a turbine speed control governor. A totally enclosed water-to-air cooling system will be used with re-cooling by air-water (fin fan) heat exchangers. The generators shall be equipped with a protection scheme to protect and prevent damage to the plant.

- **Water Supply and Consumption**: Plant water supply to the site will be from borehole water piped to the site and stored in the raw water storage tank. The raw water storage tank will have a capacity of 1,200 m3 which will be sufficient for water storage for a few days in case of disturbance to the raw water supply. A small water treatment plant will be required for the Project to supply process water for the washing of the gas turbine compressor, for the closed-circuit cooling system and general service water to the plant and potable water to the office buildings. In addition, two fire/service water storage tanks with a capacity of 700m3 each will be installed with a 300m3 fire water reserve. The plant will require approximately 1000 m3 of water from the boreholes per day.

- **Firefighting system:** This system shall comprise fire water tank, fire water hydrant. This shall provide boost the firefighting capability as well as providing coverage to fight/extinguish fire in the entire plant in an event of a fire outbreak and also for the cooling of Product tanks whenever the need arises. A firewater truck also is included in the gas plant.

- **Maintenance workshop:** This workshop is to house and provide equipment/tools for preventive and reactive maintenance (Mechanical, Electrical and Instrument) activities

- **Warehouse:** Usually, the warehouse will contain loading docks for loading and unloading of materials from racks. It will also have cranes and forklifts for moving spares which are usually placed on ISO standard pallets loaded into pallets racks.

- **Sick bay:** A sick bay will be operated on the plant. The bay will provide first aid and other medical service to staff in the event of such issues. The sick bay will commence operations during the site preparation stage of the project.

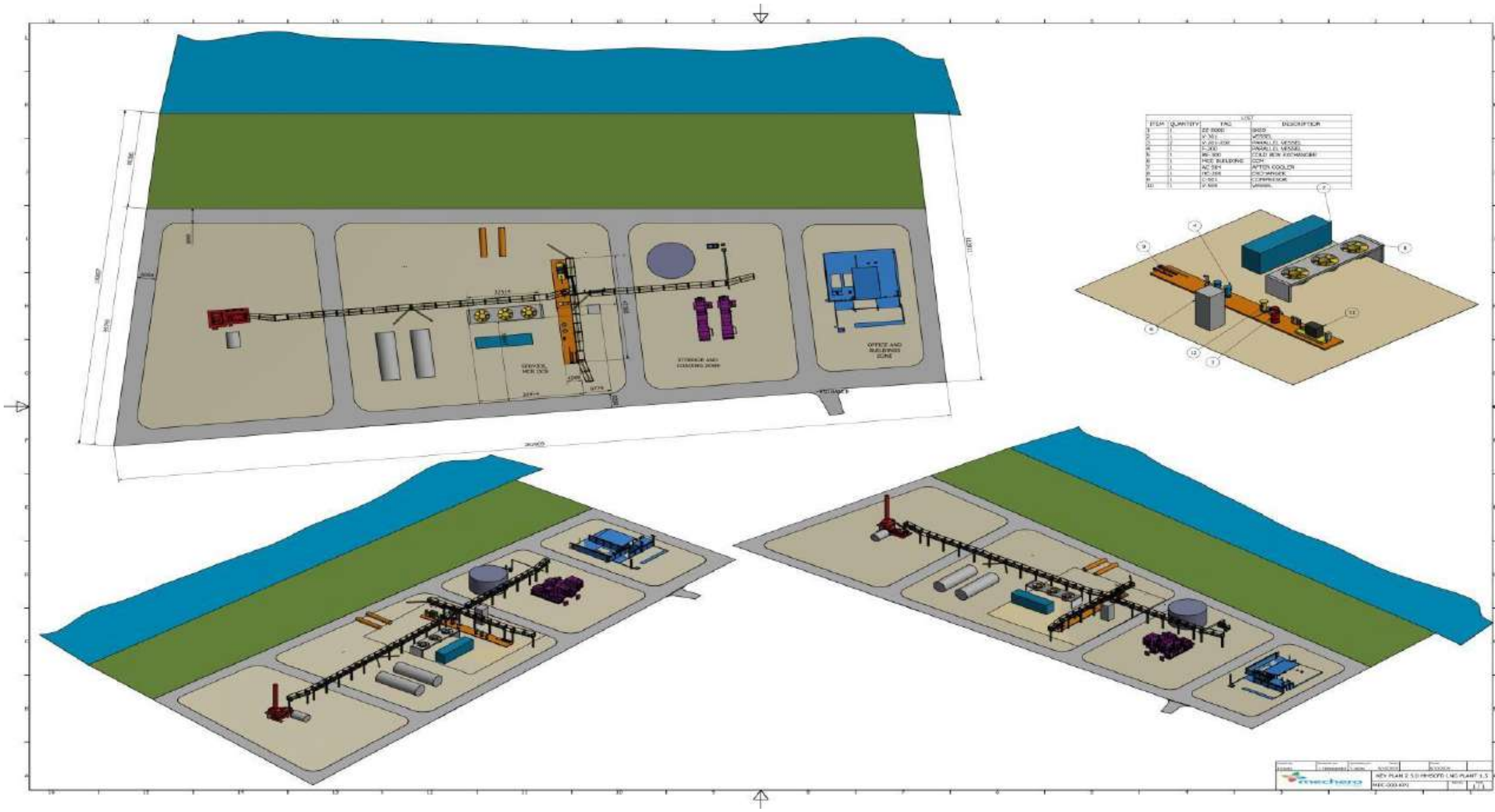


Figure 3.8: Equipment Layout

3.8 Installation and Commissioning Activities

The general preparation for start-up/commissioning is described below. All items must be finished when start-up procedures start.

1. Equipment Cleanliness

- Before any equipment is boxed up, it is the responsibility of the assigned plant operations personnel to ensure that all pipe work, vessels, columns, and other equipment are free of debris.
- Debris can cause invalidation of safety systems, destructive failure of rotating equipment, serious fouling or damage to demister pads etc.

2. Equipment checks

- Ensure that all flanges and manholes have been remade with new gaskets installed.
- Ensure that all instrumentation shall be reconnected, and all black valves and control valves shall be reinstalled.

3. Removal of Isolating Blinds

- Proceed with de-spading after vessels, columns and equipment are boxed up and the appropriate permits are signed off.

4. Inerting

- Ensure that nitrogen is available prior to the introduction of hydrocarbons into the unit, purge all equipment, including columns, vessels and pipe works with Nitrogen to atmosphere until the oxygen content is less than 3%.

5. Punch listing/line-up

- Ensure that the status of all valves and instruments are as represented in the PEFS (Process and Engineering Flow Schematic) drawings.

6. Loops /Continuity Checks

- Ensure that all loops/continuity checks are carried out.
- Ensured that all remotely controlled instruments respond to signals from the control room (simulation test).

7. Hydrocarbon Introduction

- Ensure a gradual introduction of hydrocarbon into the Unit.
- Carry out gas leaks checks at flange ends and instrument connection points at various pressure values as described in the commissioning procedure.
- Monitor and log Process Parameters until operating Conditions are attained and plant fully put in Auto-mode.

3.9 Plant Operations

3.9.1. LNG Storage Filling and Decanting Operations

Each storage will successively follow each step of the following cycle sequence:

Filling: the storage is filled with produced LNG coming from the liquefier. The liquid level inside the storage goes up until reaching the maximum storage liquid level.

Stand-by the storage is kept in stand-by waiting for unloading and the liquid level inside the storage remains stable.

Unloading: the LNG contained in the storage is loaded in the trucks. The liquid level inside the storage goes down until reaching the minimum storage liquid level.

Stand-by the storage is kept in stand-by waiting for filling and the liquid level inside the storage remains stable.

3.9.2 LNG Truck Loading Operations

In order to load a truck with LNG, it is mandatory that the truck is previously in cold condition (-160°C internally). Ten (10) loading bays are to be provided, whereby one would also serve as the cooling bay.

The loading bay is a recessed bay at the facility where cryogenic trucks will be loaded with LNG. The loading bay is exterior; it is part of the utility infrastructure typically providing direct access to storage areas. Two loading bays with four filling arms (a set of liquid and gas arm per bay, the Liquid arm to fill the truck with LNG while the gas arm to allow the gas inside the truck to exit) will be provided for the loading operation of LNG which implies that a maximum of ten (10) trucks can be loaded at a time.

The cooling down procedure is performed by injecting a very small flow of LNG inside the truck usually through a small control valve in parallel of the main filling valve. The LNG is vaporized inside the truck and as such cools down the latter; the vapors exit through the gas arm and are sent to the BOG (Boiled-off Gas) network of the LNG plants for being burnt in the fuel network. This configuration may be reviewed as necessary during implementation.

The loading bay will be equipped with the following:

- **Bumpers**: To protect the dock from truck damage; it will also be used as a guide by the truck drivers when backing-up.
- **Truck or Vehicle Restraint System**: This is a strong metal hook mounted to the base of the bay which will hook to the frame or bumper of a trailer and prevents it from rolling away during loading operations. This will be operated manually.
- **Bay Light**: A moveable articulated light mounted inside the dock used to provide lighting inside the dock during loading operations.
- **Earthing**: For proper grounding of the trucks in order to arrest any surge as a result of sparks from trucks.
- **Fire Fighting Equipment**: The loading bay shall be adequately provided with fire cover. Fire detection devices and fire water hydrants/monitors shall be installed for fire prevention and fighting.

3.9.3 Maintenance Activities

The plant will comprise of various static or non-rotational equipment that will last as long as the estimated life span of the plant (30 years). When a long shut-down is required, generally it is to perform turn-around maintenance to all train units (only when maintenance is required for the full LNG plant, e.g. during deriming of the plant). The purpose of deriming is to eliminate moisture, carbon dioxide or heavy hydrocarbons which can freeze, and cause the blockages and general malfunction of the cryogenic equipment. A cryogenic plant must be derimed at regular intervals, usually every 3 years. The deriming procedure consists in blowing dry natural gas from the outlet of the regen gas heater or gaseous nitrogen from the nitrogen generation unit through the equipment (main heat exchanger, nitrogen turbine-boosters etc.) during several hours until they reach ambient temperatures.

Typically turn around maintenance is performed every three years, although there is no general rule and longer or shorter intervals can be decided based on production and plant specific needs. However, the major equipment that will be due for frequent replacement within a five-year period is the plant's desiccant which is a hygroscopic substance (Aluminum silicate). During maintenance, the plant's desiccant shall be stored in well-labeled drums before its being transported through FMEnv and DPR licensed waste contractor for thermal decomposition.

3.9.4 Product Loading and Marketing Plan

With the wide supply and demand gap for Liquefied Natural Gas (LNG) in Nigeria, the plant will focus primarily on the domestic market for sales of its products. However, to ensure quick turnaround of the products, products shall be sold only on wholesale basis to major marketers and independent marketers at international prices. Products shall be loaded from the plant gantries into Side-Loader Trucks to support the supply chain structure for prompt delivery.

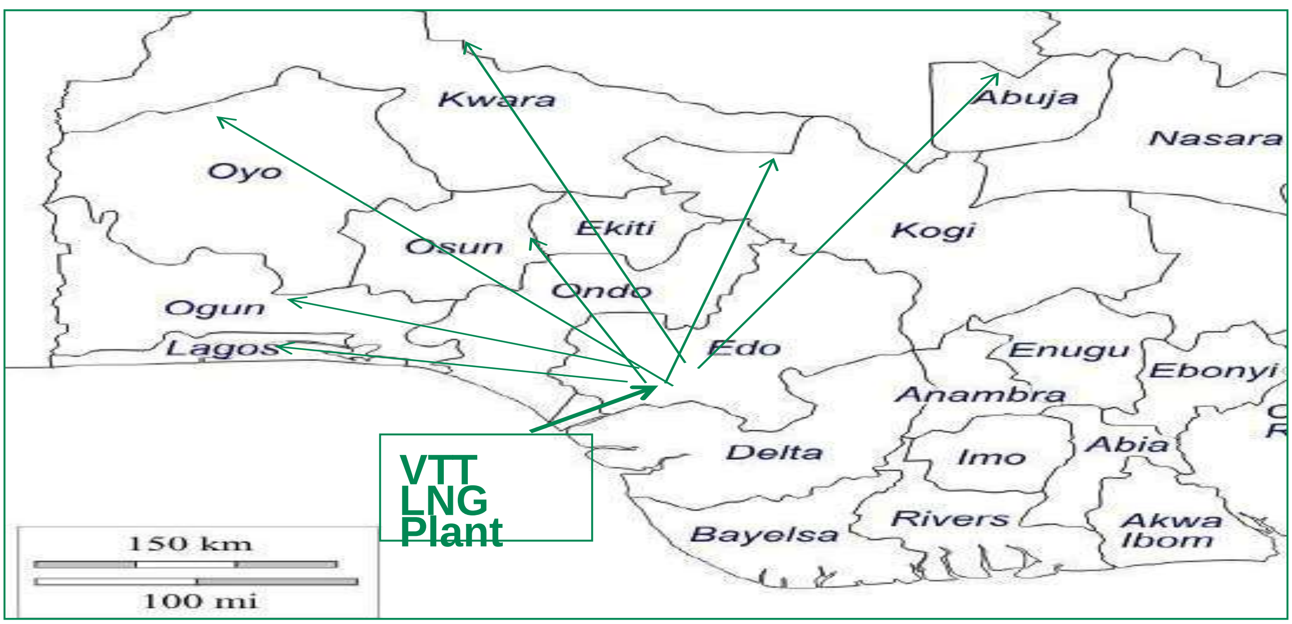


Figure 3.9: Targeted areas for marketing of LNG

3.10 Waste and Emissions Handling

3.10.1 Construction Waste

The types, sources, and management of wastes anticipated to be generated during the construction phase of the proposed project facilities are as follows:

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.
- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics will be generated during construction of the proposed project. The construction contractor shall be responsible for disposal at an approved location by an approved waste transporter.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumping, lead acid storage batteries, and used oil, will be generated during the construction and operational phases of the proposed project. Special wastes could also include items such as waste lubricants, paints, maintenance-related wastes, used air and liquid filtration media, and empty or partially full chemical containers. Special wastes will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for disposal at an approved location by an approved waste transporter.
- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment. Some human wastes shall be treated on site using engineered soak-away pit. This provides an excellent way of handling all human wastes.

3.10.2 Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.
- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.

- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.
- Combustible office waste shall be collected and transported off-site for disposal.
- Special Wastes such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumping, lead-acid storage batteries, septage, and used oil, will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for proper disposal at an approved location.
- Sewage wastes will be disposed of in an on-site septic system.

3.10.3 Air Emissions

The total annual emissions of air pollutants from various sources during the operations of the plant are shown in Table 3.5. This estimate includes emissions from: Combustion engines, Pilot flare, Vents, Heating oil furnaces, LNG loading vapors and tank vents

Table 3.5: Total Annual Emissions Tons per Annum

Total annual emissions tons per annum						
PM	**SO_2**	**NO_X**	**CO**	**CO_2**	**TOC/CH_4**	**N_20**
2.13	0	27.99	23.56	85329	3.079	0.065

3.10.4 Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the plant operations. Effluents generated will include backwash effluent from pressure filters, regeneration effluent from the demineralization plant as well as other chemical laboratory wastes, battery waste water, gas turbine compressor wash water and sludge. Further details of the effluents generated are provided in Table 3.6 below.

Table 3.6: Detail of Proposed Effluent Generation

Waste Water	Source	Characteristics / Contaminants	Disposal Method
Chemicals	Bulk chemical	Various chemicals	Fed into the neutralization pit,

	drains in water treatment plant		treated with acid/alkali and transferred to the central monitoring basin. Effluent (containing detergent, dirt and oil) from the gas turbine compressor on-line and off line wash and exhaust plenum drain will be fed to the wash water recovery pit. It will then be passed through the oil water separator and disposed by pumping to tankers.
Oil in water	Lube oil and transformer oil mixed with water from transformer yard, gas turbine water wash drain, diesel fuel from oil tank, oil water runoff and drains	Oil contents: 500 – 10000 ppm (in case of fire), pH:5-9, Suspended solids:0-30 ppm	This will be collected into an oily water capture basin and pumped into tankers for disposal offsite and the water effluent shall be pumped into an oil water separation tank for secondary treatment. The oil separation tank will collect oil by an oil skimmer, which will then run into the oil holding tank and will be transferred to a tank truck for final disposal offsite. The oily wastes will be disposed of at a registered waste disposal facility. Heavier suspended solids will settle at the bottom of the separation tank and this sludge will be

			removed via the sludge tank and disposed to sludge drying beds. The treated effluent from this oil separation tank will be led to the central waste water monitoring basin before final discharge. Effluent discharge will be as per Nigerian and World Bank requirements. The oil removal from the catch basin, sludge disposal, gas turbine wash water and lube oil drain disposal shall be done manually by using portable sump pumps.
Water Based	DM plant regeneration waste Equipment drain	Dissolved solids: <1000 ppm PH: 6-9 Chemical traces, traces of suspended solids, pH: 6-9	This will be directed to a filter backwash drain pit, and then transferred to a tube settler. The clarified effluent will be discharged into the central monitoring basin. Non-contaminated water will be directed to the stormwater system and discharged to surrounding area as per Nigerian and World Bank requirements. Sludge from the collection of the suspended solids will be disposed

			of as hazardous waste at a licensed waste disposal facility.

In addition to the above, there will be domestic sanitary waste that will be treated in a small package sewerage treatment plant. Non-contaminated water from rainwater, floor drains, and other water drains from the equipment will be routed into a storm water system and discharged to the surrounding area as per Nigerian, WHO and World Bank requirements.

All individual streams of effluents will be collected and treated as required, and the treated effluent will be collected in a central waste water monitoring basin. Effluent will be pumped and discharged from this collection basin once the water meets the discharge criteria for discharge of effluent. The effluent collection and treatment system will be controlled and monitored through a Programmable Logic controller (PLC) based local control panel situated in the water treatment building. All pumps will be equipped with pressure gauges, locking valves by chain and padlocks wherever required. The waste water treatment area will be located close to the fire water station and raw water storage dam. Effluent will be tested for pH measurement in situ before leaving the site. Turbidity and conductivity measurements will be measured at an onsite laboratory through periodic sampling at the outlet of the central monitoring basin.

3.11 Transport and Traffic Report

The existing road currently leading from the main road to the Project site shall be used as the primary access route to the site and is tarred and in good condition. During construction, an estimate of 20 to 30 Project vehicles will use this road daily. A maximum of ten Project vehicles will use this road daily during operation. VTT LNG West Africa Limited will liaise with the

Edo State government to repair any sections of the road that may be damaged during construction. Traffic levels will also peak during the annual shutdowns and periods of major maintenance.

Onsite Traffic**:** The Project currently has one 4x4 vehicle and is anticipated to require one light truck (7.5 tonne), two pick-up trucks, a fork lift truck and three 4X4 vehicles, which will operate onsite and for use offsite by Project staff. The intention is that all vehicles, new and old will be serviced and refuelled at an offsite public service station. No refuelling or vehicle maintenance will take place onsite.

3.12 Employment

There shall be 10 permanent site employees onsite during commercial operations. These will include plant management staff, maintenance staff, skilled technicians, drivers, cleaning staff and a number of semi-skilled operators who will operate and maintain the proposed plant.

In addition, 10 ancillary and contract workers will be employed during the operation phase of the LNG plant and this will include security, cleaning and gardening staff.

VTT LNG West Africa Limited shall seek to promote the development of local skills and the transfer of international technologies and expertise to local manpower and local manufacturers. It will also ensure that activities are fully compliant with the relevant (and evolving) ‘‘local content’’ provisions of Nigerian law and regulation.

Furthermore, the selection of sub-contractors by VTT LNG West Africa Limited shall ensure that only high-quality sub-contractors (whether of local, national or international provenance) are selected. They will be required to adopt the policies of both VTT LNG West Africa Limited on community liaison and local workforce employment. Based on its analysis of other projects, VTT LNG West Africa Limited believes that this approach will have a more direct and positive impact on the local community workforce and will lead to a greater degree of skills transfer.

3.13 Project Schedule

The overall conceptual project implementation schedule for the construction and commissioning of the Project is illustrated in table 3.7 below:

Table 3.7: The conceptual project schedule for VTT LNG West Africa Limited LNG Plant Project

S/N	Activity	2020				2021			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Appointment of Consultants to prepare EIA								
2.	EIA Preparation & Certification Process								
2	Design & Manufacture								
3	Preparation of site								
4	Installation								
5	Commissioning								

CHAPTER FOUR

DESCRIPTION OF THE PROJECT ENVIRONMENT

4.1 General Methodology

This chapter describes the baseline environmental conditions of the entire project area. The description of the field study methods and the key findings of the survey (biophysical, social and health) are presented. It includes data gathered from literature survey, field study and laboratory analysis. The purpose of this environmental description is to provide qualitative baseline information on the existing status of the project area against which future departures as a result of the effects of the proposed project will be weighed.

The environmental status of the area has been carefully assessed through detailed fieldwork and laboratory analysis. A multi-disciplinary approach was adopted for this study and covered all facets of the environment including surface & ground water characterization, air quality, soil, sediment, vegetation, socio-economic and health status of host community.

Preliminary data on the project was acquired from existing field surveys and literature. Field sampling and characterization was carried out in order to obtain the baseline conditions of the area. The strategies and methods for acquisition of the baseline data are as presented in this section.

Sampling was designed to present the existing characteristics of the study environment that constitute reliable measurable indices in natural environmental status.

Sampling and data collection for the various environmental components and parameters were in accordance with recommended procedures and practices for environmental data collection in Nigeria (**FMENV 1992 and DPR, 2002 (revised in 2018) Part vii D** – sampling and handling of samples)

The locations for water, sediment, air quality, geotechnical survey, groundwater and soil sampling locations are presented in Sketch Sampling Map (Appendices 4.1a-c). Measurement methods for Air quality and meteorology parameters are summarized in Table 4.1

The field work was carried out at both wet and dry season between 15th November – 17th November 2019 (3 days) and 4th February – 6th February 2020 (3 days) respectively. The Sampling radius for water, soil, vegetation and Air Quality for the ESIA study was 1km from the perimeter boundary of the proposed site. A total of twenty (20) geo-referenced sampling stations and additional two (2) control points were established in line with the ESIA Terms of Reference (ToR) for Soil, Air Quality, Noise and Vegetation Study while two (2) sampling locations and one control for Groundwater within 2km spatial boundary and three (3) sampling locations (upstream, mid-stream and downstream) with 1 control for surface water and sediment. The samples location distribution is attached in *Appendices 4.1a-c*.

4.2 METHODOLOGY

4.2.1 Air Quality & Noise Studies

Sampling was for a period of eight hours per day with readings of all the parameters determined every hour. The eight-hour monitoring period was carried out from day to day so that reading could be taken from early morning to late at night over the monitoring period. Information on air quality along the route was generated by on site monitoring of air quality at the proposed route locations. This data was supplemented by desk-based assessment of historical data from various locations.

Microclimatic Data Collection

Calibrated handheld and battery powered high precision Kestrel 4500 pocket weather Tracker (USA) was use for data collection for wind speed, humidity, temperature and wind direction.

Air Quality Parameters

Portable AeroQual Series 300 Monitor made in New Zealand and Portable Environmental Sensor meters manufactured in Florida, USA were used (ASTM D3249-95). Air was continuously pumped from the atmosphere and a portion of the sample is sent to the analyser for the determination of the pollutant gas of interest. The analyser contains modules of each gas that analyse the quality of the respective gases in the ambient air. It is a digital meter, which reads parameters at a time weighted average.

(NOx, model Z-1400; SOx model Z-1300; NH_3 model Z-800; H_2S model Z-900; CO model ZDL-500 all manufactured by Environmental Sensors Ltd and VOC using AeroQual monitor)

Suspended Particulate Matter

Suspended Particulate matters were determined using Met one instrument, Met One Aerocet 531 Mini volume portable Air sampler manufactured in USA, (ASTM D4096-91).

Plate 4.1: Air Quality Sampling

Table 4.1: Measurement Methods for Air Quality and Meteorological Parameters

Equipment	Model	Capability
Ambient Air quality: AeroQual and Environmental sensor	Series 300 and Z-Series	Gas analyser automatically extracts atmospheric air sent through the analyser gas sensors for the determination of the various gases.
Suspended particulate matter (SPM): Met one Instrument	Met One Aerocet 531 Mini volume portable Air sampler	With the aid of a pump and a flow-regulating device, air samples were pumped at a flow rate of 5 LPM at ambient conditions. Particle size separation was achieved by impaction and an impactor of 10-micron cut-point was employed.
Noise: Extech Instrument	407730 Sound meter	Noise level at each point was measured with a pre-calibrated digital readout noise meter. The sensor of the noise meter was directed towards the source of noise and the average reading over a period of ten minutes was taken to be the Noise-level at each point. The noise levels were measured in decibels (dB).
Wind direction and speed: Kestrel pocket weather Tracker	4500	A combined Wind Vane and Anemometer is used in determining wind direction and speed. The wind speeds were measured in m/s.
Ambient Temperature,	45000	The multi-parameter digital meter was used to measure temperature in ^{o}C, Atmospheric pressure in hPa and relative

Atmospheric Pressure and Relative Humidity: Kestrel pocket weather Tracker		humidity as %/ The logger is equipped with an atmospheric pressure probe (Barometer), relative humidity (Hygrometer) and a temperature probe (Thermometer).

4.2.2 Climate and Meteorology

Data acquired for this study was gotten via field work measurement (microclimatic data) and long-term data (macroclimatic data) from the Nigerian Meteorological Agency. During the course of field work survey, a weather station was set up in an open ground at various sampling station and allowed to run for a minimum of 30mins in order to establish a microclimatic baseline of that particular station.

All precautions usually taken when setting up a weather station and during measurements were observed for the onsite measurements according to the World Meteorological Organization (WMO) standard. These include setting up the weather station away from obstacles like buildings and tall vegetation, using an instrument shelter to display all temperature sensitive instruments, orienting the instrument shelter so that the sun's radiation does not fall directly on the instrument during reading and setting up the weather station in an area representative of the study area's totality.

The parameters monitored method of measurement and instrumentation are summarized in Table 4.2

Table 4.2: Instrumentation and Method of Observation for Climatic and meteorological parameters

Climatic Variable	Instrumentation	Record Availability	
		Onsite	Synoptic
Air temperature	Dry bulb thermometer	**	**
Relative humidity	Psychrometer/hygrometer	**	**
Wind speed	Anemometer	**	**
Wind direction	Wind vane	**	**
Cloud cover	Direct observation	**	N/A

Rainfall	Rain gauge	**	**

N/A = Not Available

4.2.3 Noise Level

Noise level at each point was measured with a pre-calibrated digital readout noise meter. The sensor of the noise meter was directed towards the source of noise and the average reading over a period of ten minutes was taken to be the Noise-level at each point. The noise levels were measured in decibels (dB). An EXTECH INSTRUMENT (China), model 407730 Sound level meter with measuring range of 40 dB (A) – 130 dB (A), accuracy of ±1.5 dB (A) was used for the monitoring.

4.2.4 Soil

Systematic sampling design (systematic line transect) was employed to collect soil by establishing plots across the sampled area. Soil samples were collected from each of the stations with the aid of a Dutch Hand Auger, Hand gloves, a spool and hammer at depths of 0-15cm and 15-30 cm, representing top and bottom samples. These are the soil depths at which most (>80%) of the plants feeder roots and soil micro-organisms are concentrated.

Plate 4.2: Soil Sampling

At each sampling station, three (3) samples were taken for each depth and composited to give one representative sample. All sampled points were geo-referenced in the field using the Garmin Geographic Positioning System (GPS) Equipment. Furthermore, field investigations on soil morphological properties as it affects slope, drainage/flooding, presence of soil structure impediments, texture mottling, were conducted. The physical appearances of contaminants such as hydrocarbons were also examined, alongside the land use practices. All soil samples connected were analysed in the laboratory using standard methods. The following sub-samples were taken for each depth, namely:

- Samples for physico-chemical parameters which were put into polythene bags.
- Samples for hydrocarbon analysis which were put into glass bottles.
- Samples for microbiological analysis collected McCartney bottles and stored in ice-packed coolers

4.2.5 Vegetation Studies

Vegetation studies were carried out at the same sampling stations with soil studies to determine the species composition, diversity, and population of plant species. The density and percentage of the key tree species and the herbaceous layer were determined while rare and endangered plant species and all those of special significance to the ecosystem and the local economy were categorized (Oosting, 1956). The species diversity of the plants was calculated as the ratio between the number of species and "importance value" which, for the purpose of this study, were taken as the number of individuals per quadrant (Odum, 1971).

The vegetation studies were carried out using a combination of line transects and quadrant sampling technique. At each sampling location, two quadrants measuring 10m x 10m and 1m x 1m were used to study trees and shrubs, and herbs respectively. The plant community structure was observed and the plant species within each quadrant were identified. The floral and vegetative parts of unidentified plant species were collected, pressed in the field with herbarium press, and taken to the laboratory for herbarium

4.2.6 Wildlife

This involved a survey/census of mammals, birds' reptiles and amphibians around the study area. Direct count method, using a pair of binoculars, was employed for the census of reptiles, birds and other animals which readily offered themselves for observation. The presence of some of the animals were ascertained by probing such humid habitant like logs, heaps of dead decaying leaves, forest undergrowth, ponds and burrows. Thus, all sighted, captured or dislodged animals were identified often on the spot to possible taxonomic levels using field guides and keys. (Walkey et al 1968; Elgood 1960; Happold 1987; Brach 1988).

The indirect method which makes use of evidence of animal's presence (Dasmann 1963) was used for species which do not offer themselves readily for observation. Interviews with hunters also provided further information on the wildlife diversity abundance and use in the area.

4.2.7 Aquatic Studies

4.2.7.1 Physico chemical

The hydrology of the project area consists of the ocean and channels. A total of five (5) stations were sampled for water. A water sampler was used to collect water samples at designated locations (Plate 4.3). Samples for BOD measurement were collected Winkler's bottles while samples for heavy metals analyses were collected in glass containers and acidified with concentrated nitric acid to avoid precipitation. Water samples for microbiology were collected in sterile McCartney bottles.

Unstable physiochemical parameters of water such as pH, DO, temperature, salinity, turbidity and conductivity were measured in-situ using pre-calibrated portable digital meters (Plate 4.3).

Plate 4.3: Water Sampling and In-situ Analysis

4.2.7.2 Sediment

Sediment Samples were collected at the water sampling points using an Eckman grab sampler (Plate 4.4). Sediment samples for physiochemical analysis were collected in polythene bags while those for microbiology analysis were collected in Aluminium foil.

Similarly, all the sediment samples were temporarily stored in ice packed coolers prior to transfer to the laboratory.

Plate 4.4: Sediment Sampling and Sample Preparation

4.2.7.2.1 Phytoplankton

At each water station, subsurface water was collected into pre-labelled wide mouthed (1-litre) plastic container and fixed immediately with Lugol's iodine solution. This method of phytoplankton collection was referred to the 'scan' technique. Samples were carefully packed in ice chests for transport to the laboratory.

4.2.7.2.2 Zooplankton

Zooplankton was sampled by towing 55µ mesh plankton net through the water until a volume of 50 litres of water has been filtered. In the laboratory, samples were made up to a uniform volume of 100ml using distilled water. Following a thorough agitation and homogenization, 1ml sub-samples were taken using a Stampel Pipette and transferred to a graded 1ml counting chamber for observation under a binocular microscope with magnification of 40 to 400x. The organisms were simultaneously identified and enumerated, and results entered on analysis sheets.

4.2.7.2.3 Periphyton

Periphyton was sampled by scraping them off hard substrates in the water. Area scrapped was $2cm^2$. All samples collected (except for Phytoplankton) were preserved in 5% Formalin solution. Samples were made up to 50mls, out of which 1ml sub-sample was analysed under a microscope. All organisms encountered within the counting chamber were identified and enumerated. This procedure was repeated twice for each sample. The results obtained were expressed as organism per unit area.

4.2.7.2.4 Benthos

Benthos was sampled with an Eckman grab. The grab was used to collect subsurface substrate at designated study sites and the collected substrate washed through asset of Tyler sieve nets of mesh size $1.5mm^2$. Organisms and other debris trapped by the net was transferred to a small plastic container and preserved in a 5% Formalin solution containing *Rose Bengal* stain. The solutions were made with water from the study environment.

4.2.8 Socio-Economic

Design of the Survey

The socio-economic data gathering involved the use of techniques like interview schedule, questionnaire administration, key informant interview and focus group discussion. These techniques have been found to be effective in participatory rural and learning appraisal techniques.

The field study was carried out across the identified host community and its sub-communities. This was facilitated by the community's representative and members of the community who are familiar with the data gathering exercise. These persons attended the pre-field mobilization meeting. In the study, both qualitative and quantitative techniques were used for data collection. As primary techniques of data gathering, community consultation and focus group discussions were also employed where community leaders and other participants served as respondents. In the process, probing questions on crucial socio-economic issues were posed and answers solicited from the participants in relation to their positions in community and level of knowledge **(*See Plate 4.5*)**.

Visitations were also carried out on the existing social infrastructural facilities and services such as education and health care to obtain necessary information on education and health aspects. As a survey instrument and primary data gathering tool, the administered questionnaire was structured such that binary, optional and open-ended questions were printed to generate relevant responses that regulatory authorities have always wanted addressed.

Random sampling technique was used in selecting respondents for the focus group discussions where the cross-section of community respondents was drawn from the adult population as the target. At the end of the focus group discussions (FGD) and community-wide interactions, copies of the structured questionnaire were administered to representative samples of respondents in the community with the help of the community leadership and facilitators.

Out of 55 (fifty-five) copied of the questionnaire administered, 46 (forty six) were retrieved, representing 83.6% success rate (***See Table 4.3***). Below are pictures photographed during focus group discussion (FGD) and questionnaire administration in the community.

Table 4.3: Focus Group Discussion (FGD) Venue and Questionnaire Administration

S/no	***Community***	***Questionnaire administered***	***Questionnaire retrieved***
1	Gelegele-gbene	55	46
Total		55	46 (83.6)

Socio-economic Data Analysis and Presentation

In analysing the primary and secondary data, simple descriptive methods and summary statistics like mean, range, mode and percentage were used. Some of the data were presented in table and graph formats. In addition, six key levels of aggregation and analysis were employed. These are national, regional, state, local government area, community and household/individual respondents.

Meanwhile, the population of the host community was projected using results of the 2006 national census released by the National Population Commission (NPC). The linear extrapolation and exponential growth model of population projection are often used in estimating population. While the linear extrapolation model assumes that population growth occurs in constant increment over time, the exponential model assumes that the rate of population growth is not just a constant change over time, but population grows faster as the population size increases. Put differently, population more often than not grows exponentially rather than linearly. The exponential growth model was used in estimating the population of the community, thus:

Exponential Growth Model: $P_n = P_o (1+r)^n$

Where:

P_o = Population in the base year

R = Annual growth rate of the population

N = Time lapse in years

Plate 4.5: Interactive session in Gelegele-gbene community with the CDC Chairman, Secretary, PRO and other members of the CDC ExCo present

4.2.9 Health-Impact

An integrated descriptive, cross-sectional study design was adopted for the community health survey. It involved community-based households and facility-based surveys. Quantitative data was complimented by qualitative information by way of key informant interviews of opinion leaders of the community to understand other socio-cultural and economic characteristics of the people that influenced their health statutes. Specifically, in depth interviews of the nurses in private and government medical centres were conducted.

Study Population

The study population comprised of all the individuals making up the *de facto population* of Gelegele community that were eligible for interviews and examination, health infrastructure, both public and private, that provided healthcare facility to the entire community. Nutritional Assessment of children was limited to children 0-59 months.

Sampling Size Determination

The sampling size for the study was determined using the formula:

$$n = \frac{z^2pq}{d^2}$$

Where:

n = minimal sample size

z = standard normal deviation (1.96 at 95% confidence level)

p = proportion in target population (50% or 0.5)

q = 1 – p

d = degree of accuracy (0.05)

$$n = \frac{(1.96)^2 \times (0.5) \times (0.5)}{(0.05)^2}$$

$$= 384.$$

The minimum sample size required for the survey was therefore arrived at as 400 households.

Sampling Techniques

The cluster sampling technique was adopted for the baseline survey. The technique has an advantage of being easier and faster to complete as the study populations occur in cluster and is often more acceptable to local communities. Four clusters were identified, out of which households were sampled using a random technique. I each cluster households were listed and the required number of households determined by a simple random method. This procedure was continued until a desired sample size was obtained.

In a household selected for the study, the heads of the household was interviewed by means of structured questionnaire and was physically examined. The examination consisted of blood pressure (BP) measurements, Ear, Nose and Throat (ENT) examinations, Hearing tests, Skin and Eye examinations. Children ages 0-59 months were measured for heights and weights mid-upper arm circumference.

4.2.10 Geologic Site Characterization

Penetrometer Tests

The penetrometer tests were carried out using the 2½-ton testing equipment.

The tests were terminated when the end and side resistance against the cone and the rods made the testing machine anchors to yield within the poor subsoil encountered near the ground surface at depths.

The basic principle of the penetrometer test is that a rod is pushed into the ground and the resistance on the tip (cone) of the rod is measured by a hydraulic system.

The cone, with a cross-sectional area of $1000mm^2$ and a cone apex angle of 60^0, is pushed to the required depth, at an approximate rate of 20mm/s, in the closed position by exerting pressure on the outer sounding tube. The force on the cone is then measured while the cone is pushed downward by means of the inner pressure rod independently of the outer sounding tube. This procedure is repeated at regular intervals of every 0.25m depth.

The tests carried out are as given below: -

Soil classification tests: These were carried out on disturbed samples and include inter alia the determination of the natural moisture content, the Atterberg (liquid and plastic) limits, the particle size distribution and hydrometer analysis.

Soil strength tests: Involve essentially the determination of the relevant strength parameters through the Quick Undrain Triaxial Compression Tests on undisturbed cohesive materials.

Soil deformation tests: These determine the consolidation (settlement) characteristics through the one-dimensional consolidation (oedometer) tests.

Chemical tests: The pH, sulphate and chloride content of the subsoil were determined to give an indication of the possibility of its proneness to be aggressive to concrete aggregates.

All the results of the field and laboratory tests are presented in tables and graphical forms in this report.

4.2.11 Land Use

Land use refers to the use of a given parcel of land is put into. On the other hand, the utilization of a parcel of land for any given purpose determines the use in which that land is put into.

The land use types found in the proposed project environments were measured and observed directly from the field. More so, land use types in each of the sampled communities were collapsed into one i.e., within a given local government area, all the land use types were valued and put together, and the average considered for analysis and discussion.

4.2.12 Water Quality

Methodology

Surface water samples were collected at low tide, while the groundwater was sampled from the boreholes. The sampling radius was 1 km from the perimeter boundary of the project Site. Water samples for physicochemical analyses were placed in a 2-litre plastic container which was previously rinsed three times with the water sample to be analysed and sealed appropriately. Those for total hydrocarbon (THC) measurements were placed in 1 litre glass containers concentrated hydrochloric acid (HCl) added and sealed with aluminium foil. While the samples for the heavy metal analyses were placed in 150ml plastic container concentrated nitric acid ($HN0_3$) added to adjust the pH to 2. Biochemical oxygen demand (BOD) samples were collected in 250ml brown reagent bottles, sealed to exclude air bubble while the dissolved oxygen (DO) samples were fixed immediately with Winkler's I and II reagents. All samples were preserved in a cool box and transported to the laboratory for analyses.

Quality Assurance/Quality Control

Standard field methods were used in the sample collection at the site as recommended by FEPA (1991). To ensure the integrity of some unstable physicochemical parameters *in-situ* measurements of temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), turbidity, salinity and total dissolved solids (TDS) were carried out in the field using water quality checker Horiba U-10. To maintain analytical accuracy, duplicate and blank samples were included in the analyses. Distilled water used for analysis conforms to ASTM D 1193 Type 1. Only qualified and trained personnel were employed in the laboratory work.

Sample Preservation and Storage

The water samples collected were stored in ice-packed coolers and preserved in accordance with Department of Petroleum Resources and Federal Ministry of Environment Guidelines and Standards. All water samples for heavy metals were preserved by the addition of concentrated $HN0_3$, while to the samples for total hydrocarbon concentrated HCl was added.

Laboratory (Analytical) Procedures

Laboratory analyses of the physicochemical parameters were carried out in keeping with standard practice specified in FMEnv Environmental Guidelines and Standards (FEPA 1991). Except otherwise stated, the laboratory methodologies for wastewater are from Standard Methods for the Examination of Water and Wastewater 19th Edition, 1998. Investigation involving the heavy metals concentrations was carried out using atomic spectrophotometer (AAS Unicam 969). Exchangeable cations and anions measured using flame photometer and UV/Visible spectrometer (Unicam Helios Gamma, UVG 073201; Spectronic 21D). Briefly, the methods employed are as follows:

pH, Electrical conductivity, Turbidity, Dissolved solids, Temperature and Salinity

Measured using Horiba Water Checker (Model U-10) after calibrating the instrument with the standard Horiba solution. The units of measurement are µS/cm, NTU, mg/l, ^{0}C and ‰; respectively for conductivity, turbidity, temperature and salinity.

Dissolved Oxygen (APHA-4500 C)

The dissolved oxygen (DO) was determined by the Modified Azide or Winkler's method (APHA 1998). To a 70ml BOD bottle filled with sample. 0.5ml manganous sulphate (Winkler I) solution and 0.5ml alkali-iodide-azide reagent (Winkler II) were added, stopper (excluding air bubbles) and mixed by several inversions. After about 10minutes, 0,5ml conc. H_2S0_4 is added, re-stopper and mixed for complete dissolution of precipitate. The fixed sample is taken to the laboratory for further analysis.

Bio-chemical Oxygen Demand (APHA-5210-B)

Known portion of the water sample collected is diluted with oxygenated and incubated at 20^{0}C for five days. At the end of the incubation period the samples were treated in the same manner as the DO samples stated above. Detection limits 2.0mg/l.

Total Alkalinity (API-RP 45)

Bicarbonate determination is by titration with 0.02N H_2SO_4 using methyl orange indicator. The detection limit is 1.0mg/l as $CaCO_3$ (APHA, 1985).

Chloride (APHA 4500 – Cl^- B)

Chloride is titrimetrically determined by the Argentometric method in the presence of potassium chromate as indicator. Limit of detection is 1.0mg/l

Sulphate (APHA 4500-SO_4^{2-} E/AST MID 516)

Sulphate determination is by the turbidimetric method (APHA 1998). To a 50ml sample or portion diluted to 50-ml contained in a conical flask, 2.5-ml of conditioning reagent (i.e. a mixture of 50ml glycerol with a solution of 30ml concentrated hydrochloric acid, 300ml distilled water, 100ml 95% ethanol and 75g sodium chloride) and a quarter spatula full barium chloride ($Bacl_2$). The mixture is swirled for a minute and the barium sulphate ($BaSO_4$) turbidity read at fifth minute on Spectronic 21D at 420nm against water. Sulphate level was read from a calibration curve prepared for known sulphate standards treated the same way as the samples. The detection limit is 1.0mg/l.

Phosphate (APHA 4500-P E/ASTM D 515)

Phosphate is determined using the stannous chloride method (APHA, 1998). To 50ml sample, the following were added with mixing 2.0ml ammonium molybdate reagent and 0.2ml stannous chloride reagent. After 10 minutes but before 12 minutes from addition of stannous chloride, the absorption of the treated sample is read on Spectronic 21D at 690nm. Phosphate level is obtained by reading off absorption level from standards curve of known standards treated as the samples. The detection limit is 0.05mg/l.

Nitrate

Nitrate measurement is by Ultraviolet Spectrophotometric screening method. To 50ml clear sample, 1ml HCl solution was added and mixed thoroughly. Absorbance measurements made at the wavelength of 220nm and the nitrate concentration obtained from the standard curve. Limit of detection is 0.05mg/l.

Total Hydrocarbon Content (THC) ASTM D3921 (Extraction/Spectrophotometry)

A known volume of the sample was well agitated and poured into a separatory funnel. A known quantity of sodium chloride was added to prevent emulsification. 50ml of xylene was added to the sample container and then shaken properly to rinse the container before transferring into the separatory funnel. The funnel was corked and shaken vigorously for about 1 minute. The mixture was allowed to stand for separation. The sample portion was run-off by opening the tap and then the extract transferred into a 100ml centrifuge tube by passing it through a filter paper containing 1g of sodium sulphate. The extraction process was repeated with another 50ml of xylene. The xylene layer was then collected into same centrifuge tube containing the first extract.

The separatory funnel was rinsed with 10ml xylene before transferring into the centrifuge tube. The extract was centrifuge for 15mins at 1500 rpm and placed in a standard cuvette with a light path of 10mm. The spectrophotometer was standardized, and sample readings taken. THC concentration was calculated with reference to the standard curve and multiplication by the appropriate dilution factor. Detection limit is 0.01mg/l.

Heavy metals (Cr, Cu, Pb, Fe, Cd, Ni, Zn) APHA 3111-B (AAS)

Heavy metals were determined using an Atomic Absorption Spectrophotometer (AA) as described in APHA 3111B and ASTM D3651. This involved direct aspiration of the sample into an air/acetylene or nitrous oxide/acetylene flame generated by a hollow cathode lamp at a specific wavelength peculiar only to the metal programmed for analysis. For every metal investigated, standards and blanks were prepared and used for calibration before samples were aspirated. Concentrations at specific absorbance displayed on the data system monitor for printing. Limit of detection is <0.01mg/l.

Microbiology

Methods of Sample Collection

(a) Water samples were collected in accordance with the procedures described in standard methods for water and wastewater analysis (APHA, 1998). The same is accepted and adapted by FMEnv as standards for Nigeria. According to the procedure, 200ml of sterilized sample bottle was used for collecting water sample.

(b) The samples were preserved in an ice-cooled container and transported to the laboratory for analysis. All analysis was carried out in the Jacio Environmental Services Laboratory, Warri, Delta State.

Quality Control Measures

i) Clean sterile containers were used for sample collection to avoid external contamination of the sample.

ii) Sample was transported in an ice packed cooler to the laboratory and analysed within 2 hours of collection or stored in refrigerator for analysis at other days.

iii) Procedures for sample collection were done aseptically and in accordance with standard procedures.

Methods of Sample Analysis

(a) Enumeration of Bacteria

Serial dilution procedure as described by Obire and Wemedo (1996); Ofunne (1999) was employed for cultivation and enumeration of bacteria and fungi in the water samples. The ten-fold serial dilution was used to obtain appropriate dilutions of the samples. Aliquots of the required dilutions were plated in duplicates onto the surface of dried sterile nutrient agar (for total heterotrophic bacteria). In case of total/faecal coliform bacteria, the most probable number (MPN) technique described by Collins and Lyne, (1980) was employed for estimation of their numbers in water. Appropriate volumes of undiluted water samples were inoculated into test tubes of MacConkey broth medium. All inoculated media were incubated at 37^0C for 24 hours or 3-7 days except for faecal coliform bacterial set up incubated at 44.5^0C.

(b) Media used for enumeration of microorganisms

(i) Nutrient agar medium used for enumeration of total heterotrophic bacteria prepared according to manufacturer's specifications.

(ii) MacConkey broth medium for estimation of total/faecal coliform bacteria in water.

(c) Quality Control Measures

(i) Samples were analyzed in standard microbiological laboratory in accordance with standard procedures.

(ii) Procedures for cultivation and enumeration of bacteria were carried out aseptically to avoid contamination from external sources.

(iii) All media and glass wares used were sterilized in an autoclave at 121^{o}C for 15 minutes.

4.3 BASELINE RESULTS AND DISCUSSION

4.3.1 Air Quality and Noise

The gases monitored are Nitrogen oxide (NO and NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), hydrogen sulphide (H_2S), hydrocarbon gases (CxHy) and suspended particulate matter (SPM). Generally, the concentrations of the measured air pollutants in the ambient atmosphere suggest that the area is a relatively pristine environment. More so the values recorded were within acceptable regulatory limits.

The concentrations of gaseous pollutants recorded within the community represent background levels or baseline conditions of the proposed project area. The low concentrations of gaseous pollutants obtained in the project area during this study 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.

Table 4.4 and 4.5 are National Air Quality Standards and Noise limits which results from this study are compared with.

Table 4.4: Nigerian Ambient Air Quality Standard (FMENV 1991)

POLLUTANTS	TIME OF AVERAGE	FMENV LIMIT
Particulates	Daily average of daily	250 µg/m3
	values 1 hour	600 µg/m3
Sulphur Oxides (SOx)	Daily average of hourly values 1 hour	0.01ppm(26µg/m3) 0.1ppm (260µg/m3)
Non Methane Hydrocarbon	Daily average of hourly values 3 hour	160 µg/m3
Carbon monoxide	Daily average of hourly values 8 hourly ave. 1-hour mean	10ppm (11.4 µg/m3) 20ppm (22.8 µg/m3)
Nitrogen Oxides	Daily average of hourly values (range)	0.04ppm-0.06 ppm (75.0 µg/m3 -112 µg/m3)

Photochemical Oxidant	Hourly values	0.06 ppm

Table 4.5: NOISE EXPOSURE LIMITS FOR NIGERIA

Duration per Day, Hour	Permissible Exposure Limit dB (A)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: FEPA Guidelines & standards for environmental Pollution Control in Nig. 1992)

Note: Exposure to impulsive or impact noise should not exceed 140 dB (A) peak sound pressure level.

When the gaseous pollutants (SO_X, VOCs, NOx, H_2S, CO and CO_2) were extrapolated to 24-hour averaging period concentration in the (Table 3.3) for the purpose of impact assessment. The daily equivalents of the measured SO_X were 0.00-0.25 ppm with an average of 0.039 ppm. The measured VOC_S became 76.4-361.4 ppm with an average of 123.68 ppm, while NO_X daily equivalents was measured to be 0.023-0.568 ppm with an average of 0.079 ppm. The measured daily was equivalent for H_2S was 0.000-0.083 ppm with an average of 0.013 ppm while that of CO was quantified to be 0.00-1.66 ppm with an average of 0.125 ppm. The daily averaging period concentration for CO_2 was measured to be 0.00-0.06 ppm with an average of 0.024 ppm.

Table below summarized the extrapolated 24- hour averaging for (SO_X, VOCs, NOx, H_2S, CO and CO_2) for the impact assessment study. The daily equivalents of the measured SO_X, was measured to be 0.00 ppm with an average of 0.00 ppm. The VOC_S daily concentration became 158.5-297.9 ppm with an average of 230.44 ppm while NO_X daily concentration was estimated to be 0.000-0.012 ppm with an average of 0.003 ppm, H_2S daily concentration was estimated to be 0.00-0.58 ppm with an average of 2.804 ppm while that of CO was estimated to be 0.00 ppm. The daily averaging period of CO_2 was estimated to be 0.014-0.034 ppm with an average of 0.037 ppm

Table 3.5 showed that the daily concentration of SPM_{10} in the wet season were measured to be 8.5-11.93 $\mu g/m^3$ with an average of 9.65 $\mu g/m^3$ while $SPM_{2.5}$ values were measured to be 26.7-8.69 $\mu g/m^3$ with an average of 11.811 $\mu g/m^3$ Table 3.6 showed that the daily concentrations of SPM_{10} in the dry season were measured to be 32.07-66.51 $\mu g/m^3$ with an average of 44.5 $\mu g/m^3$ while that of $SMP_{2.5}$ were measured to be 29.44-42.79$c.\ \mu g/m^3$ with an average of 33.97 ppm

- **SO_2**: After estimating 24-hour daily concentrations, it was observed that SO_2 daily concentrations were breached in 13 sampling locations out of 30 locations and one control location using 0.01 ppm 24 hour limit of Federal Ministry of Environment. However, all the 25 sampling locations measured in the dry season were within the limits including the three control locations.
- **VOC_S** : The estimated 24 hour daily concentration revealed that VOC_S concentration were breached in 5 out of 30 sampling locations using 160 $\mu g/m^3$ 24 hour limit of Federal Ministry of Environment. The two control locations were within the limits of VOC_S standard of FMEnv. In the dry season, all the 25 sampling locations (22 sampling locations and 3 control locations) breached the 160 $\mu g/m^3$ limit of FMEnv except the last control location.
- **NO_X:** The estimated 24-hours daily concentration revealed that NO_X were breached in 25 out of 30 sampling locations using 0.04 ppm 24 hour limit of Federal Ministry of Environment. One of out the 2 control locations were also breached. In the dry season, all the sampling locations including the control locations were within the limit of FMEnv. (0.04 ppm).
- **H_2S:** The estimated 24 –hour daily concentrations revealed that they are all within the 42$\mu g/m^3$ of H_2S USEPA limit for both wet and dry seasons.
- **CO:** The estimated 24 hours daily concentration of CO revealed that the concentration were detected in only 4 sampling locations and their values were all within the limit 0f 10 ppm of FMEnv in the wet season. In the dry season, there were no detection of CO concentrations in all the 22-sampling location and the 3 locations.
- **CO_2:** The estimated 24-hour daily concentrations revealed that they are all within the World Health Organization limit for CO_2 (1000 ppm) for 24-hour averaging period

Table 4.5b: Measured Toxic Gases, Greenhouse Gases and Particulates During the Field Work in the Wet Season

S/N	Sample ID	Sampling Coordinates		Toxic gases, GHGs and Particulates								Microclimates		
		N	E	SO_2 (ppm)	VOC (ppm)	NOx (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	SPM_{10} (µg/m^3)	$SPM_{2.5}$ (µg/m^3)	Temp (ºC)	RH (%)	WS (m/s)
1	AQ1	6.15599	5.33156	0.3	435	0.093	0.0	0.0	0.05	17.8	18.3	38.2	500.6	0.0
2	AQ2	6.14769	5.3316	0.1	323	0.081	0.0	2.0	0.05	20.1	20.7	36.3	60.8	0.0
3	AQ3	6.14735	5.3365	0.1	195	0.063	0.0	0.90	0.05	21.6	22.4	36.6	57.1	0.0
4	AQ4	6.1489	5.3396	0.1	311	0.064	0.0	0.0	0.06	20.8	28.7	36.1	63.3	0.8
5	AQ5	6.14764	5.3317	0	155	0.028	0.0	0.0	0.05	20	20.6	34.7	70,0	0.0
6	AQ6	6.1473	5.33146	0.1	133	0.042	0.0	0.0	0.03	18.5	19.3	34.9	76.4	0.5
7	AQ7	6.14736	5.3397	0	217	0.049	0.0	0.0	0.05	17.9	18.6	34.8	71.2	0.3
8	AQ8	6.14737	5.3447	0.0	115	0.031	0.0	0.0	0.06	19.5	25.1	33.3	74.1	0.5
9	AQ9	6.1398	5.3314	0.0	101	0.046	0.0	0.7	0.03	18.9	19.7	33.8	70.8	0.5
10	AQ10	6.1397	5.3365	0.1	92	0.092	0.0	0.0	0.05	20.5	21.3	34.2	76.2	0.0
11	AQ11	6.1398	5.3406	0.0	121	0.047	0.0	0.9	0.05	20.3	28.9	33.5	71.6	0.0
12	AQ12	6.1392	5.3453	0.0	113	0.031	0.0	0.0	0.03	21.4	22.8	37.2	77.4	0.2
13	AQ13	6.1362	5.3313	0.1	110	0.057	0.0	0.0	0.05	20.3	24.3	35.4	70.6	0.0
14	AQ14	6.1361	5.3355	0.1	106	0.065	0.0	0.0	0.05	20.8	21.7	35.8	65.2	0.1
15	AQ15	6.1361	5.3406	0.0	76.4	0.069	0.0	0.0	0.06	18.8	24.1	34.9	49.2	0.7
16	AQ16	6.136	5.3463	0.0	110	0.123	0.0	0.0	0.00	21.3	33.8	34.9	70.2	0.0
17	AQ17	6.1318	5.3313	0.0	115	0.110	0.1	0.0	0.00	23.4	52.1	34.8	71.3	0.1
18	AQ18	6.14677	5.33379	0.1	118	0.020	0.0	0.0	0.00	20.1	25.6	35.1	70.5	0.4
19	AQ19	6.1316	5.341	0.0	112	0.114	0.0	0.0	0.00	22.3	28.9	34.9	71.6	0.3
20	AQ20	6.13142	5.3463	0.0	92	0.101	0.0	0.0	0.00	21.5	24.8	34.7	70.8	0.1
21	AQ21	6.15403	5.3454	0.1	110	0.121	0.1	0.0	0.00	20.3	23.6	35.2	71.4	0.2
22	AQ22	6.15018	5.3352	0.0	108	0.085	0.0	0.0	0.00	18.8	20.6	36.9	58.7	0.1
23	AQ23	6.14952	5.3401	0.0	118	0.072	0.1	0.0	0.00	20.0	30.6	34.8	64.6	0.0
24	AQ24	6.14402	5.3489	0.1	111	0.053	0.0	0.0	0.00	22.1	55.4	35.2	65.8	0.0
25	AQ25	6.13465	5.3497	0.0	116	0.108	0.0	0.0	0.00	23.70	29.2	35.8	62.7	0.2
26	AQ26	6.12933	5.3423	0.0	94	0.0903	0.1	0.0	0.00	21,8	26.5	36.3	68.2	0.3
27	AQ27	612999	5.3342	0.1	110	0.12	0.0	0.0	0.00	24.70	28.3	33.7	61.8	0.0
28	AQ28	6.14801	5.3298	0.0	112	0.684	0.1	0.0	0.00	18.20	21.8	32.6	71.8	0.0
29	AQ29	6.15011	5.3286	0.1	115	0.102	0.0	0.0	0.00	19.80	24.7	33.3	66.4	0.3
30	AQ30	6.17194	5.3328	0.0	108	0.094	0.0	0.0	0.00	21.80	27.6	34.2	62.8	0.1
31	Ctrl1	6.15011	5.312333	0.1	100	0.111	0.0	0.0	0.00	17.60	18.0	32.4	64.5	0.4
32	Crtl2	6.17194	5.3577	0.0	110	0.120	0.0	0.0	0.00	18.1	18.8	32.7	58.6	1.5

Table 4.5c: Measured Toxic Gases, Greenhouse Gases and Particulates During the Field Work in the Dry Season

S/N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates								Microclimates			
		N	E	SO_X (ppm)	VOC (ppm)	NOx (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	SPM_{10} (µg/dm$_3$)	$SPM_{2.5}$ (µg/dm^3)	Temp (ºC)	RH (%)	WS (m/s)	WD
1	AQ1	6.14742	5.3329	0.0	315	0.00	0.6	0.0	0.05	78.9	67.2	33.4	64.2	0.0	
2	AQ2	6.14751	5.33347	0.0	359	0.012	0.3	0.0	0.05	95.3	81.0	32.8	60.8	0.0	
3	AQ3	6.14771	5.33291	0.0	267	0.00	0.5	0.0	0.05	136.1	83.0	31.7	64.5	0.0	
4	AQ4	6.14722	5.33296	0.0	234	0.00	0.5	0.0	0.06	102.1	82.9	32.9	63.2	1.0	
5	AQ5	6.14745	5.33229	0.0	333	0.00	0.7	0.0	0.05	94.0	69.3	36.4	50.2	0.0	
6	AQ6	6.14773	5.33263	0.0	193	0.014	0.5	0.0	0.03	82.6	70.0	37.9	43.3	0.0	
7	AQ7	6.14724	5.33282	0.0	205	0.00	0.3	0.0	0.05	85.5	76.7	36.6	48.9	0.0	
8	AQ8	6.14690	5.33299	0.0	211	0.016	0.65	0.0	0.06	89.8	64.8	35.1	52.5	1.7	
9	AQ9	6.14772	5.33621	0.0	227	0.00	0.6	0.0	0.03	91.3	69.5	35.3	49.4	1.8	
10	AQ10	6.14693	5.33897	0.0	273	0.012	0.5	0.0	0.05	112.2	88.6	35.1	49.1	0.0	
11	AQ11	6.14742	5.33233	0.0	265	0.00	0.5	0.0	0.05	75.7	62.4	35.7	47.6	2.5	
12	AQ12	6.14769	5.33388	0.0	285	0.014	0.3	0.0	0.03	85.8	68.3	35.4	48.2	1.8	
13	AQ13	6.14788	5.33205	0.0	293	0.012	0.6	0.0	0.05	100.8	64.3	36.8	45.6	0.0	
14	AQ14	6.14756	5.33296	0.0	276	0.00	0.5	0.0	0.05	98.2	66.0	37.6	45.0	0.0	
15	AQ15	6.14789	5.33182	0.0	237	0.00	0.7	0.0	0.06	78.0	63.6	38.7	43.6	1.8	
16	AQ16	6.14762	5.33206	0.0	241	0.0	0.1	0.0	0.05	109.8	66.7	39.0	40.0	0.0	
17	AQ17	6.14747	5.33199	0.0	235	0.0	0.0	0.0	0.07	77.6	66.4	39.2	40.7	0.0	
18	AQ18	6.14774	5.33178	0.0	226	0.0	0.0	0.0	0.05	100.9	70.7	37.0	46.2	1.5	
19	AQ19	6.14782	5.33224	0.0	256	0.0	0.0	0.0	0.05	102.4	68.3	37.3	46.4	1.8	
20	AQ20	6.14697	5.33336	0.0	226	0.0	0.0	0.0	0.06	66.4	60.9	36.4	44.4	2.3	
21	AQ21	6.14673	5.33382	0.0	238	0.0	0.0	0.0	0.03	77.7	67.7	34.8	54.3	0.0	
22	AQ22	6.14653	5.33303	0.0	231	0.0	0.0	0.0	0.05	86.9	69.1	35.1	53.1	0.0	
23	CTRL1	6.15578	5.34489	0.0	308	0.0	0.0	0.0	0.03	137.7	73.9	37.7	41.6	2.6	
24	CTRL2	6.15578	5.34243	0.0	217	0.0	0.0	0.0	0.04	85.7	68.1	37.4	39.4	2.0	
25	CTRL3	6.15026	5.34243	0.0	191	0.0	0.0	0.0	0.07	86.3	67.1	37.3	40.5	0.2	

Tables 4.5d: Extrapolated 24-hours Averaging Period for Toxic Gas and Greenhouse Gases in the Wet Season.

S/N	Sample ID	Sampling Coordinates		Toxic gases and GHGs						Microclimates		
		N	E	SO_2 (ppm)	VOC (ppm)	NOx (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	Temp (ºC)	RH (%)	WS (m/s)
1	AQ1	6.15599	5.33156	0.144	208.8	0.04464	0.0	0.0	0.024	38.2	500.6	0.0
2	AQ2	6.14769	5.3316	0.048	155.04	0.03888	0.0	0.990	0.024	36.3	60.8	0.0
3	AQ3	6.14735	5.3365	0.048	93.60	0.03024	0.0	0.430	0.024	36.6	57.1	0.0
4	AQ4	6.1489	5.3396	0.048	149.28	0.03072	0.0	0.000	0.0288	36.1	63.3	0.8
5	AQ5	6.14764	5.3317	0.000	74.40	0.01344	0.0	0.000	0.024	34.7	70,0	0.0
6	AQ6	6.1473	5.33146	0.048	63.84	0.02016	0.0	0.000	0.0144	34.9	76.4	0.5
7	AQ7	6.14736	5.3397	0.000	104.16	0.024	0.0	0.000	0.024	34.8	71.2	0.3
8	AQ8	6.14737	5.3447	0	104.81	0.015	0.0	0.000	0.029	33.3	74.1	0.5
9	AQ9	6.1398	5.3314	0	48.78	0.022	0.0	0.320	0.013	33.8	70.8	0.5
10	AQ10	6.1397	5.3365	0.0483	44.44	0.044	0.0	0.000	0.024	34.2	76.2	0.0
11	AQ11	6.1398	5.3406	0	58.44	0.023	0.0	0.430	0.043	33.5	71.6	0.0
12	AQ12	6.1392	5.3453	0	54.58	0.015	0.0	0.000	0.014	37.2	77.4	0.2
13	AQ13	6.1362	5.3313	0.048	53.13	0.028	0.0	0.000	0.024	35.4	70.6	0.0
14	AQ14	6.1361	5.3355	0.048	51.2	0.031	0.0	0.000	0.024	35.8	65.2	0.1
15	AQ15	6.1361	5.3406	0	44.45	0.04	0.0	0.000	0.03	34.9	49.2	0.7
16	AQ16	6.136	5.3463	0	53.13	0.059	0.0	0.000	0.00	34.9	70.2	0.0
17	AQ17	6.1318	5.3313	0	55.55	0.053	0.0	0.000	0.00	34.8	71.3	0.1
18	AQ18	6.14677	5.33379	0.048	56.99	0.0244	0.0	0.000	0.00	35.1	70.5	0.4
19	AQ19	6.1316	5.341	0	53.76	0.009	0.0	0.000	0.00	34.9	71.6	0.3
20	AQ20	6.13142	5.3463	0	44.44	0.049	0.0	0.000	0.00	34.7	70.8	0.1
21	AQ21	6.15403	5.3454	0.048	53.13	0.058	0.0	0.000	0.00	35.2	71.4	0.2
22	AQ22	6.15018	5.3352	0	52.9	0.041	0.0	0.000	0.00	36.9	58.7	0.1
23	AQ23	6.14952	5.3401	0	56.99	0.034	0.0	0.000	0.00	34.8	64.6	0.0
24	AQ24	6.14402	5.3489	0.048	53.15	0.025	0.0	0.000	0.00	35.2	65.8	0.0
25	AQ25	6.13465	5.3497	0	57.3	0.052	0.0	0.000	0.00	35.8	62.7	0.2
26	AQ26	6.12933	5.3423	0	46	0.045	0.0	0.000	0.00	36.3	68.2	0.3
27	AQ27	612999	5.3342	0.048	53.13	0.059	0.0	0.000	0.00	33.7	61.8	0.0
28	AQ28	6.14801	5.3298	0	55.7	0.341	0.0	0.000	0.00	32.6	71.8	0.0
29	AQ29	6.15011	5.3286	0.048	55.9	0.05	0.0	0.000	0.00	33.3	66.4	0.3
30	AQ30	6.17194	5.3328	0	53.5	0.045	0.0	0.000	0.00	34.2	62.8	0.1
31	Ctrl1	6.15011	5.312333	0.048	48.3	0.052	0.0	0.000	0.00	32.4	64.5	0.4
32	Crtl2	6.17194	5.3577	0	53.13	0.059	0.0	0.000	0.00	32.7	58.6	1.5

Tables 4.5e: Extrapolated 24-hours Averaging Period for Toxic Gas and Greenhouse Gases in the Dry Season.

S/N	Sample ID	Sampling Coordinate		Toxic Gases						Microclimates			
		N	E	SO_X (ppm)	VOC (ppm)	NOx (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	Temp (ºC)	RH (%)	WS (m/s)	WD
1	AQ1	6.14742	5.3329	0.0	152.1	0.00	0.29	0.0	0.024	33.4	64.2	0.0	
2	AQ2	6.14751	5.33347	0.0	173.4	0.006	0.14	0.0	0.024	32.8	60.8	0.0	
3	AQ3	6.14771	5.33291	0.0	129.0	0.00	0.24	0.0	0.024	31.7	64.5	0.0	
4	AQ4	6.14722	5.33296	0.0	113.0	0.00	0.24	0.0	0.029	32.9	63.2	1.0	
5	AQ5	6.14745	5.33229	0.0	160.8	0.00	0.33	0.0	0.024	36.4	50.2	0.0	
6	AQ6	6.14773	5.33263	0.0	93.2	0.007	0.24	0.0	0.014	37.9	43.3	0.0	
7	AQ7	6.14724	5.33282	0.0	99.0	0.00	0.14	0.0	0.024	36.6	48.9	0.0	
8	AQ8	6.14690	5.33299	0.0	101.9	0.008	0.31	0.0	0.029	35.1	52.5	1.7	
9	AQ9	6.14772	5.33621	0.0	109.6	0.00	0.29	0.0	0.014	35.3	49.4	1.8	
10	AQ10	6.14693	5.33897	0.0	131.9	0.006	0.24	0.0	0.024	35.1	49.1	0.0	
11	AQ11	6.14742	5.33233	0.0	128.0	0.00	0.24	0.0	0.024	35.7	47.6	2.5	
12	AQ12	6.14769	5.33388	0.0	137.7	0.007	0.14	0.0	0.014	35.4	48.2	1.8	
13	AQ13	6.14788	5.33205	0.0	141.5	0.006	0.29	0.0	0.024	36.8	45.6	0.0	
14	AQ14	6.14756	5.33296	0.0	133.3	0.00	0.24	0.0	0.024	37.6	45.0	0.0	
15	AQ15	6.14789	5.33182	0.0	114.5	0.00	0.34	0.0	0.029	38.7	43.6	1.8	
16	AQ16	6.14762	5.33206	0.0	116.4	0.0	0.05	0.0	0.024	39.0	40.0	0.0	
17	AQ17	6.14747	5.33199	0.0	113.5	0.0	0.0	0.0	0.034	39.2	40.7	0.0	
18	AQ18	6.14774	5.33178	0.0	109.2	0.0	0.0	0.0	0.024	37.0	46.2	1.5	
19	AQ19	6.14782	5.33224	0.0	123.6	0.0	0.0	0.0	0.024	37.3	46.4	1.8	
20	AQ20	6.14697	5.33336	0.0	109.2	0.0	0.0	0.0	0.029	36.4	44.4	2.3	
21	AQ21	6.14673	5.33382	0.0	115.0	0.0	0.0	0.0	0.014	34.8	54.3	0.0	
22	AQ22	6.14653	5.33303	0.0	111.6	0.0	0.0	0.0	0.024	35.1	53.1	0.0	
23	CTRL1	6.15578	5.34489	0.0	148.8	0.0	0.0	0.0	0.014	37.7	41.6	2.6	
24	CTRL2	6.15578	5.34243	0.0	104.8	0.0	0.0	0.0	0.019	37.4	39.4	2.0	
25	CTRL3	6.15026	5.34243	0.0	92.3	0.0	0.0	0.0	0.034	37.3	40.5	0.2	

Table 4.5f: Extrapolated 24-hours Averaging Period for Particulates in the Wet Season.

S/N	Sample ID	Sampling Coordinate		Particulates		Microclimates		
		N	E	SPM_{10} (μg/m^3)	$SPM_{2.5}$ (μg/m^3)	Temp (°C)	RH (%)	WS (m/s)
1	AQ1	6.15599	5.33156	17.8	18.3	38.2	500.6	0.0
2	AQ2	6.14769	5.3316	20.1	20.7	36.3	60.8	0.0
3	AQ3	6.14735	5.3365	21.6	22.4	36.6	57.1	0.0
4	AQ4	6.1489	5.3396	20.8	28.7	36.1	63.3	0.8
5	AQ5	6.14764	5.3317	20	20.6	34.7	70,0	0.0
6	AQ6	6.1473	5.33146	18.5	19.3	34.9	76.4	0.5
7	AQ7	6.14736	5.3397	17.9	18.6	34.8	71.2	0.3
8	AQ8	6.14737	5.3447	19.5	25.1	33.3	74.1	0.5
9	AQ9	6.1398	5.3314	18.9	19.7	33.8	70.8	0.5
10	AQ10	6.1397	5.3365	20.5	21.3	34.2	76.2	0.0
11	AQ11	6.1398	5.3406	20.3	28.9	33.5	71.6	0.0
12	AQ12	6.1392	5.3453	21.4	22.8	37.2	77.4	0.2
13	AQ13	6.1362	5.3313	20.3	24.3	35.4	70.6	0.0
14	AQ14	6.1361	5.3355	20.8	21.7	35.8	65.2	0.1
15	AQ15	6.1361	5.3406	18.8	24.1	34.9	49.2	0.7
16	AQ16	6.136	5.3463	21.3	33.8	34.9	70.2	0.0
17	AQ17	6.1318	5.3313	23.4	52.1	34.8	71.3	0.1
18	AQ18	6.14677	5.33379	20.1	25.6	35.1	70.5	0.4
19	AQ19	6.1316	5.341	22.3	28.9	34.9	71.6	0.3
20	AQ20	6.13142	5.3463	21.5	24.8	34.7	70.8	0.1
21	AQ21	6.15403	5.3454	20.3	23.6	35.2	71.4	0.2
22	AQ22	6.15018	5.3352	18.8	20.6	36.9	58.7	0.1
23	AQ23	6.14952	5.3401	20.0	30.6	34.8	64.6	0.0
24	AQ24	6.14402	5.3489	22.1	55.4	35.2	65.8	0.0
25	AQ25	6.13465	5.3497	23.70	29.2	35.8	62.7	0.2
26	AQ26	6.12933	5.3423	21,8	26.5	36.3	68.2	0.3
27	AQ27	612999	5.3342	24.70	28.3	33.7	61.8	0.0
28	AQ28	6.14801	5.3298	18.20	21.8	32.6	71.8	0.0
29	AQ29	6.15011	5.3286	19.80	24.7	33.3	66.4	0.3
30	AQ30	6.17194	5.3328	21.80	27.6	34.2	62.8	0.1
31	Ctrl1	6.15011	5.312333	17.60	18.0	32.4	64.5	0.4
32	Crtl2	6.17194	5.3577	18.1	18.8	32.7	58.6	1.5

Table 4.5g: Extrapolated 24-hours Averaging Period for Particulates in the Dry Season.

S/N	Sample ID	Sampling Coordinate		Particulates		Microclimates		
		N	E	SPM_{10} (µg/dm_3)	$SPM_{2.5}$ (µg/dm^3)	Temp (°C)	RH (%)	WS (m/s)
1	AQ1	6.14742	5.3329	78.9	67.2	33.4	64.2	0.0
2	AQ2	6.14751	5.33347	95.3	81.0	32.8	60.8	0.0
3	AQ3	6.14771	5.33291	136.1	83.0	31.7	64.5	0.0
4	AQ4	6.14722	5.33296	102.1	82.9	32.9	63.2	1.0
5	AQ5	6.14745	5.33229	94.0	69.3	36.4	50.2	0.0
6	AQ6	6.14773	5.33263	82.6	70.0	37.9	43.3	0.0
7	AQ7	6.14724	5.33282	85.5	76.7	36.6	48.9	0.0
8	AQ8	6.14690	5.33299	89.8	64.8	35.1	52.5	1.7
9	AQ9	6.14772	5.33621	91.3	69.5	35.3	49.4	1.8
10	AQ10	6.14693	5.33897	112.2	88.6	35.1	49.1	0.0
11	AQ11	6.14742	5.33233	75.7	62.4	35.7	47.6	2.5
12	AQ12	6.14769	5.33388	85.8	68.3	35.4	48.2	1.8
13	AQ13	6.14788	5.33205	100.8	64.3	36.8	45.6	0.0
14	AQ14	6.14756	5.33296	98.2	66.0	37.6	45.0	0.0
15	AQ15	6.14789	5.33182	78.0	63.6	38.7	43.6	1.8
16	AQ16	6.14762	5.33206	109.8	66.7	39.0	40.0	0.0
17	AQ17	6.14747	5.33199	77.6	66.4	39.2	40.7	0.0
18	AQ18	6.14774	5.33178	100.9	70.7	37.0	46.2	1.5
19	AQ19	6.14782	5.33224	102.4	68.3	37.3	46.4	1.8
20	AQ20	6.14697	5.33336	66.4	60.9	36.4	44.4	2.3
21	AQ21	6.14673	5.33382	77.7	67.7	34.8	54.3	0.0
22	AQ22	6.14653	5.33303	86.9	69.1	35.1	53.1	0.0
23	CTRL1	6.15578	5.34489	137.7	73.9	37.7	41.6	2.6
24	CTRL2	6.15578	5.34243	85.7	68.1	37.4	39.4	2.0
25	CTRL3	6.15026	5.34243	86.3	67.1	37.3	40.5	0.2

Noise Level

The average minimum and maximum noise levels recorded at the project area during wet season was 40.48 dB and 51.64 dB respectively while during the dry season the average minimum and maximum noise level was 44.88 dB and 74.99 dB respectively. A large proportion of background noise in the area is due to human activities and noise from engine of the boat around the project area. In spite of this, the mean values recorded for both seasons are still below the FMEnv limit of 90dB (A) for 8 hours exposure respectively.

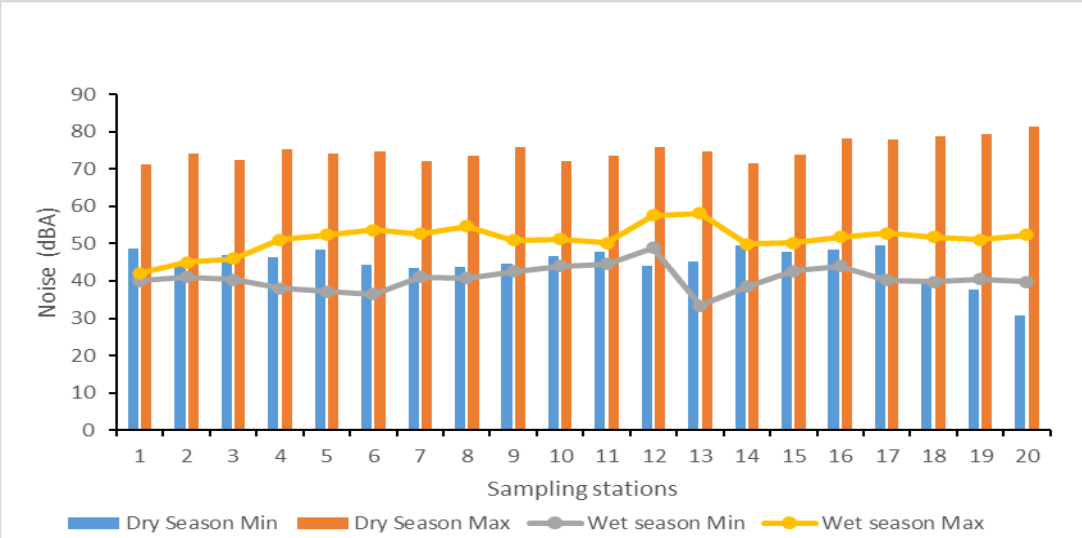


Figure 4.1: Noise Level variation for wet and dry seasons

➢ ***Baseline macroclimatic description of the study area***

Atmospheric temperature is a measure of the temperature of the atmosphere of the earth atmospheric which varies slowly with day and night season. The study area recorded average maximum temperature of 29.88 ^{O}C in the dry season and 24.48^{O}C in wet season. Based on NiMet (2017), temperature has been stable in the study area from 1991 – 2015 as the average minimum and average maximum recorded in 1991 was 23.99^{O}C and 31.36^{O}C respectively. Also, the average minimum and average maximum recorded during the field data gathering showed a stable temperature condition within the period under review. See ***Figure 4.2*** below.

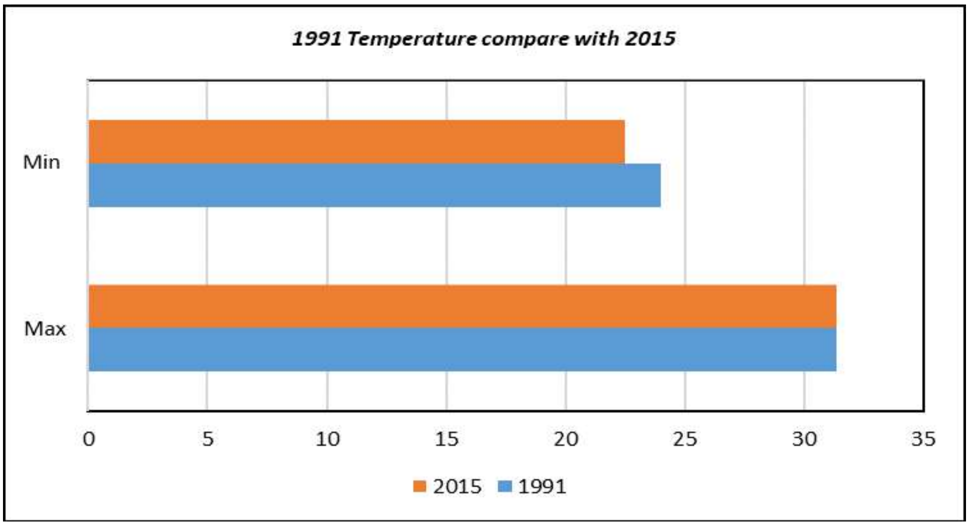


Figure 4.2: Stable temperature condition from 1991 – 2015 for the study area (based on NiMet data, 2017)

Relative humidity (RH) is the amount of water in the air compared with the amount of water required to saturate the same volume of water at the same temperature. Similar to atmospheric temperature trend, based on NiMet weather data (2017), the Relative Humidity of the study area from was observed to be in stable condition from 1991 – 2015. The average RH recorded for the study area within the period under review was 52.7% in wet season and 80% in dry season (***Figure 4.3***).

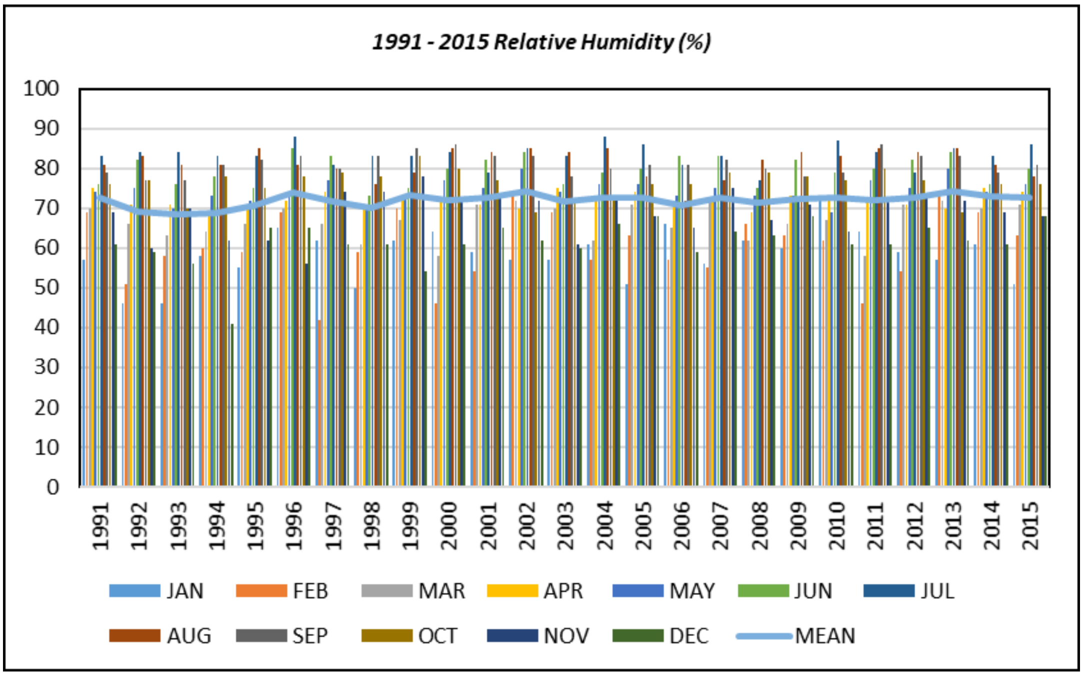


Figure 4.3: Relative humidity of the study area from 1991 – 2015 (based on NiMet weather data 2017) showing a common trend.

The mean cloud cover of 6.88 oktas was recorded for the study area from 1991 – 2015 Highest cloud cover was recorded in 1997 after which cloud cover for the study has remain stable (***Figure 4.4***). Cloud cover is another important weather variable that could be impact by the proposed project from emission related aspects such as vapour and particulates.

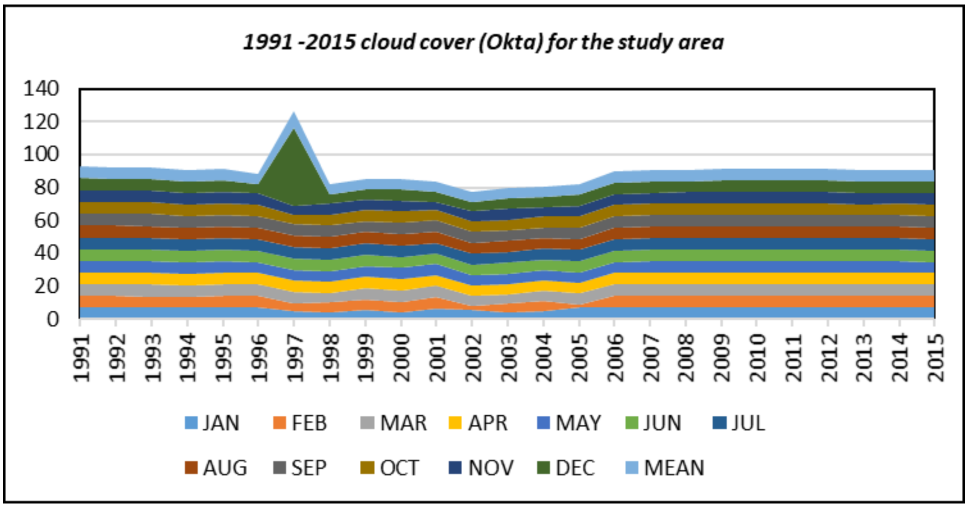


Figure 4.4: 1991 -2015 cloud cover (Okta) for the study area based on NiMet weather data 2015.

➢ ***Baseline microclimatic data of the study area***

Microclimatic data can be described as the weather data for a short period of time typically daily, unlike macroclimatic data which covers a longer period typically in years, as discussed above. The baseline microclimatic description of the study area was based on in situ data collection ***(Appendices 4.2a-b).*** The microclimatic condition of the area shows similar condition with the data derived from NiMet, 2017.

Ambient temperature is a weather variable that could be directly but temporarily affected by the proposed refinery project. Sources of heat causing ambient temperature rise include flaring, vapour emission and thermal emission from process equipment. Therefore, the ESIA established the ambient temperature for the project area. The study was carried out within the hours of 8:00 AM to 6:00 PM, to present a representative temperature value for day and night.

The study recorded 35.78^{O}C as the mean temperature of the project with the maximum being 38.3^{O}C and the minimum 31.60^{O}C (***Appendices 4.2a-b***). The temperature variation was observed to be influenced by daily time variation. It was low in the morning and gradually increases towards afternoon. Maximum temperature was recorded just after noon. Also, towards the evening, temperature also declines (***Figure 4.5***).

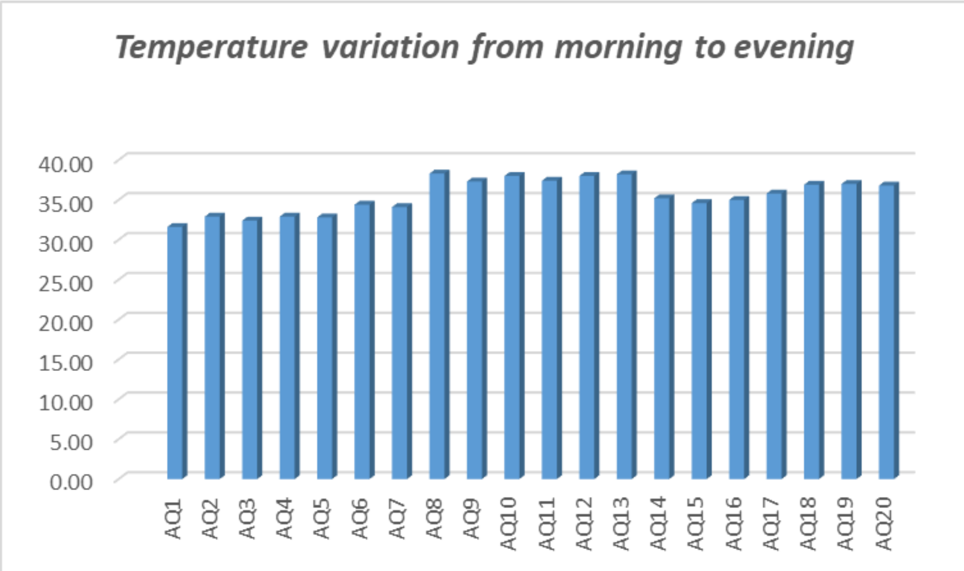


Figure 4.5: Temperature variation with time of the day

The mean ***Wind speed*** was 0.50ms^{-1}. The dominant wind direction was observed to be north-west and north-east directions.

4.3.2 Physico-chemical characteristics of Surface & Ground water

Baseline Description of Surface water

The Physico-chemical analysis results of surface water collected from existing borehole in the project area during wet and dry seasons are presented in ***Appendices 4.3 -4. 5.*** The quality of the surface water samples was compared with World Health Organisation (WHO) drinking water quality index, with most of the parameters recorded to be within WHO drinking water quality index, except for low pH value recorded at some stations. The water is generally clear and unobjectionable in terms of odour and other physical appearances.

- ***Physico-chemical Description of surface water***

During the dry season the values of pH ranged from 6.8 to 7.6 while the values ranged from 6.62 to 7 during wet season. (***Appendices 4.3 -4. 5***). These values show that surface water around the project area were slightly acidic and also were within FMENV and WHO limit of 6.5 – 8.5 for drinkable water.

The surface water temperature for dry season ranged from 27.2 – 27.9 ^{O}C while it ranged from 26.2 to 26.8 ^{O}C during the wet season. The water Turbidity ranged from 3.1 to 3.6 NTU during the dry season while the values ranged from 3 to 4.1 NTU during the wet season. Total Suspended Solids in both dry and wet season ranged from 1.68 to 2.31 mg/l and 1.26 to 2.21 mg/L respectively. Electrical conductivity varied between 38 and 48 µS/cm in dry while the values ranged from 133 and 138 µS/cm in wet season. Total Alkalinity ranged from 20 to 50 mg/L in dry season while the parameter has a value ranging from 8 to 20 mg/L during wet season.

The surface water Dissolved Oxygen (DO) recorded for dry season was between 6.7 and 8.9 mg/L while the values ranged from 8.6 to 9.5 during the wet season. The surface water Chemical Oxygen Demand (COD) values as an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were generally low. The values ranged from 30.93 mg/l to 42.67 mg/l for dry season while the values ranged from 15.6 to 26.26 mg/L in wet season. The surface water Biological Oxygen Demand (BOD^5) as the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 6.18 mg/L in dry season while it has a mean value of 4.15 mg/L in wet season.

Table 4.6: Statistical Summary of Physicochemistry and Microbiology of Surface water

Parameters	Unit	DRY SEASON			WET SEASON		
		Min	Max	Average	Min	Max	Average
pH		6.8	8.9	7.6	6.62	7	6.774
E/COND	(µS/cm)	38	48	42.4	133	138	135.6
Temp.	(^{o}C)	27.2	27.9	27.52	26.2	26.8	26.5
Redox	Potential (mV)	15	171	59.2	145	213	186
TDS	(mg/l)	19	22	20	73.15	75.9	74.58
Colour	(Pt-Co)	6	11	7.8	6	14	9.8
Alkalinity	(mg/L as $CaCO_3$)	20	50	36	8	20	12.4
Chloride	(mg/l)	9	13.5	11.3	51.48	55.98	53.78
TSS	(mg/l)	1.68	2.31	2.048	1.26	2.21	1.792
Total Hardness	(mg/L as $CaCO_3$)	5	13	9.6	13	18	15.6

DO	(mg/l)	6.7	8.9	8.06	8.6	9.5	9
Turbidity	(NTU)	3.1	3.6	3.32	3	4.1	3.5
BOD_5	(mg/l)	5.1	7.5	6.18	3.3	5.7	4.5
COD	(mg/l)	30.93	42.67	36.906	15.6	26.26	21.352
O & G	(mg/l)	0.344	0.984	0.664	1.12	2.02	1.424
THC	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Carbonate	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phosphate	(mg/l)	0.007	0.033	0.0184	0.098	0.151	0.114
Ammonium	(mg/l)	0.011	0.08	0.051	0.05	0.1	0.074
Nitrate	(mg/l)	0.036	0.241	0.1474	0.135	0.225	0.1808
Salinity	(mg/l)	16.26	24.39	20.416	0.06	0.07	0.066
Sulphate	(mg/l)	2.934	6.78	5.1454	3.655	4.737	4.208
Na	(mg/l)	6.24	9.632	8.4804	15.93	19.9	18.17
K	(mg/l)	0.14	0.28	0.208	0.18	0.47	0.32
Mg	(mg/l)	0.45	1.13	0.848	1.48	2.35	1.858
Ca	(mg/l)	2.02	3.24	2.602	5.55	6.3	5.928
Fe	(mg/l)	0.443	0.965	0.6582	0.315	0.776	0.5406
Cd	(mg/l)	0.005	0.019	0.0105	0.006	0.013	0.0095
Cr	(mg/l)	0.004	0.006	0.005	0.002	0.004	0.003
Pb	(mg/l)	0.316	0.626	0.4558	0.34	0.56	0.47
Cu	(mg/l)	0.003	0.015	0.0094	0.004	0.015	0.0096
Hg	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	(mg/l)	0.108	0.139	0.1226	0.102	0.129	0.1164
Ba	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	(mg/l)	0.025	0.163	0.107	0.065	0.15	0.118
THB	(cfu/ml)	0.7	2.1	2.5	3	6.6	5.32
THF	(cfu/ml)	0.2	1.4	0.7	1.2	5	2.28
HUB	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
HUF	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Coliform	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil
TPH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
PAH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
BENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
TOLUENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
ETHYLBENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
XYLENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

The surface water cations were dominated by Sodium (Na), Calcium (Ca) and Potassium (K) as presented in Table 4.6**.** Sodium has values ranging from 6.24 to 9.63 mg/L in dry and 15.93 to 19.9 mg/L in wet. Also, Potassium has values ranging from 0.14 to 0.28 mg/L in dry and 0.18 to 0.47 mg/L in wet season. During the wet and dry season study, the heavy metal concentration values were low in all the sampling locations and do not pose any pollution threat related to hydrocarbon contamination. The highest value recorded for heavy metals was for Iron, followed by zinc.

Surface water hydrocarbon concentration is a very important quality monitoring parameter for oil and gas activities, as it can be used to detect any oil related surface water pollution. Hydrocarbon concentration of the surface water was generally low (***Table 4.6***). Similarly, during dry season study, the surface water hydrocarbon concentration also recorded low concentration below detection limit. This is an indication of no oil pollution in the project area. Both season surface water hydrocarbon concentration is within FMENV limits.

- ***Surface water microbial analysis***

From the Microbiology results recorded, THB count which varied from 0.7 x 10^3 cfu/ml to 2.1 x 10^3 cfu/ml for dry season while the values ranged from 3 x 10^3 cfu/ml to 6.6 x 10^3 cfu/ml during wet season. THF count of 1.2 x 10^2 cfu/ml to 5 x 10^2 cfu/ml was recorded for wet season while THF count of 0.2 x 10^2 cfu/ml to 1.4 x 10^2 cfu/ml was recorded for dry seasons . The hydrocarbon utilizing bacteria and fungi was not detected in both dry and wet seasons during the field sampling.

- **Baseline Description of Groundwater**

The Physico-chemical analysis results of groundwater collected from existing borehole in the project area during wet and dry seasons are presented in ***Appendices 4.3 -4. 5.*** The quality of the groundwater samples was compared with World Health Organisation (WHO) drinking water quality index, with most of the parameters recorded to be within WHO drinking water quality index, except for low pH value recorded at some stations. The water is generally clear and unobjectionable in terms of odour and other physical appearances.

Physico-chemical Description of groundwater

During the dry season the values of pH ranged from 6.34 to 6.84 while the values ranged from 5.7 to 7.2 during wet season. (***Appendices 4.3 -4. 5***). These values show that groundwater around the project area were slightly acidic and also were within FMEnv and WHO limit of 6.5 – 8.5 for drinkable water.

Table 4.7: Statistical Summary of Physicochemistry and Microbiology of Ground water

Parameters	Unit	DRY SEASON			WET SEASON		
		Min	Max	Average	Min	Max	Average
pH		6.34	6.84	6.57	5.7	7.2	6.38
E/COND	(µS/cm)	45	346	149.4	44	192	76.2
Temp.	(^{o}C)	25.4	26	25.76	27.2	33.2	31.06
Redox	Potential (mV)	98	134	116.4	-37	82	23.6
TDS	(mg/l)	24.75	190.3	82.17	22	96	37.6
Colour	(Pt-Co)	1	7	4.2	1	4	2.6
Alkalinity	(mg/L as $CaCO_3$)	2	30	18	30	180	110
Chloride	(mg/l)	17.49	102.97	46.786	7	28.99	13.496
TSS	(mg/l)	0.86	7.48	4.778	1.03	8.77	5.116
Total Hardness	(mg/L as $CaCO_3$)	6	43	23.8	3	19	10.8
DO	(mg/l)	8.3	10.6	9.52	5.7	6.8	6.3
Turbidity	(NTU)	11.4	13.9	12.633	5.2	7.6	6.233
BOD_5	(mg/l)	1.3	1.6	1.4	4.5	9.3	7.14
COD	(mg/l)	2.41	6.01	4.192	29.87	51.2	41.388
O & G	(mg/l)	0.364	0.474	0.419	<0.001	<0.001	<0.001
THC	(mg/l)	0.15	0.261	0.206	<0.001	<0.001	<0.001
Carbonate	(mg/l)	0	0	0	<0.001	<0.001	<0.001
Phosphate	(mg/l)	0.075	0.107	0.087	0.004	0.028	0.01825
Ammonium	(mg/l)	0.06	0.1	0.080	0.012	0.12	0.0566
Nitrate	(mg/l)	0.126	0.21	0.165	0.03	0.18	0.110
Salinity	(mg/l)	0.02	0.16	0.072	12.65	52.37	24.38
Sulphate	(mg/l)	1.612	22.28	7.116	1.973	9.304	4.760
Na	(mg/l)	8.19	58.39	25.522	9.24	18.24	11.76
K	(mg/l)	0.1	1.02	0.52	0.11	1.36	0.626
Mg	(mg/l)	0.67	3.16	1.66	0.52	3.24	1.688
Ca	(mg/l)	1.29	8.04	4.366	1.56	8.45	3.71
Fe	(mg/l)	0.201	2.078	1.409	0.235	2.113	1.457
Cd	(mg/l)	0.013	0.06	0.037	0.015	0.073	0.044
Cr	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	(mg/l)	0.03	0.09	0.06	<0.001	<0.001	<0.001
Cu	(mg/l)	0.031	0.12	0.068	0.011	0.134	0.059
Hg	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	(mg/l)	0.1	0.329	0.184	0.113	0.425	0.210
Ba	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	(mg/l)	0.117	0.268	0.164	0.204	0.314	0.259

THB	(cfu/ml)	0.7	2.1	2.5	0.7	2.4	1.42
THF	(cfu/ml)	0.2	1.4	0.7	0.5	1.2	0.84
HUB	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
HUF	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Coliform	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil
TPH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
PAH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
BENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
TOLUENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
ETHYLBENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
XYLENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

The water temperature for dry season ranged from 25.4 – 26 ^{O}C while it ranged from 27.2 to 33.2 ^{O}C during the wet season. The water Turbidity ranged from 11.4 to 13.9 NTU during the dry season while the values ranged from 5.2 to 7.6 NTU during the wet season. Total Suspended Solids in both dry and wet season ranged from 0.86 to 7.48 mg/l and 1.03 to 8.77 mg/l. Electrical conductivity varied between 45 and 346 µS/cm in dry while the values ranged from 44 and 192 µS/cm in wet.

The groundwater Dissolved Oxygen (DO) recorded for dry season was between 8.3 and 10.6 mg/L while the values ranged from 5.7 to 6.8 during the wet season. The groundwater Chemical Oxygen Demand (COD) values as an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were generally low. The values ranged from 2.41 mg/l to 6.01 mg/l for dry season while the values ranged from 29.87 to 51.2 mg/L in wet season. The groundwater Biological Oxygen Demand (BOD^5) as the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 1.4 mg/L in dry season while it has a mean value of 7.14 mg/L in wet season.

The groundwater cations were dominated by Sodium (Na), Calcium (Ca) and Potassium (K) as presented in Table 4.7**.** Sodium has mean values of 25.52 mg/L in dry and 11.76 mg/L in wet. Also, Potassium has mean values of 0.52 mg/L in dry and 0.626 mg/L in wet season. During the wet and dry season study, the heavy metal concentration values were low in all the sampling locations and do not pose any pollution threat related to hydrocarbon contamination. The highest value recorded for heavy metals was for Iron, followed by zinc.

Groundwater hydrocarbon concentration is a very important quality monitoring parameter for oil and gas activities, as it can be used to detect any oil related groundwater pollution. Hydrocarbon concentration of the groundwater was generally low (***Table 4.7***). Similarly, during dry season study, the ground water hydrocarbon concentration also recorded low concentration below detection limit. This is an indication of no oil pollution in the project area. Both season groundwater hydrocarbon concentration are below limits.

- ***Groundwater microbial analysis***

From the Microbiology results recorded, THB count which varied from 0.7 x 10^3 cfu/ml to 2.1 x 10^3 cfu/ml for dry season while the values ranged from 0.7 x 10^3 cfu/ml to 2.4 x 10^3 cfu/ml during wet season. THF count of 0.2 x 10^3 cfu/ml to 1.4 x 10^3 cfu/ml was recorded for dry season while THF count of 0.5 x 10^3 cfu/ml to 1.2 x 10^3 cfu/ml was recorded for dry seasons . The hydrocarbon utilizing bacteria and fungi was not detected in both dry and wet seasons during the field sampling.

4.3.3 Hydrobiology

The characteristics of the plankton community were determined by adopting the Margelef's Species Richness Index, Shannon-Wiener Index and the Evenness coupled with the dominance approach so as to determine the densities of the different groups within the sampling stations that make up the study area and the community. The dominance will provide information about the ecological dominants or dominant species that exert a major controlling influence by virtue of their size, numbers, or activities (Verma and Agarwal, 2006). The benthic population did not meet the criteria for diversity indices where appropriate, tables and graphs shall be employed so as to have a *"Birds-Eye-View"* of the spatio-temporal distribution of the species within the project area.

Benthic fauna

Quantitative samples for benthic fauna were collected at each station using the Ekman Grab (0.0225m^2) and sieved in the field using 250 and 500µm Tyler sieves. All samples were preserved in wide mouthed plastic containers by adding some quantities of 40% formaldehyde and stained with Rose Bengal solution.

Laboratory analysis was carried out by using the binocular dissecting microscope and Nikon compound microscope for sorting, dissection of relevant taxonomic parts, and preparation of slides. Specimens were identified to the lowest possible taxonomic level using reliable identification keys and texts (Pennak, 1978; Barnes, 1980).

Statistical Analysis

Indices of diversity and evenness were used to characterize biotic communities. The following indices were used:

a. Margalef's index (d) of taxa richness

$$d = \frac{S-1}{In\ N}$$

Where S = number of taxa

N = total number of individuals

In = Natural log.

b. Shannon's Index (H')

$$H' = -\sum_{i=1}^{s} pi\ \ In\ pi$$

where pi is the proportion of individuals found in the ith species (i.e. $pi = {ni}/{N}$, N being the total abundance).

c. Evenness Index (E')

$$E' = \frac{H'}{In\ \ S}$$

Evenness is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant. Evenness measures the degree of uniformity in the distribution or spread of individuals among the species. (Odum, 1971; Zar, 1983; Ogbeibu, 2005).

Fisheries

Interviews, consultations and literature review were used to obtain information on species diversity and relative abundance of fish species in the study area. Fishes were caught using the services of local fishermen. Funnel entrance traps were used, and fishes caught were stored in the cooler containing ice blocks. This study was supplemented by observations of fishing gear. The fishermen were interviewed on the common fish species available in the area, their seasonality of abundance, sizes and palatability/commercial value. In the laboratory, fish samples were identified using reliable identification keys (Holden and Reed, 1972), analysed for measurement of morphometric features and determination of condition factors.

The condition factor (kF), an index of the wellbeing of the fish was computed using the formula.

$$kF = \frac{100W}{L^3}$$

Where,

W = weight of fish in grams

L = standard length of fish in centimetre

Phytoplanktons

The phytoplankton community comprised of 60 taxa consisting of the following Divisions: Bacilliariophyta (33), Cyanophyta (12), Chlorophyta (7), Dinophyta (5) and Euglenophyta (3). The bacilliariophyta were the most dominant in terms of population density and relative proportion (with a total of 33 species) and constituted about 67% of the entire phytoplanktonic community with *Coscinodiscus centalis* (3.77%, 260 No/m^3) being the most dominant species. Furthermore, the family of bacilliariophyceae ranged in numerical values from *Achnanthes echrenbergii* (0.43%, 30No/m^3) to *Coscinodiscus centalis* (3.77%, 260No/m^3) showing a significant positive correlation between species number and relative abundance ($p<0.01$). Also, the population density ranged from 941 No/m^3 in WS3 to 1238 No/m^3 in WS1 (Control (WS2) = 1235 No/m^3). Some dominant species of the division Bacilliariophyta include: *Coscinodiscus centalis* (3.77%, 260No/m^3), *Biddulphia longicruris* (3.74%, 258 No/m^3), *Cheatoceros emeroli* (3.42%, 236 No/m^3), *Coscinodiscus radiate* (3.52%, 243 No/m^3), *Cyclotella striata* (3.54%, 244 No/m^3), *Navicula cuspidate* (3.03%, 209 No/m^3), *Rhizosolenia habetata* (3.36%, 232 No/m^3).

The second dominant division in the phytoplankton community were the Cyanophyta with a proportion of 21.1%. Cyanophyceae with a total of 12 species ranged from *Isocystis planktonica* (0.67%, 46 No/m^3) to *Oscillatoria pseudomina* (3.17%, 219 No/m^3) and showed significant positive correlation between species number and relative abundance ($p<0.01$). Moreover, the total population density of the family Cyanophyceae ranged from 213 No/m^3 in WS3 to 430 No/m^3 in WS1 (Control (WS2) = 452 No/m^3). Some dominant species of the division Cyanophyta include: *Anabaena flos-aquae* (2.46%, 170No/m^3), *Oscillatoria formosa* (3.07%, 212No/m^3), *Oscillatoria pseudomina* (3.17%, 219 No/m^3), *Synchococcus aquatilis* (2.54%, 175 No/m^3).

In increasing order, the dominance pattern of the divisions of phytoplankton were Bacillariophyta (67.3%, 4502 No/m^3) > Cyanophyta (21.1%, 1384 No/m^3) > Chlorophyta (4.67%, 322 No/m^3) > Dinophyta (3.83%, 265 No/m^3) > Euglenophyta (3.04%, 210 No/m^3). Also, the total population density of phytoplanktons in the sampling station ranged from 1295 No/m^3 in WS3 (44 species) to 1948 No/m^3 in WS1 (57 species (Control (WS2, 53 species)) = 1921 No/m^3). The species density was generally high and showed consistent trend in taxa number among the sampling stations (Figure 4.6 and Figure 4.7).

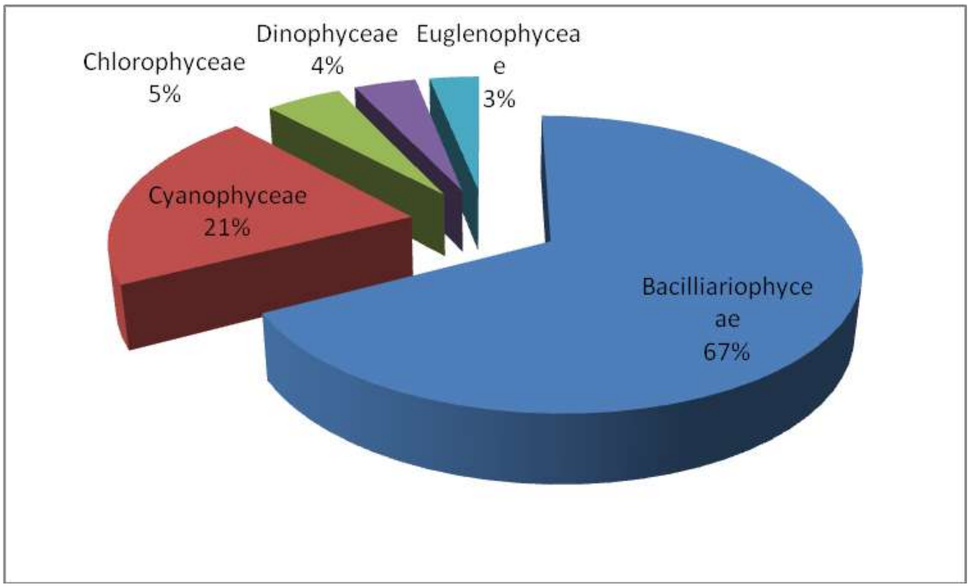


Figure 4.6: Relative abundance of families of phytoplankton identified within the project area

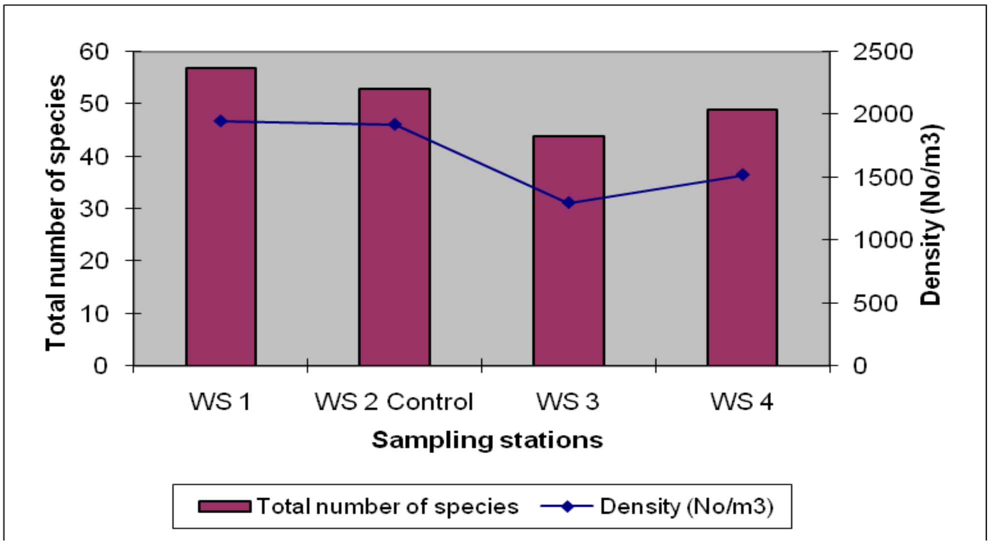


Figure 4.7: Spatial variation in the number of taxa and density of phytoplanktons

Species Diversity Indices

The general diversity of phytoplankton was computed using the Shannon Index (H'), Evenness (E') and species richness (d) indices. The species richness and diversity were generally high in almost all the sampling stations and revealed the uniformity in distribution of the plankton species. It can be deduced from Figure 4.8 that the comparative trend in the species diversity and species richness which ranged from 3.56 to 3.83 (Control= 3.79) and 5.86 to 7.39 (Control= 6.75) indicates a rich phytoplankton species diversity and richness and this indices corresponds to those described by Lenat *et. al.*, 1981.

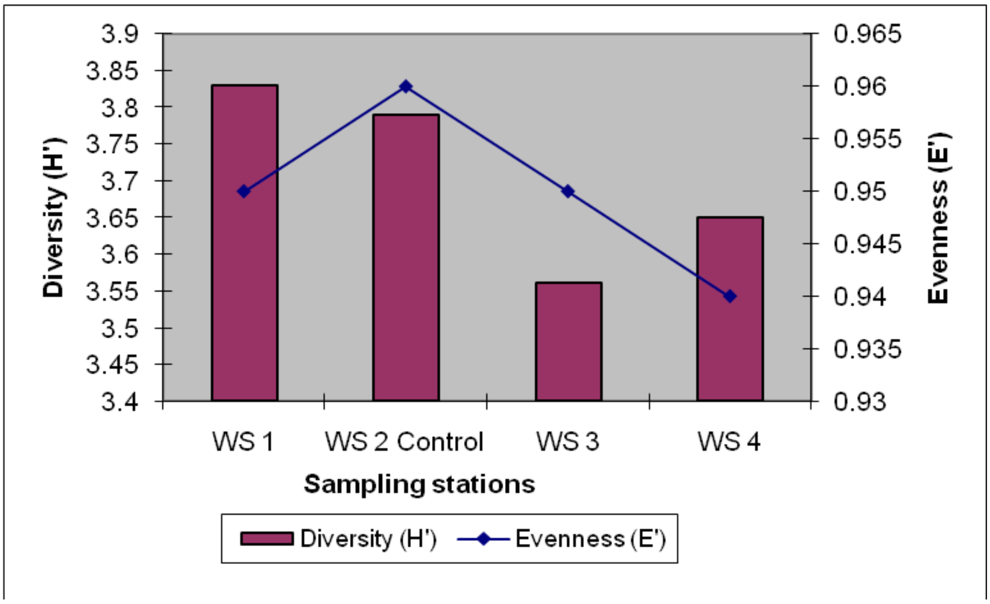


Figure 4.8: Variation in Diversity (H') and Evenness (E') in the sampling stations

Zooplanktons

The identified zooplankton taxa were categorized into Crustaceans (copepods (12 species, 52%) and decapods (3 species, 16%)), Rotifers (6 species, 11%), Cladocera (5 species, 14%), Molluscan larvae (2 species, 6%), and Pisces (1 species, 1%). Crustacea (copepods) were the most dominant zooplanktons with a total composition of 52% and a population density of 593No/m^3. Among the dominant copepods include: *Candacia speciosus* (4.82%, 55 No/m^3), *Centopages typicus* (8.68%, 99No/m^3), *Cyclops americanus* (7.46%, 85No/m^3), *Diaptomus oregonensis* (7.72%, 88No/m^3), *Paracalanus parvus* (5.09%, 55 No/m^3) (figure 4.9 and figure 4.10). The crustacean (copepods) ranged in population density and proportion from *Candacia armatia* (0.96%, 11No/m^3) to *Centopages typicus* (8.68%, 99No/m^3) showing a significant positive correlation between species number and relative abundance ($p<0.01$). Also, in the sampling stations the population density ranged from 94No/m^3 in WS3 to 188No/m^3 in WS1 (Control (WS2) = 149 No/m^3).

The second dominant taxa in terms of population were the **Crustacea (Decapods)** and ranged from *Upogebia nauplii* (3.77%, 43 No/m^3) to *Veliger larvae* (6.40%, 73 No/m^3) and showed significant positive correlation between species number and relative abundance ($p<0.01$). The total population density of the **Crustacea (Decapods)** ranged from 39 No/m^3 in WS3 to 62 No/m^3 in WS1 (Control (WS2)) = 36. All decapods identified showed a significantly high population density although the species number was low as compared to other taxa.

In increasing order, the dominance pattern of the taxons of the zooplanktons were Crustacea (copepods) > Crustacea (decapods) > Cladocera > Rotifera > Molluscan larvae > Pisces. The total population density of zooplanktons in the sampling station ranged from 223 No/m^3 in WS3 (18 species) to 354 No/m^3 in WS1 (22 species) (Control (WS2, 21 species) =262 No/m^3). These observations are in tandem with literature value published by Chowdhury (2008) and Davies *et. Al*. (2009).

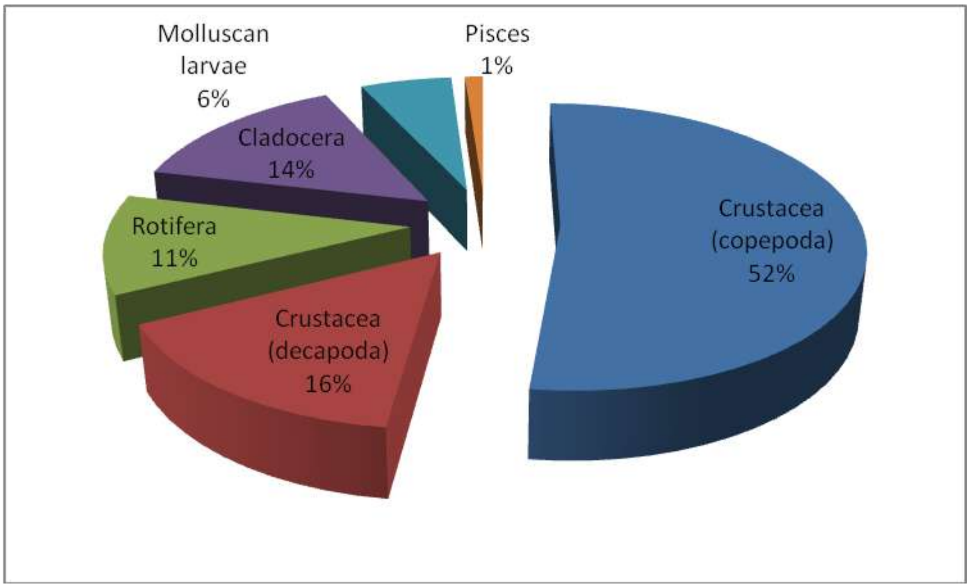


Figure 4.9: Relative abundance of families of zooplankton identified within the project area

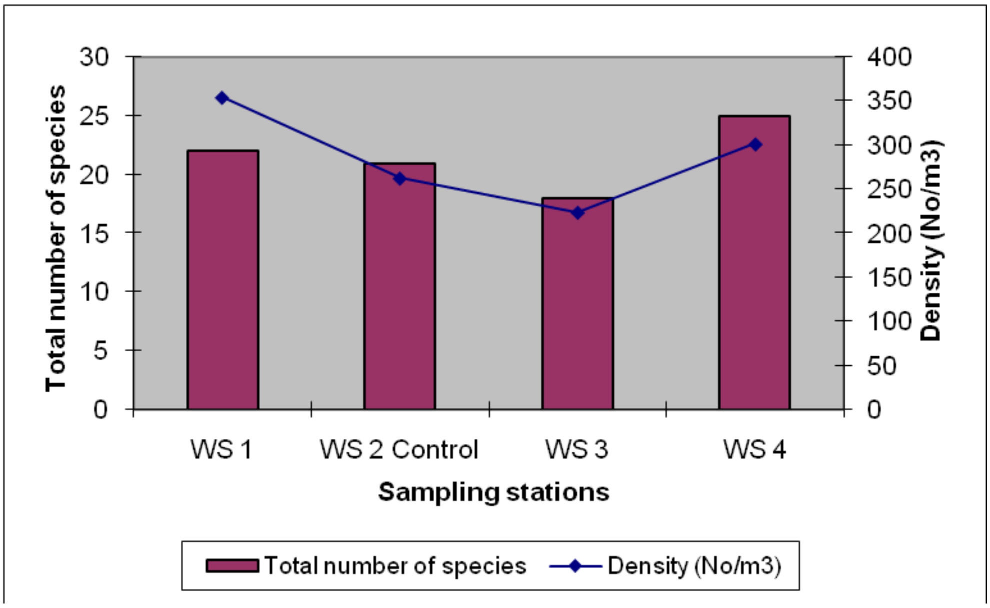


Figure 4.10: Spatial variation in the number of taxa and density of zooplanktons

__Diversity Indices of Zooplankton Community__

The Shannon diversity index (H'), Evenness or Equitability index (E') and the species index (d) were used to characterize the community. The analysis revealed appreciable high species uniformity in the sampling stations with no species showing concentrated dominance. The diversity and species richness which indicates the relative sensitivity of the ecosystem was high and ranged from 3.14 to 4.21 (Control= 3.59) and 2.79 to 3.06 (Control= 2.88). Variations in these indices among stations are shown in figure 4.11.

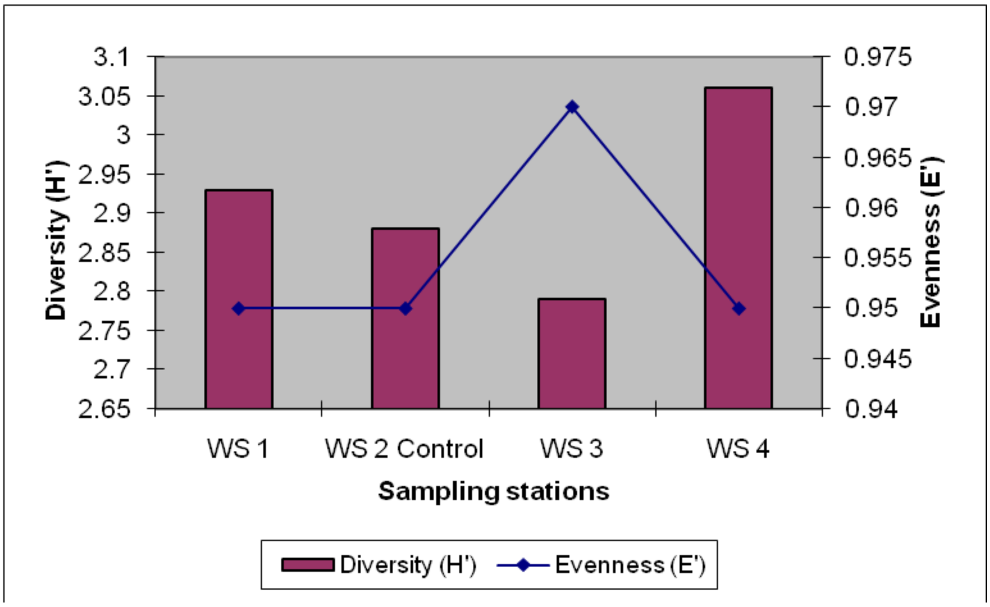


Figure 4.11: Variation in Diversity (H^1) and Evenness (E) in the sampling stations

Macro benthic invertebrates

Species Composition, Density and Distribution

Twenty-two taxa were recorded and belonged to Crustacea (7), Bivalve molluscs (2), Polychaete (9) and Gastropods mollusc (4). The Gastropods Molluscs, *Tympanotonus fuscatus* constituted the most dominant taxa in terms of number, while other species showed poor distribution in terms of density and dominance among the sampling stations. In increasing order, the dominance pattern of the taxons of the macro benthic fauna in terms of population density are Gastropods molluscs (38%) > Polychaete, Crustecea (27%) > Bivalve molluscs (8%). The spatial variation in the density and number of taxa among the stations is shown in figure 4.12 and 4.13.

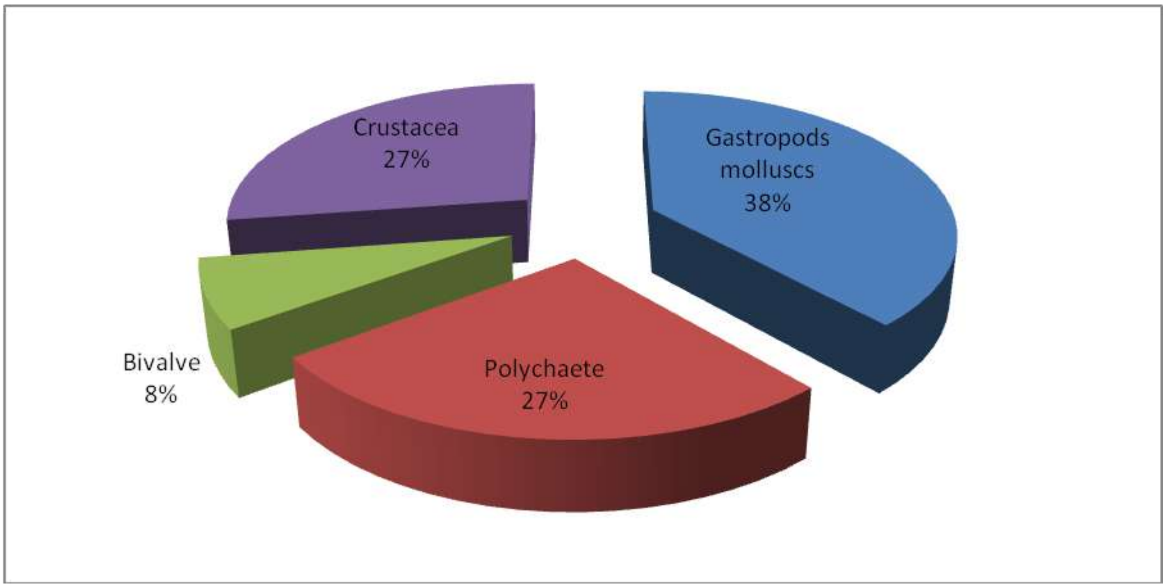


Figure 4.12: Relative abundance of families of macro benthic invertebrates identified within the project area

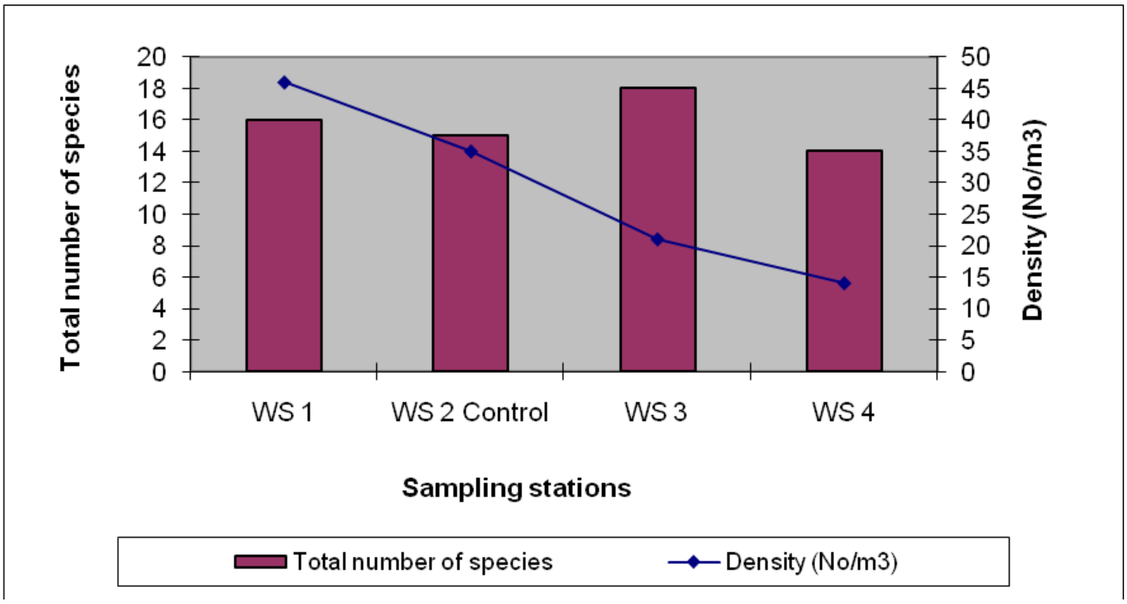


Figure 4.13: Spatial variation in the number of taxa and density of macro benthic invertebrates

Species Diversity Indices

The Shanon diversity index (H'), Evenness or Equitability index (E') and the species richness index (d) were used to characterize the community. The sampling stations showed a relatively high diversity index, species richness and evenness and indicates a positive correlation between species diversity and its relative abundance (P<0.01). Furthermore, the results obtained correlated with literature reports (Olomukoro and Ezemonye, 2007, Victor and Ogbeibu, 1985) of some brackish water ecosystems in Nigeria. Variations in these indices among the sampling stations are shown in figure 4.14.

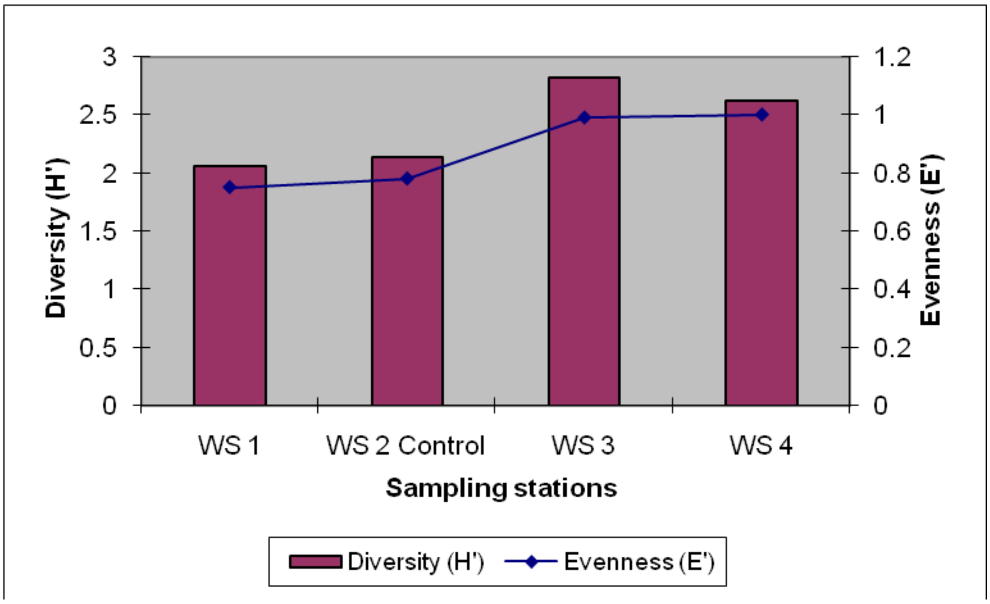


Figure 4.14: Variation in Diversity (H^1) and Evenness (E) in the sampling stations

Fisheries

Fisheries studies investigated the utilization of harvestable aquatic organisms, their abundance and the population involved in fisheries activities in the study communities. It also covered the fishing gears/methods, catch composition, fish species composition in the study area, catch per unit effort, fish landing, sales and price, spawning grounds, migration routes and patterns, productivity and pathology.

The study area is primarily a freshwater ecosystem with no tidal influence, and fishing is carried out mainly by few artisanal fishermen from the riparian communities. The fishing techniques utilized include such basic gears as gill nets, cast net, long lines and traps. Fisheries involve the utilization of harvestable aquatic organisms in fresh, brackish and marine waters; it represents complex interaction between the population of organisms being harvested, the population of fishermen, and the prevailing environmental conditions.

Fisheries Activities

Fish catch in this area, according to response from the fishermen are on the average, though gradually declining, when compared to the past years. Fishing activity was very low in the project area. Only few fishermen were seen in fishing canoes checking their overnight fish traps and nets for catch. Women fish mainly using basket traps but sometimes they use long lines, set gill nets and lift nets. The fishermen operate different types of gears such as cast nets, gill nets, beach seines, filter nets, long lines and encircling nets in near and distant waters.

Only few members of the communities are involved in aquacultural practices, using monoculture fishponds constructed near homes, for the rearing of catfishes.

The checklist of fish species

Table 4.8 shows the checklist of commercially important fish species recorded during the study, based on data from direct sampling and secondary information from fisherfolk. The list shows that 38 species in 18 families of fish were recovered from the study area.

The families Characidae, Bagridae and Cyprinidae appeared extensively in the catches. The bagrid species included *Chrysichthys nigrodigitatus,* and *Clarotes macrocephalus*.

The details of species composition and the relative abundance in the study area are given the Checklist Table: 4.8.

Table 4.8: Checklist of fish species in the study area. (+ Low Abundance, ++ Moderate Abundance, +++ High Abundance)

Family	Scientific Name	Common Name	Relative Abundance
Bagridae	*Chrysichthys nigrodigitatus*	Silver cat fish	++
	Clarotes macrocephalus	,, ,,	+
Channidae	*Channa obscura*	Snakehead	+
Characidae	*Alestes macrolepidotus*		+
	A. longipinis		+++
	A. nurse		+
Cichlidae	*Hemichromis fasciatus*	Cichlid fish, tilapia	++
	Pelmatochromis taeniatus		+
	Sarotherodon niloticus		+
	Tilapia macrocephala		+
	T. melanopleura		+
	T. zillii		++
Citharinidae	*Citharinus citharus*	Moonfish	++

Family	Scientific Name	Common Name	Relative Abundance
	Citharinus distichodoides		+
	Citharinus latus	Moonfish	++
	Distichodus engycephalus	Grass-eaters, fin-nippers	++
Clariidae	*Clarias anguillaris*	Mudfish, clariid catfish	+++
	C. gariepinus	,,	+++
Cyprinidae	*Epiplatys sexfasciatus*	African carp	+
	Labeo sendgalensis		++
Gymnarchidae	*Gymnarchus niloticus*		++
Hepsetidae	*Hepsetus odoe*	African pike	+
Malapteruridae	*Malapterurus electricus*	Electric cat fish	++
Mochokidae	*Parauchenoglanis* sp.		+
	Synodontis omias	Catfish	+
	Synodontis clarias		+++
	Synodontis nigrita	,,	+++
Mormyridae	*Gnathonemus abadi*		
	Hyperopisus bebe accidentalis		+
	Gnathonemus cyprinoids	Elephant – Snout fish	
Notopteridae	*Papyrocranus afer*	Featherback	+
	Xenomystus nigri	Knife-fish	+
Osteoglossidae	*Heterotis niloticus*	Bony -tongues	++
Polynemidae	*Polynemus quadrifillis*	Shiny-nose	
Polypteridae	*Erpectoichthys calabaricus*	*Bichirs*	+
	Eutropius niloticus	*Butter Catfish, Glass Catfish*	++
Schilbedae	*Schilbe mystus*	Glass catfish	++
Tetraodontidae	*Tetraodon fashaka*	Puffer fish	+

The commonest species caught during the study were *Clarias gariepinnis, Alestes macrolepidotus, Synodontis clarias, S. nigrita, Gnathonemus abadi, Schilbe mystus* and *Labeo senegalensis* (Plates 4.6 – 4.10). Other abundant species reported by the interviewed fishermen include *Heterotis niloticus* mostly caught in October, *Citharinus latus, Synodontis clarias Gymnarchus niloticus* and *Distichodus brevipinus.* The fishing season that gives the fishermen the greatest catch per unit effort is usually October to December of every year.

Plate 4.6 ***Labeo senegalensis***

Plate 4.7 ***Brycinus longipinnis***

Plate 4.8: ***Alestes macrolepidotus***

Plate 4.9 ***Synodontis clarias***

Plate 4.10 *Synodontis nigrita*

The fishing population in the study area is about 300 persons on 150 fishing boats with an average of 2 persons per boat.

Catch per Unit Effort Assessment

The castnet and surface set gill nets were used in assessing catch per unit effort at two fishing locations. The average catch per unit effort was low. Interview with fishermen indicates that sometimes, the day's effort can be fruitless without any catch. Because of the low catch from the castnet gear, the locals resort mainly to the use of fenced seine nets and traps and hooks for littoral bank edge fishes like *Clarias* and *Gymnarchus*, which ensures more yield. The net stays up to 6 hrs in the water. The catch however depends on the time, season and the type of net.

Fish Pathological Conditions

The dominant and commercially important fish species were subjected to parasitic analysis. In *Clarias gariepinus*, a popular fish species in Nigeria, the parasites identified were mainly intestinal and they included the nematodes, *Spirocamallanus spiralis*, *Camallanus* sp. and *Procamallanus laeviconchus.*

In *Brycinus*, an acanthocephalan worm, *Acanthogyrus tilapiae* was recovered from the intestine while a trematode metacecaria *Clinostomum* sp. in scales, muscles and gills. In *Synodontis clarias* and *Hemichromis fasciatus*, the nematodes *Procamallanus laeviconchus* and *Cucullanus* sp were recovered from the body cavity and intestine.

Although the effects of these parasites were not pronounced on the fishes examined, they are known to cause nutritional imbalance and stunted growth in fishes. No observable physical deformities were examined in the fishes.

Heavy Metals in Fish Species

Heavy metal concentrations and the TPH content in selected fish samples are presented in Table 4.9. The laboratory results indicate that all heavy metals associated with crude oil such as V, Hg, Cd, As, Cr and Ba were below detection limit. Trace metals like Zn and Fe were high in fish tissue, slightly above WHO limits but below FAO limits. In general, the toxic heavy metal concentrations in the tissue of fish were within the recommended acceptable limits and in most cases not detectable (WHO, 1989).

Table 4.9: Concentration (mg/kg) of heavy metals in selected fish samples

Fish species	Pb	Zn	Cu	Cr	Fe	Ni	V	Hg	Cd	As	Mn
	mg/kg										
Labeo senegalensis	ND	15.7	0.59	ND	32.7	ND	ND	ND	ND	ND	0.08
Brycinus longipinnis	ND	19.4	1.22	ND	29.4	ND	ND	ND	ND	ND	0.05
WHO (1989) LIMITS	2	10	1	0.5	1	0.5			2		0.1
FAO (1983) LIMITS	0.5	30	30						2		

ND = Below detection limit, Not Detected

4.3.4 Sediment Studies

The summary (in mean and range) of the physiochemical characteristics of the sediments in the study area is presented in table 4.10. The sediments are slightly acidic to almost neutral and the Total Hydrocarbon level of the sediments was low. The heavy metals have a relatively high and wide range of concentrations.

pH: The sediments in the entire area were mainly acidic with pH ranging from 4.3 to 5.6 in the dry season and 6.72 to 7.25 in the wet season indicating slightly acidic to neutral pH

Total Organic Carbon (TOC %): The sediments exhibited wide variability in terms of total organic carbon content. TOC ranged from 0% to 0.1%, with a mean value of 0.04% in the dry season and mean level of 2.34% in the wet season. The production, accumulation and degradation of organic matter are greatly dependent on climate. Temperature, sediment moisture and topography are the major factors affecting the accumulation of organic matter in sediments.

Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature (Buol, 1990) or excess moisture which results in anaerobic conditions (Trofimov et al 2008). Conversely, excessive rain and high temperatures of tropical climates as in the present assessment enables rapid decomposition of organic matter and leaching of plant nutrients. Excessive slope may encourage the erosion of the top layer of sediment which holds most of the raw organic material that would otherwise eventually become humus.

Nitrate: The trend exhibited by the total organic carbon content was also manifested by the total organic matter content. Nitrate content varied between 0.221% to 0.354% with a mean value of 0.283% in the dry season. In the wet season, nitrate range from 2.21% to 5.53% with a mean value of 3.76%. In the present study, the reasons given for the trend in the observed in the total organic carbon content in the sediments is also applicable to the nitrate content in the sediments.

Anions: Sulphate, Chloride, Phosphate: The mean levels of these anions (dry season) were generally low as follows; Sulphate (55.03 mg/kg) and Chloride (49.63 mg/kg) respectively. In the wet season, the values were: sulphate (38.49 mg/kg) and chloride (38.29 mg/kg). In sediment, iron and aluminum hydroxide clays are able to exchange their hydroxide anions (OH^+) for other anions. The order reflecting the strength of anion adhesion is as follows; $H_2PO_4^{2-}$ replaces SO_4^{2-} replaces Cl^-.

Electrical Conductivity (E.C): The E.C. of the sediments varied between 141 to 251 µS/cm with a mean value of 171 µS/cm (dry season) and range from 32 to 413 µS/cm in the wet season with a mean value of 190 µS/cm.

Total Hydrocarbon Content (THC): The THC of the sediments ranged from 0.02 mg/kg to 0.45 mg/kg with a mean value of 0.28 mg/kg in the dry season while in the wet season, it ranged from 0.43 mg/kg to 2.12 mg/kg with a mean value of 1.17 mg/kg.

Heavy metals: The mean concentration of the heavy metals in the dry season and related sediment micronutrient elements were as follows; Iron (924 mg/kg), Zinc (14.5 mg/kg), Chromium (0.25 mg/kg), Lead (3.25 mg/kg), Copper (1.47 mg/kg), Cadmium(0.45 mg/kg), Nickel(<0.001 mg/kg), Barium(0.55 mg/kg). However, in the wet season, the mean values were iron (788.80 mg/kg), zinc (12.81 mg/kg), chromium (0.23 mg/kg), Lead (2.48 mg/kg), Copper (1.28 mg/kg), Cadmium (0.75 mg/kg). These values are consistent with levels of these metals as found in non-contaminated or none anthropogenically impacted sediments, except for lead in the wet season.

Total Heterotrophic Bacteria (THB). The mean amount of the THB in the sediments was $7.42x10^5$cfu/g in dry season and $9.14x10^5$cfu/g in wet season.

Total Heterotrophic fungi, (THF). The mean value of THF in the sediment was $4.64x10^3$cfu/g in dry season and $4.66x10^5$cfu/g in wet season

Table 4.10: Characteristics of Sediments

Parameter	Unit	Dry Season			Wet Season		
		Min	**Max**	**Mean**	**Min**	**Max**	**Mean**
pH		4.3	5.6	5.098	6.72	7.25	6.976
Electrical Conductivity	µs/cm	141	251	171	32	413	190
Redox Potential	mV	82	169	113.6	57	72	68
Chloride	mg/kg	35.45	70.9	49.632	7.09	88.63	38.288
Sulphate	mg/kg	37.76	76.47	55.03	2.36	92.71	38.498
TOC	%	0	0.1	0.04	0.12	6.32	2.34
Phenols	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Carbonate	mg/kg	0	0	0	0	0	0
Nitrate	mg/kg	0.221	0.354	0.2828	2.21	5.53	3.76
THC	mg/kg	0.02	0.45	0.28	0.43	2.12	1.17
SAND		79	93	84.8	18	99	65.4
SILT		4	9	6	0	46	19.2
CLAY		3	15	9.2	1	36	15.4
Fe	mg/kg	345.00	1624.00	924.00	279.40	1417.80	788.80
Cd	mg/kg	0.14	0.96	0.45	0.25	1.25	0.75
Cu	mg/kg	1.18	1.96	1.47	0.90	1.80	1.28
Pb	mg/kg	0.93	6.02	3.25	0.80	4.40	2.48
Cr	mg/kg	0.00	0.39	0.25	0.14	0.32	0.23
Hg	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	mg/kg	<0.001	<0.001	<0.001	0.850	1.230	1.007

Mn	mg/kg	5.34	63.24	21.99	4.36	55.80	19.34
V	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/kg	9.96	27.92	14.50	7.93	25.14	12.81
Ba	mg/kg	0.23	0.96	0.55	0.17	0.74	0.41
K	meq/100g	0.23	0.93	0.61	0.13	0.83	0.48
Mg	meq/100g	1.65	3.93	2.58	1.00	3.89	2.12
Ca	meq/100g	2.84	4.94	3.70	2.07	4.47	3.14
Na	meq/100g	0.36	1.08	0.74	0.40	1.15	0.70
THB	cfu/g	2.70	10.20	7.42	3.80	12.20	9.14
THF	cfu/g	3.10	6.90	4.64	2.00	7.90	4.66
HUB	cfu/g	1.00	3.20	2.36	1.30	5.30	3.36
HUF	cfu/g	0.60	2.80	1.40	0.50	4.20	1.70

4.3.5 Soil

pH: The soils in the entire area were mainly acidic with pH ranging from 2.9 to 5.1 in the dry season and 6.8 to 7.3 in the wet season indicating slightly acidic to neutral pH

Texture: The soil texture manifested properties of sand and loamy sand in the dry season. Mean sand amount of 83.9%, clay (11.78%) and silt (4.2%) were determined in the fractions. These varied from the means levels found in the wet season: clay (30.3%), silt (20.1%) and sand (19.5%). High precipitation especially during the rainy season accompanied by inundation may be responsible for the change in the textural properties in the two seasons.

Total Organic Carbon (TOC %): The soils exhibited wide variability in terms of total organic carbon content. TOC ranged from 0.70% to 6.44%, with a mean value of 2.55% in the dry season and mean level of 1.55% in the wet season. The production, accumulation and degradation of organic matter are greatly dependent on climate. Temperature, soil moisture and topography are the major factors affecting the accumulation of organic matter in soils.

Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature (Buol, 1990) or excess moisture which results in anaerobic conditions (Trofimov et al 2008). Conversely, excessive rain and high temperatures of tropical climates as in the present assessment enables rapid decomposition of organic matter and leaching of plant nutrients. Excessive slope may encourage the erosion of the top layer of soil which holds most of the raw organic material that would otherwise eventually become humus.

In view of the observations during the field studies, the present variability in total organic carbon content of the soils could be attributed to its high accumulation around the densely vegetated and unhampered secondary forest portion of the area. The other areas possess less dense vegetation cover leading to reduced rate of plant residue returns and accumulation with inherent high decomposition rate on the sandy, loamy sand texture soil.

Total Nitrogen: The trend exhibited by the total organic carbon content was also manifested by the total organic matter content. Total nitrogen content varied between 0.06% to 0.56% with a mean value of 0.22% in the dry season. In the wet season, Total Nitrogen range from 0.02% to 0.08% with a mean value of 0.05%. The total nitrogen content of soil depends on the climate, vegetation, topography, age and soil management. Usually more nitrogen is under grassland than under forest. Humans formation promotes nitrogen immobilization. Cultivation decreases soil nitrogen by exposing soil to more air which bacteria can use and no-tillage maintains more nitrogen than tillage. In the present study, the reasons given for the trend in the observed in the total organic carbon content in the soils is also applicable to the total nitrogen content in the soils.

Cation Exchange Capacity (CEC(meq/100g): The cation exchange capacity of the soils ranged from 3.95 meq/100g to 9.94 meq/100g with mean value of 5.74 meq/100g (dry season), while the wet season value range from 2.95meq/100g to 7.10meq/100g, with a mean value of 4.89meq/100g. Most of the soil's CEC occurs on clay and humus colloids, and the lack of those in hot, humid, wet climates (as in the present study) due to leaching on sandy soils and decomposition respectively, explains the relative low levels of the exchangeable cations in these soils.

Anions: Sulphate, Chloride, Phosphate: The mean levels of these anions (dry season) were generally low as follows; Sulphate (3.33mg/kg); Chloride (8.88mg/kg) and Phosphate (0.17mg/kg) respectively. In the wet season, the values were: sulphate (119.59mg/kg), phosphate (13.69mg/kg). These values are consistent with the relatively low CEC determined in the soils. In soil, iron and aluminum hydroxide clays are able to exchange their hydroxide anions (OH^+) for other anions. The order reflecting the strength of anion adhesion is as follows; $H_2PO_4^{2-}$ replaces SO_4^{2-} replaces Cl^-.

Electrical Conductivity (E.C): The E.C. of the soils varied between 21.00 to 235.0061µS/cm with a mean value of 59.61µS/cm (dry season) and range from 6.25 to 980.00µS/cm in the wet season with a mean value of 641.90µS/cm.

Total Hydrocarbon Content (THC): The THC of the soils ranged from 1.94mg/kg to 16.08mg/kg with a mean value of 7.36mg/kg.

Heavy metals: The mean concentration of the heavy metals in the dry season and related soil micronutrient elements were as follows; Iron (2222.15mg/kg), Zinc(4.83mg/kg), Chromium (0.02mg/kg), Lead (3.92mg/kg), Copper (2.95mg/kg), Cadmium(0.18mg/kg), Nickel(1.94mg/kg), Barium(0.19mg/kg). However, in the wet season, the mean values were iron (1503.66mg/kg), zinc (44.85mg/kg), chromium (1.87mg/kg), Lead (85.92mg/kg), Copper (7.30mg/kg), Cadmium (1.54mg/kg). These values are consistent with levels of these metals as found in non-contaminated or none anthropogenically impacted soils, except for lead in the wet season.

Total Heterotrophic Bacteria (THB). The mean amount of the THB in the soils was 1.78×10^5cfu/g.

Total Heterotrophic fungi, (THF). The mean value of THF in the soil was 0.70×10^3cfu/g.

Table 4.11: Physicochemical and Microbial Properties of Soils

Parameter	Unit	Dry Season						Wet Season					
		0-15 cm			15-30 cm			0-15 cm			15-30 cm		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH		5.23	6.79	5.98	4.75	6.74	5.97	6.1	7.3	6.61	6.24	7.1	6.58
Conductivity	µs/cm	184	488	293.57	107	425	258.74	35	326	164.82	42	268	142.86
Chloride	mg/kg	35.45	124.08	71.10	17.73	106.35	60.50	3.55	88.63	31.26	3.55	70.9	23.85
Sulphate	mg/kg	37.76	138.99	91.48	19.89	130.06	78.80	2.36	87.4	39.96	2.36	74.11	40.41
TOC	%	0.23	5.11	2.34	0.08	4.52	1.83	0.2	4.37	1.85	0.04	3.12	1.32
Phosphorous	%	0.002	0.006	0.00	0.001	0.005	0.00	0.006	0.018	0.01	0.005	0.016	0.01
Ammonium	mg/kg	0.077	0.206	0.14	0.065	0.181	0.12	1.802	4.64	3.14	1.54	4.12	2.73
Nitrate	mg/kg	0.265	0.707	0.48	0.221	0.619	0.41	4.635	11.94	8.08	3.975	10.605	7.02
Nitrogen	%	0.06	0.16	0.11	0.05	0.14	0.09	0.06	0.16	0.11	0.07	0.18	0.12
THC	mg/kg	0.02	2.57	1.37	0.02	2.15	1.03	0.26	1.44	0.98	0.09	1.43	0.83
Density	g/cm3	1.47	2.42	1.93	1.49	2.41	1.98	1.34	2.33	1.75	1.42	2.62	1.93
Porosity	%	8.7	44.5	27.04	9.1	43.8	25.39	21.9	49.4	34.40	16.2	47.2	33.71
CEC	(meq/100g)	9.63	18.24	13.61	10.01	16.3	12.64	10.26	19.069	13.48	9.665	16.462	12.62
Phenols	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SAND		50	82	67.17	52	89	69.43	46	88	71.36	38	83	70.59
SILT		4	30	17.00	3	35	15.26	3	46	16.32	6	51	16.64
CLAY		8	34	15.83	4	33	15.22	4	32	12.32	2	23	12.77
TEXTURE		Sandy Loam	Sandy Clay	Sandy	Sandy Loam	Sandy Clay	Sandy	Sandy Loam	Sandy Clay	Sandy	Sandy Loam	Sandy Clay	Sandy
Fe	mg/kg	886	30245	3410.26	993	3624	1954.70	772.4	3528	2100.21	879.2	3558.4	2023.91
Cd	mg/kg	0.12	1.26	0.56	0.08	0.95	0.50	0.52	0.95	0.72	0.3	0.83	0.54
Cu	mg/kg	1.25	8.68	4.07	0.65	10.25	3.49	0.81	7.26	3.34	0.77	9.47	2.88
Pb	mg/kg	1.04	5.32	3.18	0.36	5.22	2.83	0.45	4.95	2.84	0.55	4.8	2.42
Cr	mg/kg	0.4	4.23	1.66	0.4	4.79	1.62	0.9	5.5	2.25	0.5	4.7	1.80
Hg	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	mg/kg	0.36	4.39	1.99	0.49	3.9	1.59	0.2	4.2	1.74	0.25	4.15	1.28

Mn	mg/kg	4.18	115.36	46.84	5.06	119.05	48.16	8.32	107.52	44.81	7.92	107.14	40.49
V	mg/kg	0.01	0.08	0.04	0.01	0.07	0.04	0.01	0.06	0.04	0.02	0.09	0.05
Zn	mg/kg	3.67	50.78	19.89	2.46	44.8	19.07	6.315	49.8	18.44	6.445	34.15	16.08
Ba	mg/kg	0.11	0.7	0.40	0.08	0.91	0.39	0.07	0.495	0.31	0.105	0.6	0.27
As	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
K	meq/100g	0.21	1.49	0.66	0.12	1.41	0.69	0.385	1.323	0.675	0.497	1.103	0.681
Mg	meq/100g	1.56	5.13	3.02	0.86	4.12	2.72	1.407	5.141	2.919	0.735	3.552	2.508
Ca	meq/100g	1.53	7.73	4.19	2.01	7.02	4.00	1.988	7.161	4.171	1.927	6.063	3.890
Na	meq/100g	0.43	3.26	1.55	0.82	2.74	1.46	0.492	2.216	1.309	0.700	2.317	1.337
THB	cfu/g	0	0	0	0	0	0	0	0	0	0	0	0
THF	cfu/g	0	0	0	0	0	0	0	0	0	0	0	0
HUB	cfu/g	0	0	0	0	0	0	0	0	0	0	0	0
HUF	cfu/g	0	0	0	0	0	0	0	0	0	0	0	0
SRB	cfu/g	0	0	0	0	0	0	0	0	0	0	0	0
TPH	mg/kg	0	0	0	0	0	0	0.1474	0.9572	0.56	0.051	0.8046	0.45
PAH	mg/kg	0	0	0	0	0	0	0.01	0.12	0.06	0.02	0.13	0.06
BTEX	mg/kg	0	0	0	0	0	0	0	0	0	0	0	0

Source: Fieldwork 2019

4.3.6 Land Use

Over the millennia, land use had been determined by tenurial systems evolved over time and determined by the perceived demand as well as the potential and actual social pressures associated with its supply and use (Powell, 1995; Swallow and Kamara, 2000).

Land Use Pattern

Land use in the entire area comprises farmlands used for the cultivation of cassava, maize and oil palm. These are mainly subsistence agriculture. There were a few infrastructures for residential and commercial use outside of the main oil production (Flow station) facilities

4.3.7 Vegetation and Wildlife

Vegetation Studies

The study area is located within the tropical rainforest belt of Nigeria and is made up of two rainforest vegetation sub ecosystems: The Lowland tropical rain forest and the Raffia swamp forest variant of the freshwater swamp vegetation. The study area is dominated by the Lowland tropical rain forest; and the proportion of vegetation cover area for each of the vegetation cover types is presented in Figure 4.15.

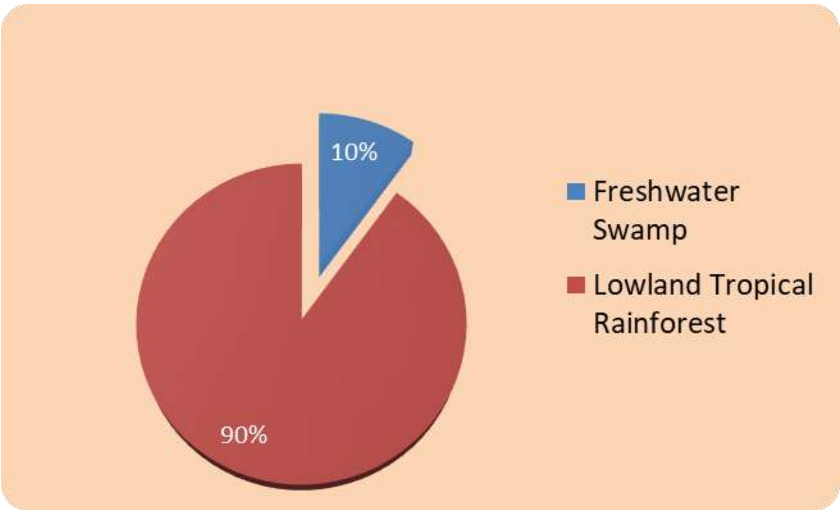


Figure 4.15: Percentage Composition of Vegetation Cover

The vegetation of the study area is discussed in order of prominence:

4.3.8 Lowland Tropical Rain Forest

A typical tropical primary rainforest is tree dominated and has a characteristic vegetation canopy that is stratified into several vertical storeys with a minimum of three ranks of trees heights reaching great heights. The typical layers are the emergent (> 40 meters), the canopy (30-40 meters), and the understorey layer (20-30 meters). Normally tree diversity is high consisting of very tall trees with straight trunks and dense canopy layer (populated by a diversity of climbers and lianas) which results in a poorly lit and almost bare forest floor (Shukla and Chandel, 2006).

Vegetation Physiognomy and Structure

The tropical rainforest vegetation of the study area is a mosaic of vegetation cover types of different physiognomy and at different stages of succession as there is continuous uneven forest degradation. There are neither areas of primevial nor secondary tropical rain forests within the study area. This is due to a history of anthropogenic activities especially lumbering and shifting cultivation land use patterns that has greatly altered the structure and species composition of the vegetation cover. Field observations reveal that the lowland tropical rainforest of the area is differentiated into three basic categories on the basis of structure, physiognomy, species composition, and level of maturity of vegetation which are:

Regrowth Forest, Open Canopy Forest, and Agricultural farmlands/bush fallow; the percentage contribution of this categories to the overall rainforest vegetation cover is shown in Figure 4.16. The structure and species composition of this rain forest is discussed under these headings.

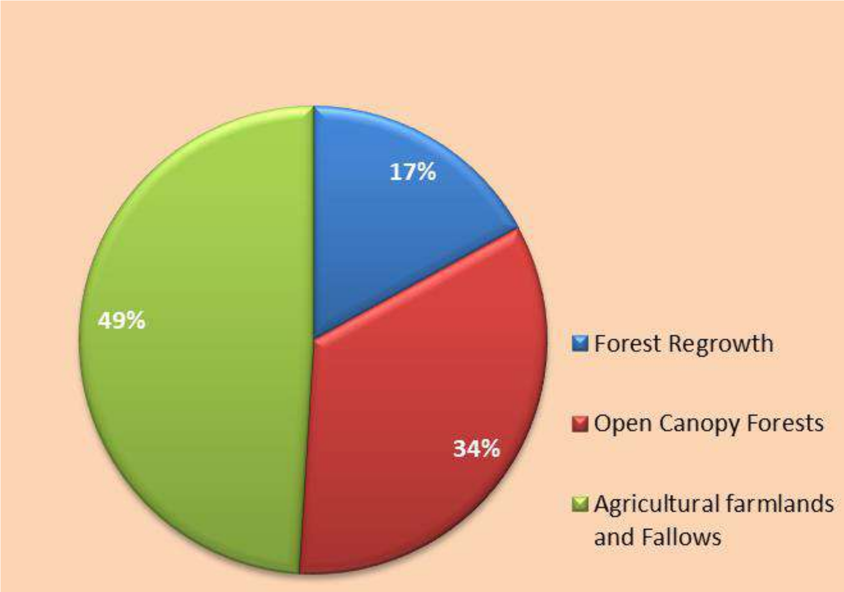


Figure 4.16: Composition of the Rain Forest Vegetation

Regrowth and Open Canopy Forest Vegetation.

The tropical rainforest vegetation in the study area is transitional, and not climax. It consists of mostly open canopy vegetation structure and is less tree dense than the more mature regrowth forest areas. The regrowth forest vegetation is characterized by an absence of the uppermost storey (emergent tree canopy) of traditional rainforests, has a canopy cover of less than 50 percent, and a predominance of the understorey (Plate 4.11). According to the Raunkiaer's life form classification scheme for vegetation structure, the vegetation cover in the forest regrowth is mostly Mesophanerophytic with < 15% Megaphanerophytes. The vegetation is thus fairly vertically stratified into two layers of tree canopies; the uppermost layer (consisting of volunteer emergents) reaches 22 meters, while the lower and thicker layer of volunteer canopy trees reach an average of 17 meters. A number of timber sized trees most of which are trees that have very little economic value are still present.

The open canopy forest areas however is mostly rainforest understorey vegetation; it is lacking in Megaphanerophytes with a significant presence of Microphanerophytes (<35%) and predominance of Mesophanerophytes. Average vegetation height is 7 meters with trees reaching 15 meters (Plate 4.11c, d). This forest structure is present at VG 15, 13, 17, 14, and 11.

These vegetation systems show a history of commercial lumbering of economic timber species; the regrowth forest areas, however not being subject to forces of primary destruction such as fire. Logging for domestic fuel use and agricultural encroachment are observed to be the major activities resulting in the degradation of the rain forest in the open canopy forest areas (Plate 4.11g,h). The resulting physiognomy of the vegetation is that of a forest consisting of undersized timber species and saplings, with a preponderance of pioneer species of disturbed forests eg. *Musanga cercropioides*, *Cleistopholis patens*, and *Ricinodendron heudoletii*. The shrub layer and undergrowth is observed to be prominent in the open canopy areas because of the more or less open canopy which encourages the growth and diversity of regrowth species.

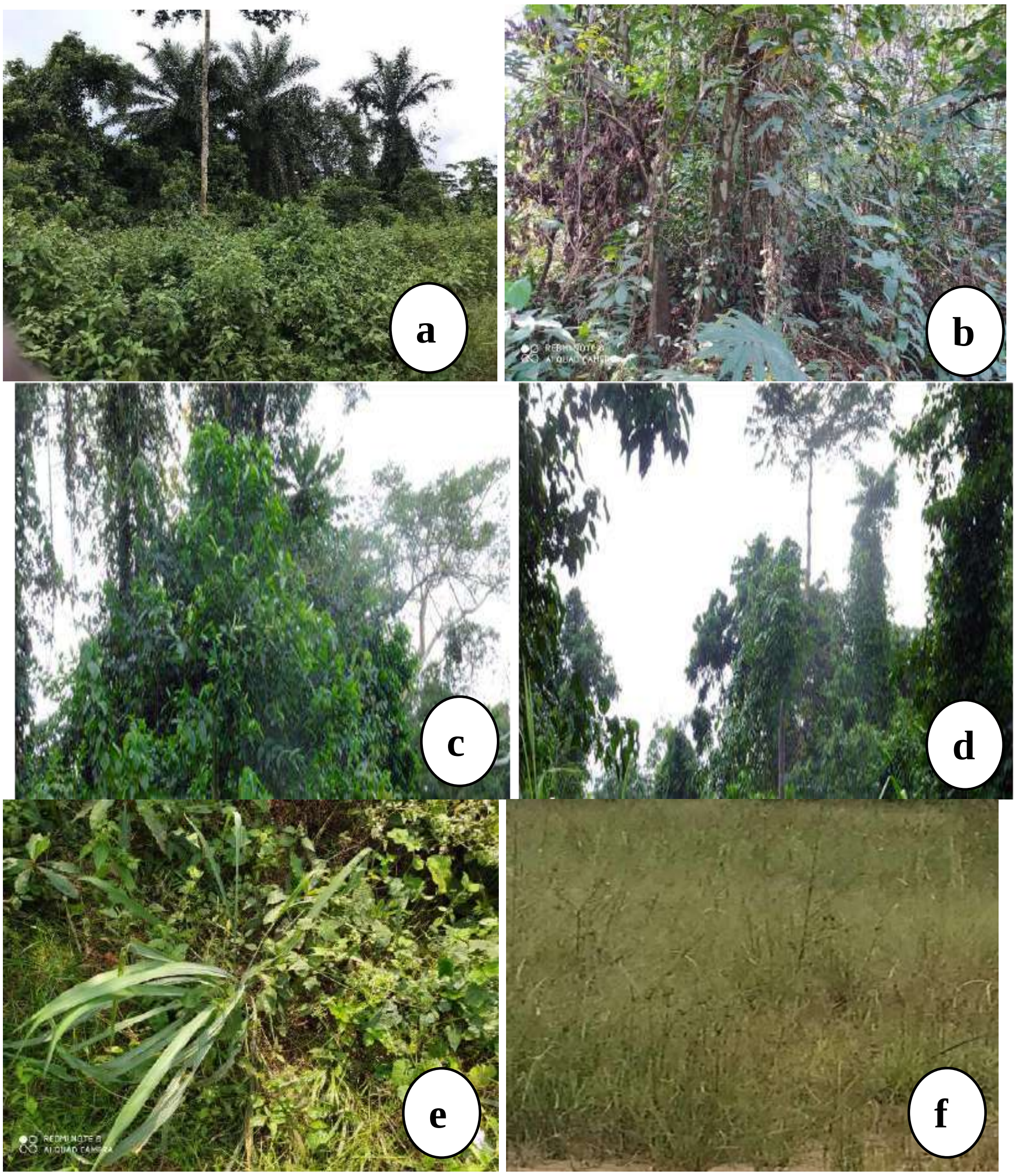


Plate 4.11: Panoramic view of lowland rain forest vegetation of the study area: **a,b:** rainforest regrowth (VG 16); **c,d:** open canopy forest (VG 13, 17); **e,f:** forest floor vegetation (VG 17); **g,h:** agricultural and lumbering activities (VG 14, 16).

Species Composition

A total of 58 species belonging to 32 families were identified as making up the taxonomic diversity in the forests of the study area. Diversity at the rank of family is in the following order: Euphorbiaceae (9) > Fabaceae (6) > Meliaceae (4) > Asteraceae, Rubiaceae, Poaceae (3). Twenty (20) Families were represented by single species. Species composition is fairly consistent with disturbed areas of rainforest ecosystem. A few incidences of invasive species (*Mimosa pudica*) were observed at VG 15 and C1.

Dominant economically important undersized timber species present in this tropical low land rain forest canopy include: *Lophira alata, Alstonia boonei, Fleroya ledermanii, Ceiba pentandra, Ricinodendron heudelotii, Musanga cercropioides, Albizia zygia, Parkia bicolor, Ficus mucoso, Khaya ivorensis, Irvingia gabonensis, Pycnanthus angolensis, Cleistopholis patens, Lovoa trichilioides, Nauclea diderrichii, Terminalia superba, Terminalia ivorensis, Caesalpinia bonduct, Vitex grandifolia, Elaeis guineensis, Ficus exasperata, Funtumia elastica, Trycoscypha arborea.*

Hevea brasiliensis (especially coppices and saplings) is very common at VG 10, 14, 16 and 17 indicatives of an area previously a rubber plantation but now overtaken by natural process of extenuation; the old rubber trees are a choice fuel wood for the locals. The vegetation is mostly open canopy with dense primary forest floor species around VG 16, 17 and 13;

dominant floor species include *Thalia welwitschii*, *Aframomum spp*, and *Costus afer, Chromolaena odorata, Vernonia amygdalina, Manniophyton fulvum* and *Alchornea cordifolia* are common plants of cleared areas.

Agricultural Farmlands and Bush Fallow

This type of vegetation cover is identified as occupying a significant portion of the study area whose agriculture is characterized by non-mechanized mono or mixed cropping system. Agricultural activity is generally on commercial scale exceeding an acre characterized by slash and burn activities and shifting cultivation. Mono cropped plantation of Plantain (VG 15) and Cassava (VG 13, C1, and C2) are observed in the study area. A mixed cropping system (< 4 ha) is present at VG 10 consisting of Oil palm intensively cropped with Plantain and Pawpaw. Planting density is standard: 3700 tree per acre for cassava, and 900 plants per acre for plantain. Conversion of forested areas for plantain agriculture is observed around VG 17. Fallow lands especially areas that have lost arability are common and are observed at VG 15, 13, and 18.

Raffia Swamp Forest

This vegetation type is found along the Gelegele banks of the Osse river at VG C4. The Raphia swamp forest is a near homogenous vegetation community and derives its nomenclature from the name of the dominant plant species, which in this case is *Raphia hookeri.* In this community, a few other species are found in association with Raffia. *Fleroya ledermanii* (timber trade name = Abura) is observed to be more or less codominant with raffia and grows gregariously in patches on the landward side of this vegetation with oil palms sparsely distributed (Plate 4.12). Vegetation height of this community ranges from 12 – 15 meters. Vegetation ground cover is over 90% with tree density reaching 300 trees per acre. This vegetation system is observed to have experienced lumbering of *Abura* in recent past. This vigorous swamp species is however left with undersized timber trees some of them reaching 16meters in height.

Plate 4.12: Raffia swamp vegetation at VG C4.

Plant Phytochemistry

Plants are bio-indicators of chemical pollution of the environment especially the soil and air and are therefore used to assess the quality of the environment and how it changes over time (Holt, 2011). Heavy metal level was assessed in plant leaf and stem samples taken from all the sample locations visited during the dry and wet season studies. This was done to ascertain any incidence of phytotoxicities and establish the baseline condition with regards to heavy metal contamination. Chemical pollutants assessed include the toxic trace metals Iron, Copper, Manganese, and Zinc; and five non-essential toxic heavy metals: Cadmium, Chromium, Lead, Vanadium, and Nickel which are possible pollutants in an oil and gas operational environment. Results show slight variation in concentration levels across the study area, and seasons (Table 4.12). There is also a consistent pattern of distribution of heavy metals across stem and leaf tissue of plants in all the samples (Figure 4.17).

Table 4.12: Summary of Heavy Metal Concentrations found in Plant Leaf and Stem tissue During the Wet and Dry Seasons.

PARAMETER	LEAF		STEM	
(mg/kg)	Wet Season	Dry Season	Wet Season	Dry Season
Iron (Mean) (Range)	**75.05** (39.2 - 120.3)	**108.57** (58.8 - 163.5)	**65.38** (31.7 – 110)	**74.2** (33.3 - 106.2)
Copper	**0.57** (0.12 - 0.91)	**0.93** (0.17 - 1.99)	**0.4** (0.18 -0.72)	**0.55** (0.09 - 1.77)
Manganese	**0.24** (0.14-0.42)	**0.6** (0.09 - 0.91)	**0.19** (0.1 - 0.33)	**0.3** (0.04 - 0.60)
Zinc	**30.13** (19.7- 48.4)	**62.1** (25.6 – 96)	**24.46** (11 - 38.6)	**44.38** (11.8 - 74.30)
Cadmium	ND	ND	ND	ND
Chromium	ND	ND	ND	ND

Lead	ND	ND	ND	ND
Nickel	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND

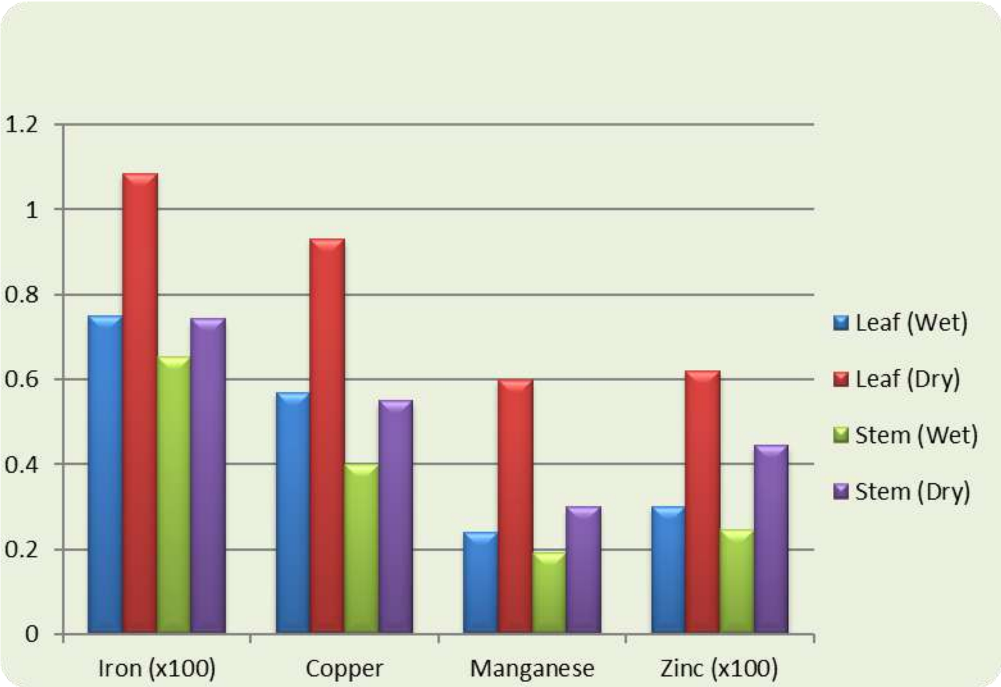


Figure 4.17: Comparison of Means of Leaf and Stem Heavy Metal Content (mg/kg) for Wet and Dry Seasons.

None of the non-essential toxic heavy metals was detected in the plant tissues across both seasons; only the trace heavy metals were present. Copper and Manganese concentrations were found to be below normal concentrations for plant tissue: 5 – 12 mg/kg and 20 – 240 mg/kg (Fifield and Haines, 2000) respectively. Concentrations ranged from 0.12 – 0.19 mg/kg for Copper in wet season leaf samples to 0.17 – 1.99 mg/kg in dry season leaf samples. The average concentrations of Copper were higher in leaves than in Stem tissue; a similar finding across all the trace heavy metals sampled. This pattern is consistent with patterns of heavy metal distribution in plant tissue for which plant leaves are not only a storage organ but are also positioned to easily bioaccumulate heavy metals from dust in the air over time. The detailed laboratory results of heavy metal screening for both seasons are provided in **Appendices 4.3-4.5.**

Iron and Zinc are important trace heavy metals for plant growth and development. It was found that Iron concentration was within the range for normal concentration in plant tissue for both seasons; and Zinc although found in elevated levels in several samples was not present at toxic concentrations in any of the location assessed. Dry season values for the heavy metals found in the tissue samples were higher than those obtained during the wet season. This finding is ecologically normal as metals accumulate easily in plant tissues during dry season (El-Sharkawy, 2008).

4.3.9 Plant Pathology

Generally, the vegetation is free from disease epidemics. Damages due to fires or spills were not observed neither were there direct physical damage to the vegetation as a result of the company's operations. Very minor disease infections which is normal with plant communities included leaf spot caused by *Cercospora* spp

4.4 Ethnobotany and Forest Resource Utilisation Patterns

The vegetation structure of the study area clearly shows the nature and degree of forest resource use. During the field trotting, at various points, different forms of timber forest products were observed (Plate 4.13). They include stacks of twigs, and logs of old rubber trees harvested for domestic fuel use; they are harvested using portable hand equipment including axes, machetes, and transported by family members on foot and or using bicycles and motorcycles. A total of twenty-one timber species composed of 11 species of hard wood and 10 species soft wood, were identified all of which have varying degrees of utility but generally of great economic value. Commercial harvest of timber forest products is observed in the forms of lumbering on site, or logging and evacuation using heavy duty trucks specially built to convey large diameter logs of wood. Target timber species however include commercial hard wood species with the following trade names: *Allanblackia*, *Opepe, Ekhimi, Iron wood* (Eki/Eba), Lagos Mahogany, Walnut, *Urhuaro*, yellow and black Afara; and soft wood species like *Abura*, *Alstonia*, *Nikiba*, *Okha* (Silk Cotton), *Obonekwi,* Scented guarea, and *Okhuen.*

Plate 4.13: Dominant Patterns of Forest Resource Use in the Study Area.

4.4.1 Wildlife

4.4.2 Wildlife Composition and Biodiversity

Information from native hunters and observations of key indicators of animal presence show that the project area harbours at least 23 Species of animals belonging to 17 Families, which cut across three classes in the phylum chordata. The three classes identified include: Mammalia, Reptilia and Aves. The diversity within these classes in decreasing order is Mammalia (13 species) > Reptilia (5 species) > Aves (5 species). The absence of Amphibia reflects the rain forest ecological conditions. However, the possibility of Crocodiles wandering into the portion of the river is limited because of the volume of activity on the main river course even though they are present in the nearby Ughoton Stream.

It is observed that the Rodents and Bovidae make up a large part of the population of wildlife in the area. These species are usually abundant where there are large areas of farmlands, fallows and degraded forests; as well as areas close to human settlements. During the field trotting exercise, fresh footprints of small ungulates was observed at VG 13 area. Very common birds in the area include the village weaver, and yellow billed kites.

4.4.3 Conservation Status / issues

The Nigerian National biodiversity report on the conservation status of wildlife species in Nigeria categorises 5 of the identified species as Endangered, 3 Threatened and 1 Rare. However, investigations show that the ungulates which are nationally endangered, as well as the Red River Hog and Brushtailed Porcupine which are nationally threatened, are all locally abundant. Monkeys, ground squirrel, pangolin, Civet Cat, Rock Python are locally 'Vulnerable'. Information gathered from hunters show that these vulnerable species have become very few and are only likely to be killed during hunting expeditions once in over 6 months, or when hunters venture far into uncharted territory. While the species that are common in the study area are among the animals easily killed on a weekly basis during hunting. The major threats to the fauna include Hunting activities, lumbering and agricultural practices; these displace wildlife out of the locality, destroy their habitat, or kill them directly. Birds are very rarely hunted. Table 4.13 provides the check list of wildlife and their taxonomic treatments as well as conservation status of the species.

Table 4.13: Check list of Animals in the study area.

s/n	MAMMALS		STATUS		
	ORDER PRIMATES		Local	IUCN	Dcr 11
	Family Lorisidae				
1	Bosmann's Potto	*Perodicticus potto*	Endangered		1
2	Golden Potto	*Arctocebus calabarensis*	Endangered		2
	Family Cercopithecidae (monkeys)				
1	*Mona* Monkey	*Cercopithecus mona***	Vulnerable	LC EWA	2
	ORDER PHOLIDOTA				
	Family Manidae (scaley anteaters)				
1	Tree/White Bellied Pangolin	*Manis tricuspis***	Endangered	NT	1
	ORDER RODENTIA				
	Family Scruidae (True Squirrels)				
1	Geoffrey's Ground Squirrel	*Xerus erythropus*	Vulnerable	LC	
	Family Cricetidae (Pouched Rats)				
2	Emin's Giant Rat	*Cricetomys emini*	Common	LC	
3	Common African Dormouse	*Graphiurus murinus*	Abundant	LC	
	Family Hystricidae				
4	Brushtailed Porcupine	*Atherurus africanus***	Common		
	Family Thryonomidae				
5	Grater Cane Rat	*Thryonomys swinderianus*	Common		
	ORDER CARNIVORA				
	Family Viverridae				
1	African Civet	*Civettictis civetta**	Vulnerable	LC	2
	ORDER ARTIODACTYLA				
	Family Suidae				
1	Red River Hog (Bush Pigs)	*Potamochoerus porcus****	Abundant	LC	-
	Family Bovidae Subfamily Bovinae				

2	Marsh Buck	*Tragelaphus spekii**	Abundant	LC	1
	Family Bovidae Subfamily Antilopinae				
3	Maxwell's Duiker	*Philatomba maxwelli**	Abundant		

Key: LC = Least Concern. Dcrn = Decreasing population. Dcr 11 = Decree 11 which prohibits the capture and or killing of Endangered species. 1 = Absolute prohibition; 2 = License required.

Table 4.14: Check list of animals in the study area. – Contd.

S/N	REPTILES		STATUS		
			Local	**IUCN**	**Dcr 11**
	Family Varanidae				
1	Forest/Ornate Monitor	*Varanus ornatus**	Abundant		
	Family Boidae				
2	African Rock python	*Python sebae**	Vulnerable		1
	Family Elapidae				
3	Black Cobra	*Naja melanoleuca*	Rare		
4	Spitting Cobra	*Naja nigricollis*	Rare	-	
5	Jameson's mamba	*Dendroaspis jamesoni*	Common		

Table 4.15: Check list of animals in the study area. – Contd.

S/N	BIRDS / AVES		STATUS		
	ORDER FALCONIFORMES		Local	IUCN	Dcr 11
	Family Accipitridae				
1	Yellow-billed Kite	*Milvus aegyptius parasites*	Abundant		1
	subfamily Polyboroidinae (Harrier Hawks)				
2	African Harrier Hawk	*Polyboroides typus*	Common		
	ORDER PASSERIFORMES				
	Family Ploceidae/Passeridae				
1	Village Weaver	*Ploceus cucullatus*	Abundant		
	Family Pycnonotidae				
2	Common bulbul	*Pycnonotus barbatus*	Common		
	ORDER COLUMBIFORMES				
	Family Columbidae				
1	Laughing dove	*Stigmatopelia senegalensis*	Common	LC stable	-

Source: Fieldwork 2019

Key: C.E = Critically Endangered.

Plate 4.14: wildlife presence in the study area. a: Snake skin shed (VG 11); b: foot prints of ungulates suspected to be Maxwelli's Duikers; c : Killed snake observed around the project site

4.4.4 Geology/Hydrogeology/Hydrogeochemistry

4.4.5 Local Geology

The local Geology of the study area (Gelegele and environs), in the context of environmental study is the Quaternary sands, gravels and clays of the Menander belt, Back swamps and Fresh water swamps. This at depth is underlain by the youngest of the Niger Delta Tertiary chronostratigraphic unit - Benin Formation. The Menander belts and swamps are lithologically characterized by sands and gravels that are texturally medium to coarse and clays that are thicker near the surface. The underlying Benin Formation lithologically consists of sands and sandstones with minor clay intercalations in places (Short and Stauble, 1967). Figure 4.18 represents an extract of the local geology of Gilli-Gilli and environs from the regional Niger Delta Geological Map (after GSN, 1974).

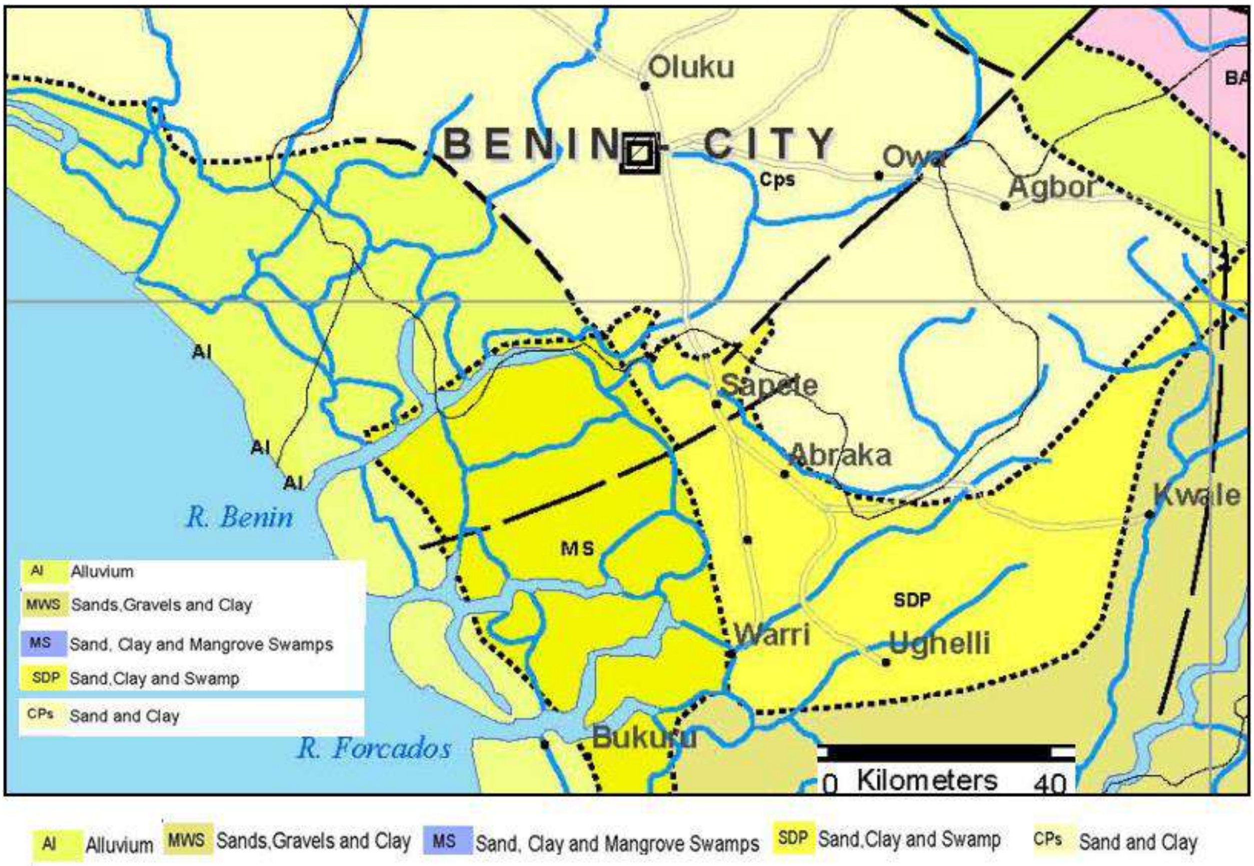


Figure 4.18. Geological Map of Gelegele and Environs (after Geological Survey of Nigeria, 1974)

4.4.6. Local Stratigraphy.

The local, near surface lithostratigraphy within the project area as revealed by well bore is presented in Figure 4.19 The subsurface of Gelegele project site and environs is characterized basically, by clay, clayey sands silty sands and sands. The sands are generally medium to coarse grained. The preponderance of brown sand matrix colour may in part be as a result of long time contact with water with high concentration of iron. The coarseness of the sands and lighter coloration at depths of 35ft and below is suggestive of good reservoir development.

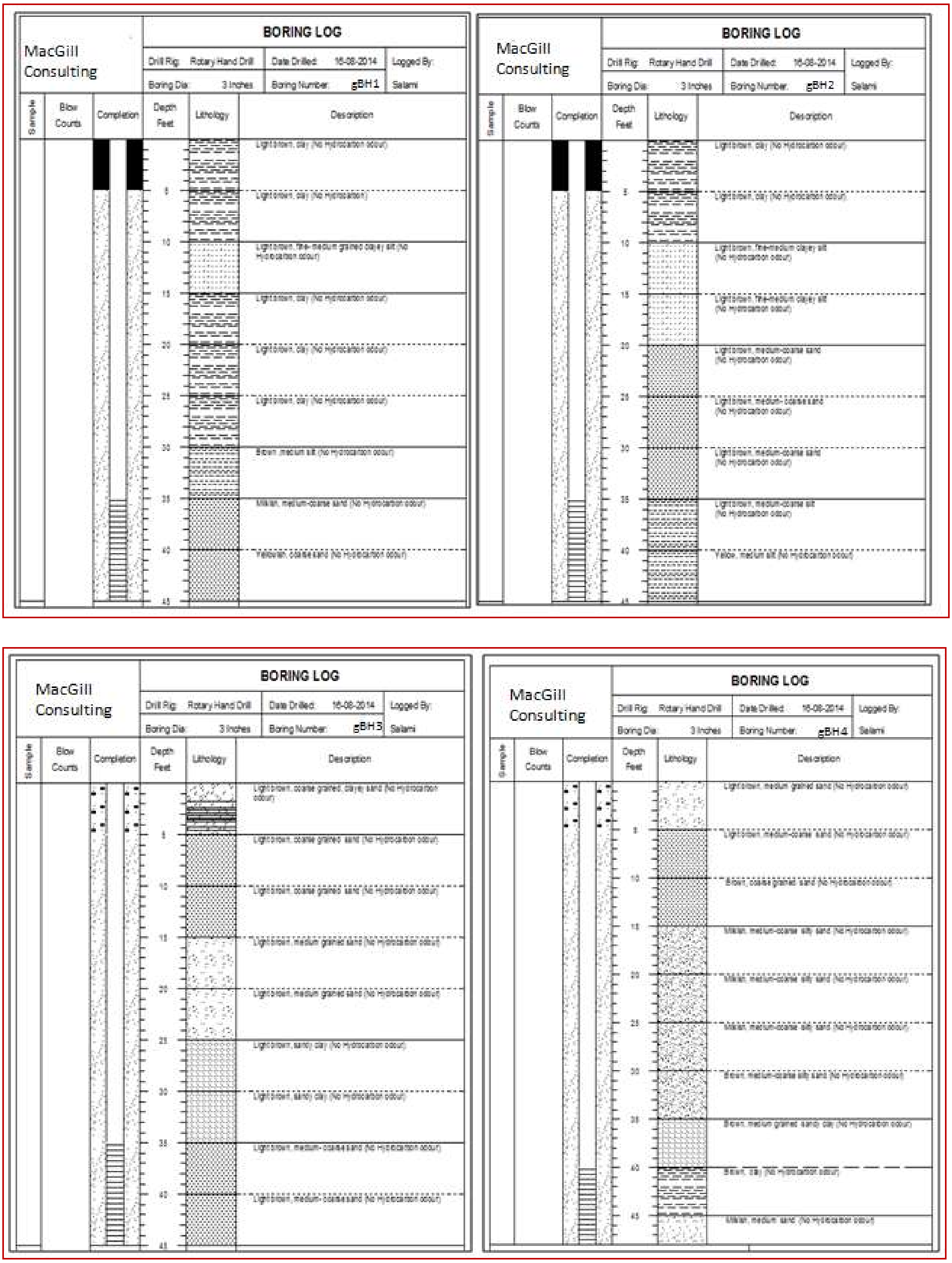


Figure 4.19: Lithostratigraphy of the Study area. (Left-Right: BH1, BH3, BH4 and BH5)

4.4.7 Hydrogeology

The results of field measurements directed at the evaluation of groundwater system within the project site and it's immediate environ are presented in Table 4.15 and Figs 4.20 to Figure 4.22. The results depicted in the figures are hydraulically related. Figure 4.19 is a map of the limited local ground topography which may exert influence on groundwater system especially in terms of aquifer recharge mechanisms. The landmass is characterized by a gentle slope from the north-western area to the south-eastern area. The low-lying area is marked by a river course with a southward flow direction. Figure4.7.4 is a map depicting the variation in depth to the groundwater level vis-à-vis the surface topography within the area.

The map expectedly indicates shallow depth to groundwater at borehole one location which is within the flood plain of a river. Farther away, the depth increases with borehole 3 area marking the deepest part. Figure4.7.5 are maps depicting the groundwater piezometric surface and flow direction in the immediate vicinity of the study area. The potentiometric surface defines the hydraulic head that drives the groundwater flow in the south-east direction. This, apart from vertical infiltration, indicates an aquifer recharge area in the northern to north-western area. The overall flow in the south-east direction may suggest that groundwater in part contributes to the river base flow within this vicinity. However, this flow regime as characterized by flow direction may be dynamic and reversed when river water head is high and above the groundwater level.

Table 4.16 Field Measured Hydrogeological Parameters

	NORTHING	EASTING	GROUND ELEVATION (m)	WATER LEVEL DEPTH(Ground Surface Ref),m	WATER LEVEL ELEVATION, m	WATER LEVEL DEPTH (Casing Top Ref), m	WELL TD(m)	PIPE LENGTH (m)
BH 4	6° 09.229'	5° 20.591'	5.7	1.24	4.46	2	13.7	0.76
BH 1	6° 08.686'	5° 21.154	22.5	5.7	16.8	6.6	13.7	0.9
BH 3	6° 08.957'	5° 21.227'	30.4	3.5	26.9	4.3	9.1	0.8
BH 5	6° 08.467'	5° 20.500'	37.8	2.5	35.3	3.6	15.24	1.1

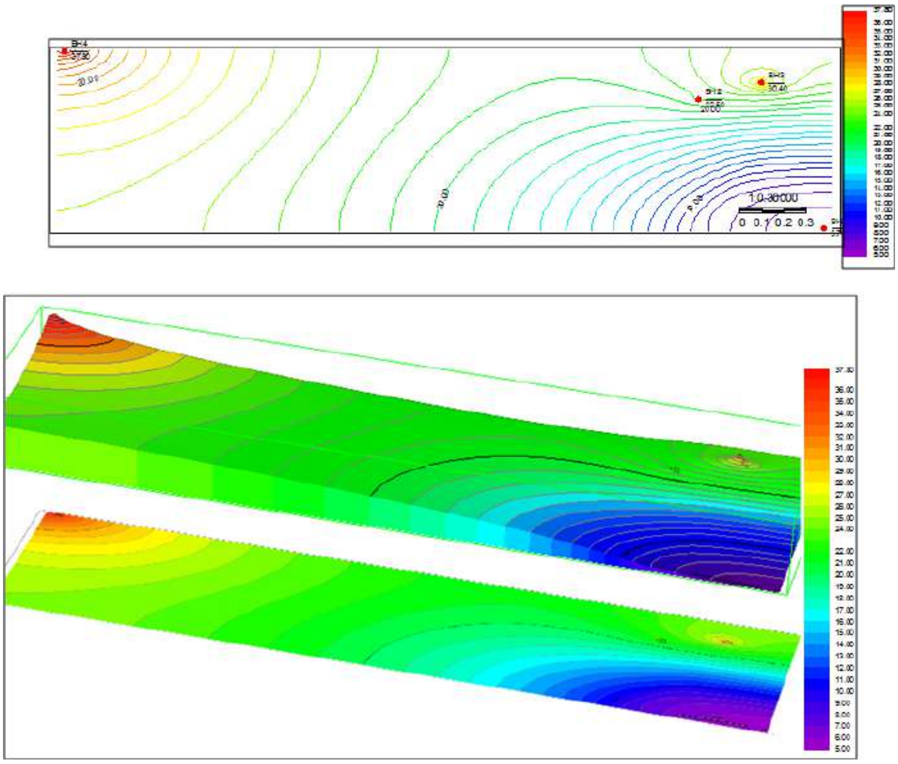


Figure 4.20. Gelegele Area Limited Topographical Map. Top: 2D View; Below: 3D View

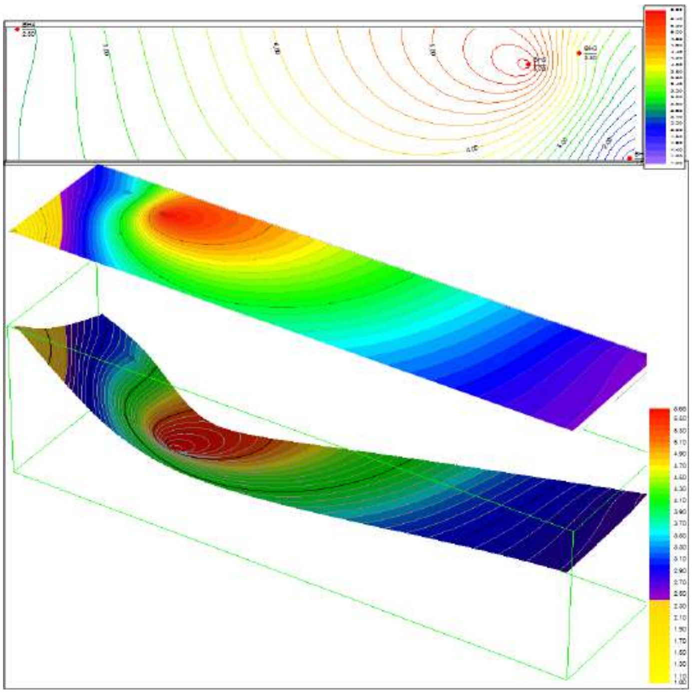
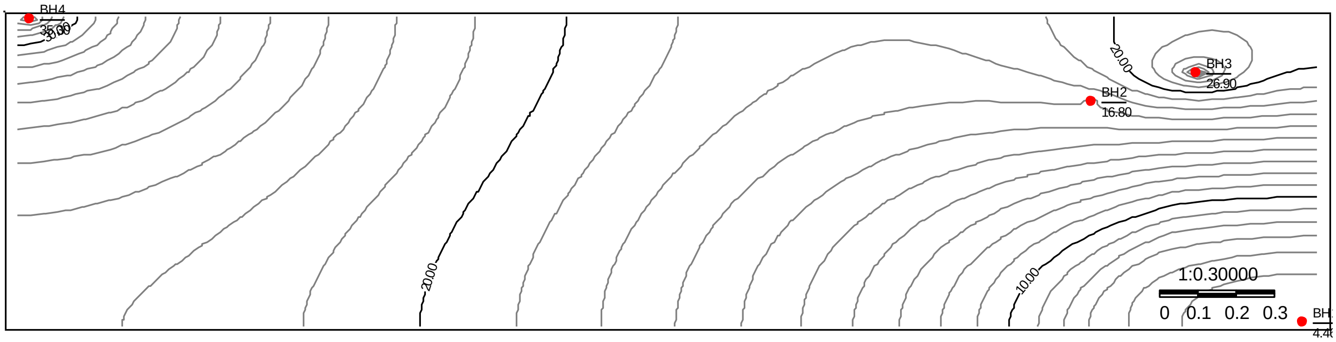


Figure 4.21. Gelegele Depth to Groundwater Map. Top: 2D View; Below: Rotated 3D View



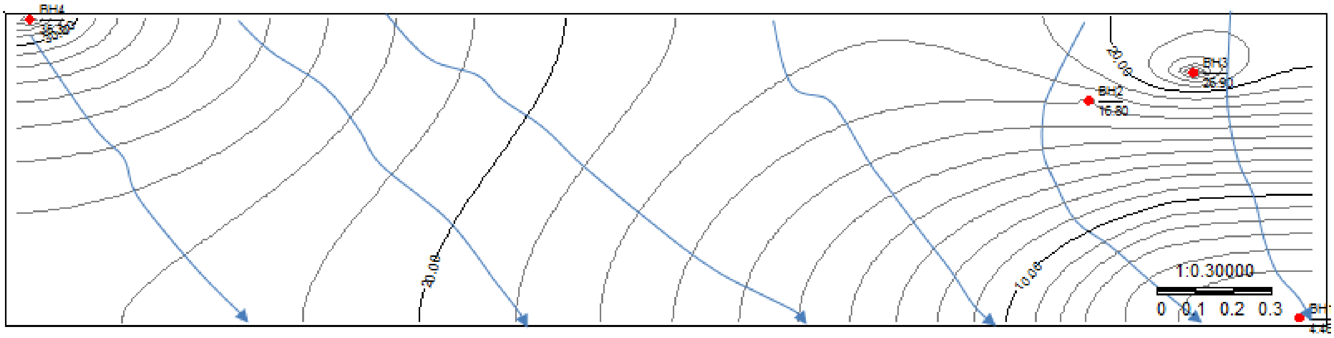


Figure 4.22 (Top) Local Groundwater Head and (Below) Groundwater Flow Direction

Finally, it is noted generally that groundwater hydraulics as presented here is of local significance because of the limited number of sampled data points and limited area coverage. The proximity of BH1 to a nearby water course, which serves as transportation medium for the evacuation of produced hydrocarbons may significantly affect the overall local flow regime but was not investigated.

4.4.8. Environmental Evaluation

The environmental sensitivity of the subsurface geological environment can be evaluated in terms of the ease with which harmful by-products of surface activities infiltrate/diffuse downward to the groundwater system. Quantitatively, the ease of flow of fluids which in large part accounts for contaminants transport in clastics materials is driven by two petrophysical variables, namely, hydraulic conductivity (intrinsic permeability) and porosity (Reddy,2006 and Todd,1980). While porosity defines the available rock volume for fluid residence, hydraulic conductivity quantifies the interconnectivity of the pore throats. Hydraulic conductivity, therefore, determines the ease of travel of contaminants from the surface environment to the subsurface hydrogeological environment. Table 4.16 is a presentation of the summary of the estimated hydraulic conductivity (k), rock matrix percentage composition and bulk material density within the area. The results are obtained from empirical estimation using pedotransfer functions of Wösten and van Genuchten (1988), Wösten (1997), Wösten *et al.* (1995) and Cosby *et al.* (1984). While the two values are expectedly low and within limits for fine clastics as depicted by the rock matrix decomposition (Table 4.17), Wösten's estimates are generally higher than Cosby. The two values therefore represent a range depicting lowest to highest transmission rates scenario. The study area presents a near surface clayey/silty/ sand matrix to investigated total depth (TD). The correspondingly low Hydraulic conductivities indicate a protected subsurface environment. Groundwater quality, therefore, is expected to be high and meet standards for both domestic and industrial uses.

Table. 4.17 Rock Matrix Decomposition and Hydraulic Conductivity

		Bulk Density	Rock Matrix Decomposition			Hydraulic Conductivity Estimate, m/s		
			% Clay	% Silt	% Sand	Wösten et al. (1997)	Cosby et al., 1984	Average (Wos&Cosb)
	Depth (ft)	BD	Clay	Silt	Sand	K_s	K_s	K_s
GG BH4	5	1.33	13.2	2.7	84.1	8.27321E-05	1.67383E-05	4.97352E-05
GG BH4	10	1.33	9.2	0.7	90.1	8.7891E-05	2.11306E-05	5.45108E-05
GG BH4	15	1.3	11	0.9	88.1	9.62762E-05	1.94174E-05	5.78468E-05
GG BH4	20	1.32	11.7	0.7	87.6	8.86668E-05	1.89414E-05	5.38041E-05
GG BH4	25	1.45	10.7	0.7	88.6	5.27982E-05	1.97884E-05	3.62933E-05
GG BH4	30	1.34	10.2	0.7	89.1	8.33967E-05	2.02261E-05	5.18114E-05
GG BH4	35	1.31	15.7	0.7	83.6	8.90893E-05	1.59005E-05	5.24949E-05
GG BH4	40	1.32	6.2	1.2	92.6	9.54661E-05	2.37471E-05	5.96066E-05
GG BH4	45	1.55	14.7	0.7	84.6	3.2719E-05	1.66116E-05	2.46653E-05
GG BH1	5	1.33	12.2	1.2	86.6	8.44501E-05	1.82647E-05	5.13574E-05
GG BH1	10	1.33	10.7	1.7	87.6	8.52792E-05	1.92226E-05	5.22509E-05
GG BH1	15	1.34	11.2	2.2	86.6	8.11998E-05	1.85358E-05	4.98678E-05
GG BH1	20	1.36	11.2	1.7	87.1	7.53607E-05	1.88067E-05	4.70837E-05

GG BH1	25	1.33	5.2	1.2	93.6	9.40723E-05	2.48091E-05	5.94407E-05
GG BH1	30	1.29	7.2	0.7	92.1	0.000106009	2.30628E-05	6.45358E-05
GG BH1	35	1.3	11.7	1.2	87.1	9.52874E-05	1.86686E-05	5.6978E-05
GG BH1	40	1.29	8.2	0.7	91.1	0.000104112	2.20755E-05	6.30938E-05
GG BH1	45	1.3	6.2	1.2	92.6	0.00010311	2.37471E-05	6.34287E-05
GG BH3	5	1.26	9.2	2.2	88.6	0.000112548	2.02307E-05	6.63893E-05
GG BH3	10	1.37	7.7	0.7	91.6	7.68061E-05	2.25638E-05	4.96849E-05
GG BH3	15	1.35	8.2	0.7	91.1	8.24853E-05	2.20755E-05	5.22804E-05
GG BH3	20	1.33	7.2	1.2	91.6	9.00211E-05	2.27306E-05	5.63759E-05
GG BH3	25	1.43	6.2	0.7	93.1	6.1902E-05	2.40941E-05	4.29981E-05
GG BH3	30	1.42	11.2	0.7	88.1	5.95856E-05	1.93603E-05	3.94729E-05
GG BH3	35	1.33	10.2	0.7	89.1	8.67351E-05	2.02261E-05	5.34806E-05
GG BH3	40	1.29	8.7	0.7	90.6	0.000103288	2.15979E-05	6.24427E-05
GG BH3	45	1.22	11.2	0.7	88.1	0.000129486	1.93603E-05	7.44232E-05
GG BH5	5	1.4	14.7	0.7	84.6	6.27082E-05	1.66116E-05	3.96599E-05
GG BH5	10	1.41	13.2	0.7	86.1	6.09154E-05	1.77383E-05	3.93268E-05
GG BH5	15	1.41	11.7	1.2	87.1	6.14825E-05	1.86686E-05	4.00755E-05
GG BH5	20	1.51	14.2	0.7	85.1	3.93248E-05	1.6979E-05	2.81519E-05
GG BH5	25	1.56	14.7	1.2	84.1	3.11421E-05	1.63724E-05	2.37572E-05
GG BH5	30	1.55	12.2	0.7	87.1	3.34344E-05	1.85315E-05	2.5983E-05
GG BH5	35	1.46	11.2	0.7	88.1	5.03063E-05	1.93603E-05	3.48333E-05
GG BH5	40	1.51	13.2	1.2	85.6	3.94862E-05	1.74828E-05	2.84845E-05
GG BH5	45	1.37	10.7	0.7	88.6	7.35651E-05	1.97884E-05	4.66768E-05
GG BH5	50	1.44	13.2	1.2	85.6	5.34906E-05	1.74828E-05	3.54867E-05

4.5. Hydrogeochemistry.

Hydrogeochemistry deals with the evaluation of the origin, chemical composition and reactions of groundwater. The evaluations of these are achieved through careful field sampling and laboratory analyses following best practices. Following chemical analyses, water quality attributes and relationships i.e. hydrochemical facies are often investigated using ternary diagrams, typically, piper diagrams. A piper diagram consists of three plots, two basal plots representing the cationic and ionic water chemistry components and a third plot representing the space into which both cationic and ionic components are combined and projected. Figure 4.23 shows possible water type interpretations and geological environments of groundwater that can be interpreted from ternary diagrams.

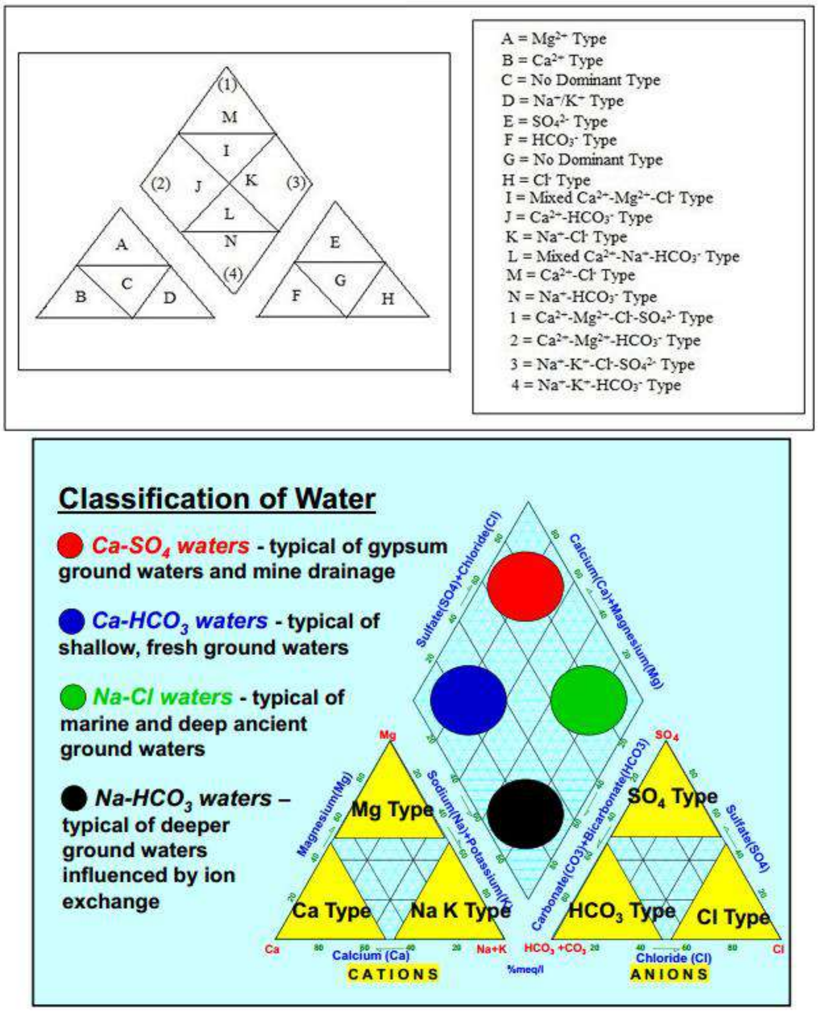


Figure 4.23: Trilinear Diagram and Groundwater Types Interpretation.

Groundwater sampling and analyses for environmental conditions evaluation are motivated and driven by a number of reasons. Sundaram et al, 2009 discussed several of such reasons but the most relevant to the present operational environment of this study include the following:

i. Identification of the aquifers intercepted by water boreholes.
ii. Determination of leakage and hydraulic connection between aquifers.
iii. Assessment of groundwater movement and flow patterns.
iv. Understanding of recharge-discharge mechanisms.
v. Determination of the nature of surface water and groundwater interconnectivity.
vi. Identification of the magnitude, sources and transport of salt, nutrients, pesticides and other contaminants.
vii. Evaluation of baseline groundwater quality and the relevant beneficial uses of the groundwater resource.
viii. Understanding of the evolution of the groundwater chemistry and flow patterns, and possible causes for groundwater quality changes.

The results of hydrochemical facies analyses of groundwater for the present study, 2014 and a previous study conducted in 2006, are presented in Figure 4.7.7a and b. Figure 4.7.7a depicting the status of the groundwater in Gelegele indicate an overall Ca-HCO_3 water regime typical of shallow, fresh groundwater. A comparison of the present status with the old (Figure 4.24) shows an essentially unperturbed hydrochemical facies and groundwater regime. In summary, the results demonstrate that the groundwater has not been negatively impacted over the years between the reference and present studies. The presence of significant levels of clay/silt in the rock matrix may be responsible for keeping the groundwater isolated from surface activities. The soil horizons which constitute the first line of receptor to industrial and anthropogenic activities may, however, prove more sensitive to soil chemistry changes over the years.

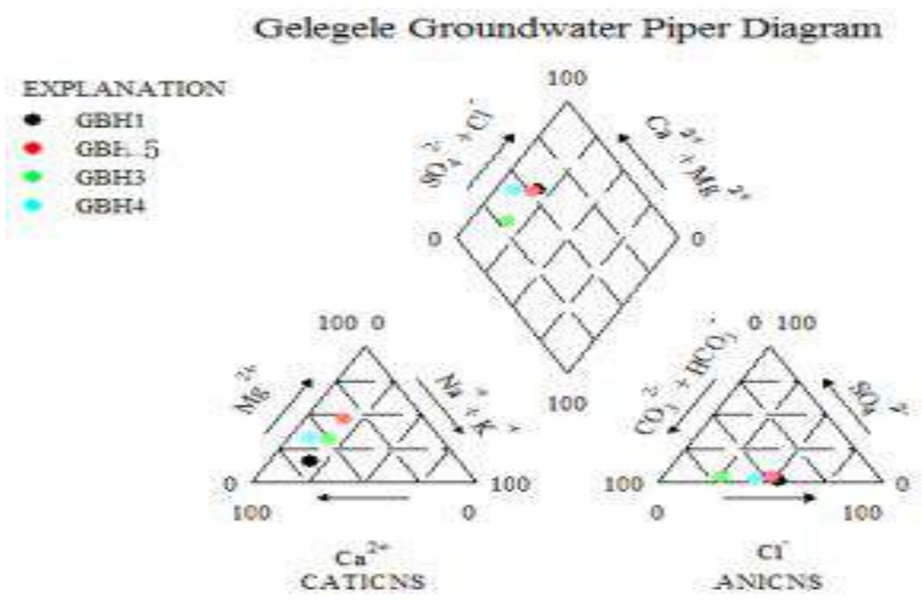


Figure 4.24a: Gelegele Groundwater Piper Plot Present Study

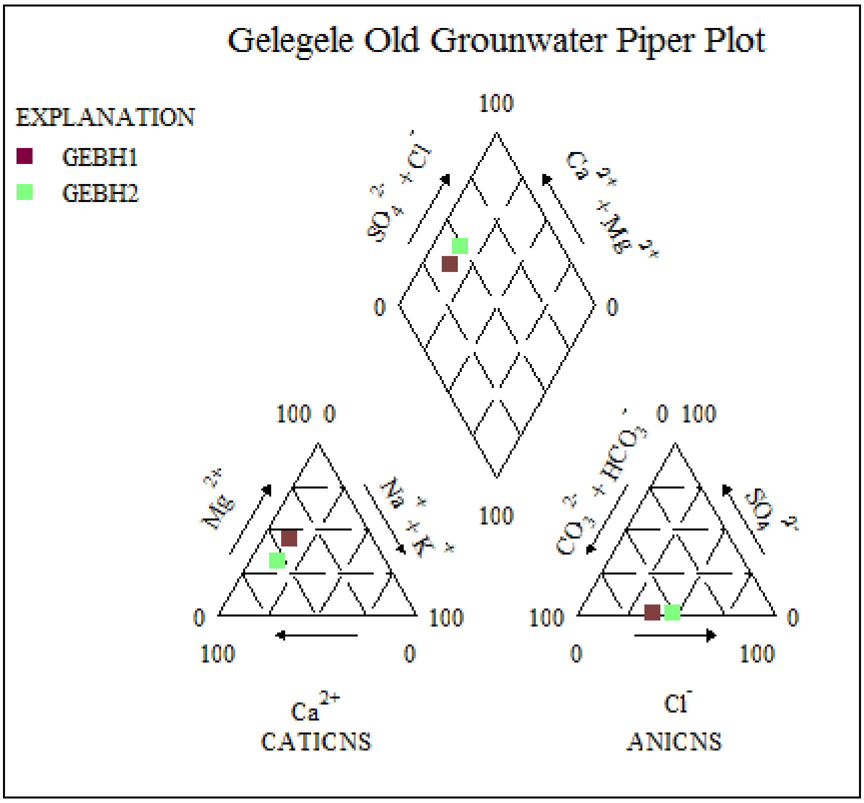


Figure 4.24b: Gelegele Groundwater Piper Plot

4.6 Socio Economic Impact Assessment

Community Structure and Settlement Pattern

The identified host community for the proposed gas plant project is Gelegele-gbene community and adjoining riverine sub-communities namely, Owubuloba-gbene, Atunkpo-gbene, Ukulebor-gbene, Lanu-gbene, James-gbene, Cinima-gbene, Itilan-gbene, Agbada-gbene, Sanimo-gbene, Nene-gbene, Omaria-gbene, Apur-gbene, Ugbodudu I & II, Oje-gbene, Reme-gbene, Felicia-gbene, Danikoba I & II, Jimmy-gbene, Pukpaye-gbene, Zimmy-gbene and Ukponme-gbene. There are also impacted Gelegele-gbene upland sub-communities namely, Camp-1 Opuosuwo, Camp-2 Pere, Camp-3 Desmond, Camp-4 Lucky, Camp-5 Midwest, Camp-6 Benson and Camp-7 Richard-obey.

Gelegele, an ancient historical Ijaw community, is about 45 km South West of Benin City in Ovia North-East Local Government Area of Edo State, Nigeria. Ovia North-East whose Local Government headquarters is in Okada town has an area of 2,301 km^2, a Density of 88.44/km^2 and a population of 155,344 based on the 2006 National Population Census figures. Some of the neighbouring communities near and around Gelegele-gbene are Ughoton, Ikpako, Egbetan, Oduna and Ugbine.

The town is accessible by land. The Gelegele people speak the Izon language of the Olodiama Clan in Edo State that is similar in all ways to the Olodiama Clan in both Delta and Bayelsa States. Gelegele-gbene Community had been an international trade center before the colonial era. Gelegele traded in slaves, cowries, leather and shells of sea animals with the Portuguese and British traders before the advent of colonial rule in Nigeria. Gelegele-gbene Community served as a hinterland port to the colonial people who had their base in Forcados. The traditional occupations of Ijaw people are fishing, farming, palm wine tapping, timber logging and craft making.

Edo State: Edo state is an inland state in central southern Nigeria. Its capital is Benin City. It was formed in August 27, 1991 with the split of Bendel State into Edo and Delta States. Edo State is home to several ethnicities, among them the Bini, Esan and Afemai. The state is renowned for its sports, cultural endowment and scholastic excellence.

The University of Benin, one of Nigeria's prominent universities is located in Edo State, as are other institutions of higher learning. Edo State share boundaries with Delta State to the South, Ondo to the West and Kogi to the North-East. The main towns in the state are Benin city, the capital of the ancient Benin Kingdom, which is also the state capital, Ubiaja, Auchi, Ekpoma and Uromi.

Edo State, according to the 2006 National Population Census, has a population of about 3,233,366 with sex ratio of 1,633,946 males and 1,599,420 females showing that male population is higher than the female population. It has 18 local government areas namely which are Akoko-Edo, Egor, Esan Central, Esan North-East, Esan South-East, Esan West, Etsako East, Etsako West, Igueben, Ikpoba-Okha, Oredo, Orhionmwon, Ovia North-East, Ovia South-West, Owan East, Owan West and Uhunwonde. The population is estimated to be growing at an annual growth rate of 3.2% like that of the entire country of Nigeria.

Nigeria: Africa's largest and most populous country, Nigeria is located in West Africa. The country covers an area of about 923,768 km2 with an estimated 4,049km of land boundaries shared with Cameroon in the east, the Republic of Niger in the north, Chad in the north-east and Benin in the west. In the south, Nigeria's 853km-long coastline opens onto the Atlantic Ocean. The southern lowlands join into the central hills and plateaus, with mountains in the south-east and plains in the north. The country's largest river is the Niger, which joins with the River Benue to form a confluence at Lokoja.

Niger Delta: The Niger Delta, situated in the southernmost part of Nigeria and covering an area of about 70,000km^2, is the largest river delta in Africa and the third largest in the world. From a coastal belt of swamps stretching northwards, the land becomes a continuous rainforest which gradually joins with woodland and savanna grasslands in central Nigeria. The swamp, forest and woodland areas occupy about 12 per cent of the Niger Delta's land surface.

Nigeria gained her independence from the Britain in 1960. With a population in excess of 158 million people, Nigeria is a multi-ethnic federation divided into 36 states and the Federal Capital Territory, within which lies the capital city of Abuja. More than 250 ethno-linguistic groups are spread across the country; however, the three dominant groups are the Hausa in the north, the Igbo in the south-east and the Yoruba in the south-west.

Nigeria is rich in natural resources, including natural gas, petroleum, tin, iron ore, coal, limestone, niobium, lead, zinc, timber and an extensive arable land. Prior to the discovery of oil in the 1950s, agriculture was the mainstay of the economy, with agricultural produce exported to the more developed parts of the world. By 1971 there had been a shift from agriculture to petroleum production such that between 1973 and 1981 the value of agricultural exports declined from more than USD 1.5 billion to about USD 0.3 billion. Currently, oil and gas provide 80% of budget revenues and 95% of forex earnings.

The host community in the proposed VTT LNG gas project is a permanent community and rural settlements. The housing pattern, type and structure of the settlements reveal a typical rural setting. Houses, it is said, are built according to family/lineage ties, transportation and communication routes. Before the discovery of oil in the area in the 1970s, Land was not that much of an issue and so the major influence on the pattern of settlements was basically the kinship/lineage ties and land ownership right. Even though the host community and its sub-communities are mostly rural, their cultural affinities to family ties still play a major role on how houses are built. Housing patterns are both nucleated and scattered in most Edo State communities ***(See Plate 4.15)***.

Plate 4.15: showing Gelegele-gbene community traversed by both tarred and un-tarred roads with internal streets/quarters. The housing pattern and stock reveal a typical rural environment

4.6.1: Religion, Customs, Belief System and Heritage

The host community is predominantly Christians by religion. Over 90% of the respondents across the surveyed community are Christians as against the few who practice the African

Traditional Religion (ATR) and Islam. There are also shrine venerated in the community like Egbesu (Supreme god), Amaye, Masquerade, Mammy Water, Seibo (forbidden forest), and Opuaduell. The most popular among them is Egbesu (the supreme god of the Ijaw people). The aforementioned deities are mostly associated with festivals celebrated annually with fixed calendar dates while the dates of the other festivals are communicated by the Chief Priest as revealed by the deity. Once the date is revealed, the priest sends the message across to the community.

Egbesu, for instance, is usually celebrated on the 14th day of January. During the festival, sons and daughter of Gelegele-gbene community from far and near assemble to mark the date with merriment and colourful cultural dances. Egbesu is highly celebrated because of its role of providing protection for the people from external aggression.

Like Egbesu, other mentioned deities are also significant. Masquerade festival is used by the people to spiritually cleanse the land. It was further revealed that unauthorised persons are not allowed in and around the deities as any trespass attracts a penalty.

It was gathered the festivals often attracts dignitaries from all walks of life who troop into the community in their numbers to watch observe the events.

As stated above, Christianity is the predominant religion of the people. Some of the different faiths observed in the community include The Redeemed Christian Church of God, Anglican Church, Catholic Church, Assemblies of God Church, Living Faith Church (Winners Chapel) and Christ Apostolic Church.

Even though Christianity is the most dominant religion of the people, some other customs and traditions show that the people maintain strong ties to the tradition of the deities. Traditional worship takes place in the community and numerous family shrines exist in the studied community. Cultural and traditional practices are either conducted at the individual level with the nuclear family or at the community level. Apart from providing protection to the people from external aggression, these divinities are said to help the community to maintain law. The fear of these gods deters the people from stealing, forcing them to want to do the right thing to avoid the wrath of the deity.

It is important to note that the beliefs of the people as it relates to land ownership and use are still very much dependent on the dictates of the deities.

Sacred groves exist either within the community centre or are located far out in the forests or close to the water courses. Field visit showed that traditional places of worships are cultural heritage center although not much attention is given to it these days due to widespread and acceptance of the Christian religion. More often than not, trespasses can cause outrage and involves financial reparation. Seasonal cultural festivals and dances with revered deities, for which infringements attract serious punishments, are also available in the community.

The local Ijaw ethnic groups which make up the stakeholder community have a rich and well established cultural and traditional institutions. The community folklore and songs mirror its inhabitants as portrayed in the numerous cultural societies of its men and women. These groups practice a healthy competition in folk dances, songs and religious serenades.

The Ijaw ethnic groups have many things in common, including food, dressing and socio-cultural organizations. The studied community has different festivals celebrated in honour of its gods and goddess or to mark important events. The beginning of the planting season as well as the harvest season is celebrated annually.

Practices such as incest, adultery, sexual intercourse in the forest are a taboo to the people. Other deviant behaviours that are outlawed include stealing, fighting with a weapon like a knife, a cutlass, a bottle or a gun. Any violator is severely dealt with, either by payment of fines or appeasing the gods and/or ancestors. Polygamy is practiced as a form of marriage in the community. Inheritance is patrilineal and payment of bride price on girls getting married is a custom among the Gelegele-gbene community.

4.6.2: Resident Status

Resident status of Gelegele-gbene community according to survey analysis shows that significant proportion of the community respondents has spent a greater part of their life in the community. About 47.8% of the respondents have lived in the community their whole lives i.e. since birth, while about 19.6% have spent over 20 years in the community. Another

19.6% spent between 16 and 20 years in the community while 17.4% spent between 11 and 15 years in Gelegele. A further 15.1% have lived in the community for between 1 and 10 years. The implication of this is that most of the respondents are mainly natives of the community who have spent enough time within the immediate environment and as such have a thorough knowledge of the prevailing circumstances of the socio-economic environment with respect to the proposed VTT LNG project. (***See Figure 4.25)***

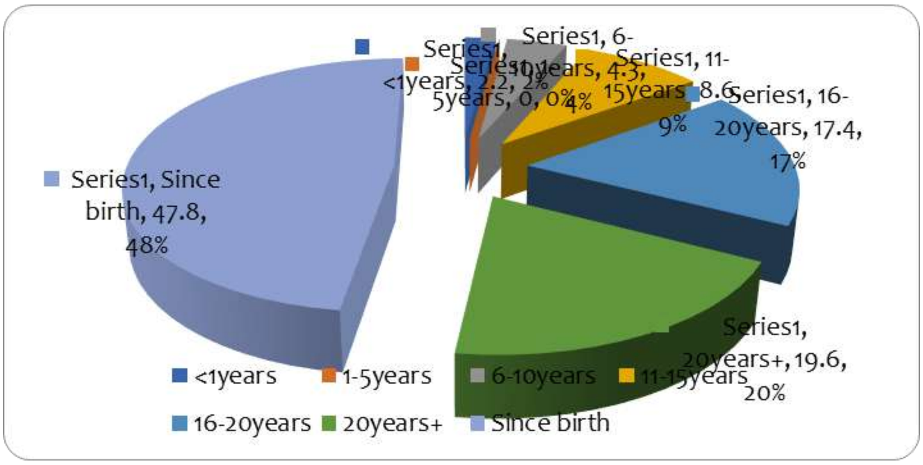


Figure 4.25: Residential status

4.6.3: Population and Socio-Demographic Characteristics

Gelegele and its constituent communities, in the absence of official population figure from the 2006 National Population Census figure for the community, were estimated at about 10,000 by community members. Natural increases like excess of births over deaths and migration are the two most important determinants of population growth in Gelegele.

The community population may have been over-estimated by the people, but population growth may have been influenced by the oil and gas exploration activities and entitlements given to the various community leaders.

In addition, population projection using the exponential model reveals practically that rather than population growths occurring in constant increment over time, i.e. linearly, the rate of growth changes geometrically, growing faster as the population size increases. It is not surprising, therefore, that the host community has actually witnessed an increase in population over the years.

4.6.4: Household Size and Marital Status of Sampled Population

Sizes of families vary from community to community and are influenced greatly by the culture of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. For instance, a total of *3,919,364* households were enumerated during the preparation of the Niger Delta Regional Master Plan Development with an average household size of 7.5, but with more than 70% of them having an average of 8 occupants. Large households were found more prevalent in the rural areas (NDDC 2006). The average household size in the region however comes down to 6 persons with considerable variations among the individual States, Local Government Areas and Senatorial districts.

Socio-economic survey of the studied community shows that 19.6% of the respondents are single, 56.5% married, 4.3% divorced, 8.6% separated and 10.9% widowed. Women have an average of 5 children and average household size approximates to 7.6. If other dependants living in the households were added (a minimum of 2 and maximum of 5 was reported within the community), then household would come to 10 persons. Large household sizes are attributed to several reasons in Gelegele and its constituent communities in particular and the Niger Delta region as a whole. Marriage is a socio-cultural custom that is highly recognized and those that marry do so at relatively early age. Some men marry more than one wife (i.e. polygamy) in addition to the concubines they keep ***(See Figure 4.26).***

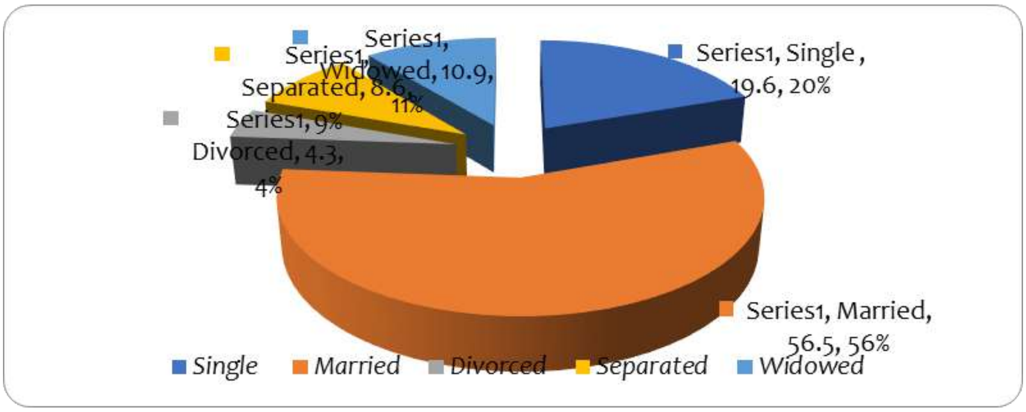


Figure 4.26: Marital Status

4.6.5: Household and Population Structure (Age/Sex Distribution and Ratio)

The household structure of the host community parallels the patriarchal leadership structure of most Nigerian ethnic groups. 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 the traditional one-husband-one-wife type, the polygamous type and single male type (males with no spouse, widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

The survey analysis of the community shows household structures to be typically pyramidal i.e. broad-based with the younger ones more in number. Children aged 0-4 years (infants) make up about 12% of the households and children aged 5-12 years (primary school age) make up about 16.4% of the population. The age range of 13-25 years (Secondary school age) is about 44.9%- and 26-59-years bracket make up 17.3% (active working proportion) of the population. The aged (60 years and above) make up 9.3% of the household composition. ***(See Figure 4.27)***

What this implies as far as the age profile is concerned is that the population is young and growing and this places a heavy burden on the adult population or a high dependency ratio. This is a potential source of high unemployment rate. There is therefore the need to provide more training, vocational education and educational facilities to build the capacity of this young and growing population. The project proponent can intervene in these areas as part of its Corporate Social Responsibilities (CSR) to the community.

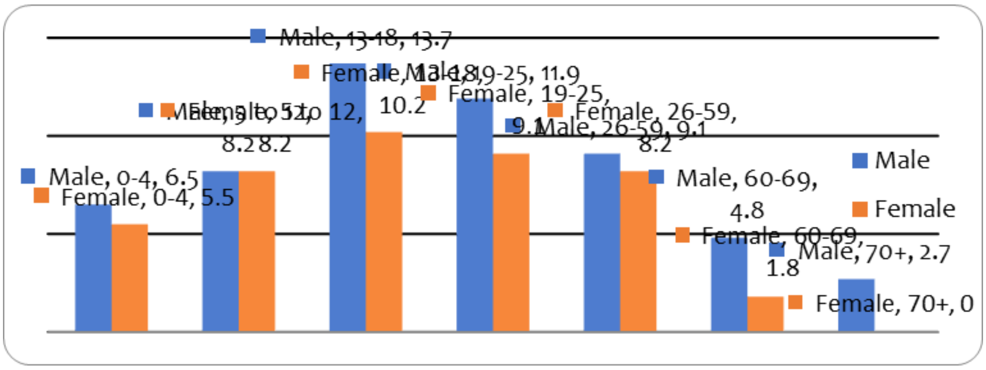


Figure 4.27: Age and sex structure of respondent's households

The analysis further shows that most of those surveyed are adults of at least 20 years old whose ages are as follows: 10.6% are ranged between 20 and 29, 26.2% between 30 and 39, 28.4% between 40 and 59, 21.7% between 50 and 59, 8.6% between 60 and 69 and 4.4% from 70 years and above. The implication of this age coverage is that a wide age range representative of the collective opinion of the host community was sought during the field study.

However, there is an obvious dominance of the younger generation in decision-making and discussions in the community as it has become common the trend across the Niger Delta region in recent years. This is indicative of the decline in respect for the aged ones, even as youths have hijacked the powers of the elderly in most communities. ***(See Figure 4.29)*** About one half of the younger generation in question are already married and serve as heads of households.

Sex distribution of the population in the community shows a disproportionate sex structure. The field survey revealed that the males are more in number constituting approximately 67.4% to the females' 32.6% of the population, ***(Figure 4.30)***. Like 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. It went further to show that for every 100 females, there are to be found only 103 males.

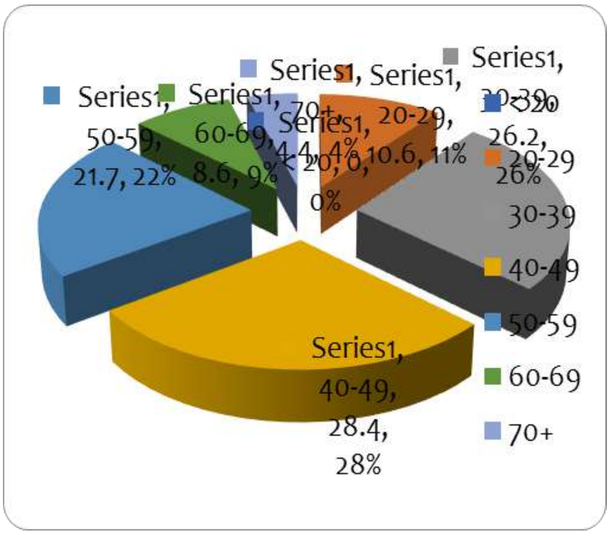


Figure 4.28: Age range of respondents

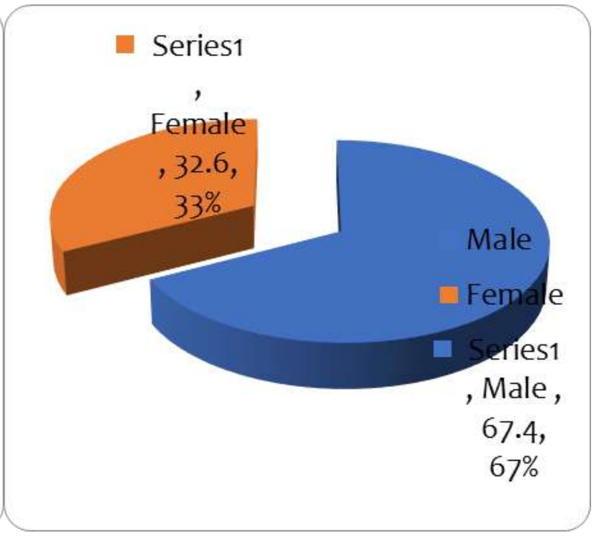


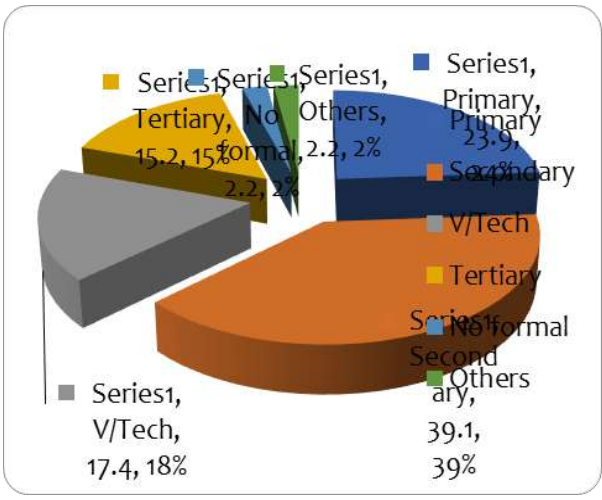
Figure 4.29: Sex respondents

4.6.6: Educational Characteristics

Education is a key determinant of the lifestyle and societal status an individual enjoys. Studies have continually shown that educational achievement is highly correlated with an individual's health behavior and attitude. Survey analysis revealed that 23.9% has attained primary education while 39.1% has secondary education. Also, 17.4% of the sampled respondents have vocational/technical training and the proportions of the population with tertiary education account for 15.2%. Those without any formal educational training take up 2.2%, leaving 2.2% to the rest of the surveyed respondents. (***See Figure 4.30***)

Meanwhile, the number and proportion of the population without any formal education actually can be higher but questionnaire administration may have omitted this category of the people because the younger members were more available during the field study.

School enrollment rate of the children/wards of the respondents covered reveals that 58.9% of the boys and 41.1% of the girls are presently enrolled in various schools within and outside the community**.** About 35.8% and 31.5% of the school-age children are currently attending primary and secondary schools respectively. Vocational training and skill acquisition of respondents' children/ward in the studied community is at 9.6%. Children in the process of attaining some tertiary education and other forms of education amounted to 15.1% and others take up 8%. (***See Figure 4.31***)



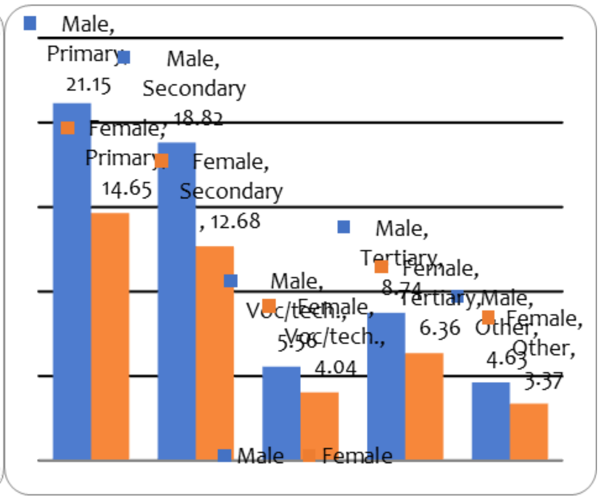


Figure 4.30: Educational level *Figure 4.31: Educational Characteristics*

4.6.7: Institutional Arrangements and Traditional Governance

The internal structures of a community living in a single settlement and the structures of the community belonging to a larger community spread out over several hamlets are the same. The men of the community are subdivided into the youths (young men able to work) and the elders, the latter being committed persons who have actively contributed to the development of the community and have to be recommended for appointment by other elders or the chiefs/traditional ruler.

The women of a community are organized in the same way. Also, there is the young person's group, married women of working age and the group of the older women. The "elders" (senior women and men) have a high status in the community. Why? It is because of their experience and these are the ones that make the final decisions regarding important activities at the community level. Be that as it may, for over a decade now, many youth groups and movements have hijacked this position due to the perceived inaction of the elders against exploitation.

Even though a more dynamic indigenous political system based on representative participation and fair sharing of power and responsibilities among the community members and age-grade associations have emerged, many of the independent villages of the Ijaw ethnic group are still being governed on the principles of gerontocracy. This means that executive, legislative and judicial functions are still vested in the hands of the oldest man and his cohorts. As a result, in the majority, if not in all of the Ijaw communities, the traditional governance and power structure are organized into hierarchies from the clan level to the individual village/community down to the quarters that constitute each settlement.

The *Amagusuwei* is the traditional leader and the oldest man in the community. The Council of elders, Community Chairman & ExCo, Youth Chairman & ExCo, Women Chairperson & ExCo and the Vigilante group complete the governance structure of the community. The CDC, youth group and the women's forum respectively constitute the local and traditional administrative structures of the Gelegele-gbene community, ***Figure 4.32.***

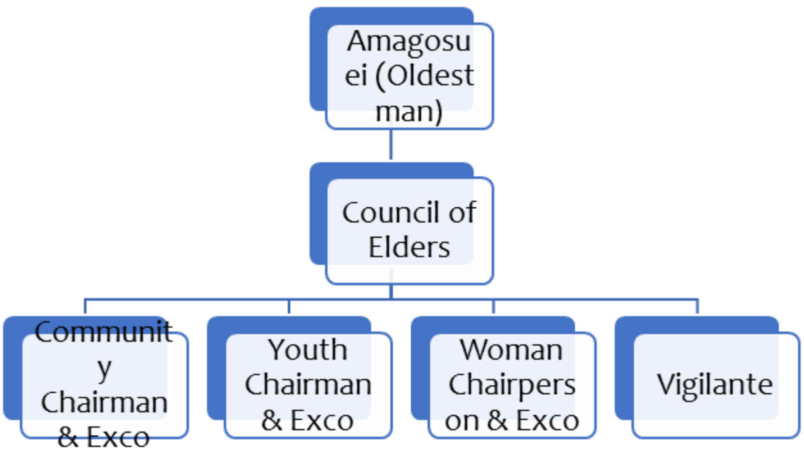


Figure 4.32: Traditional power and administrative structures in Gelegele-gbene community

4.6.8: Conflicts and Conflict Resolution

From the preceding narratives, conflicts and contentious issues are often resolved in the community in conjunction with the traditional head *(Amagusuwei)*, the Elders Council, the youth and the women groups. The rungs of power are many as revealed by the well-organised leadership structures, starting from the family heads, quarter heads, all through to the various organs and ends at the feet of the paramount ruler, the *Amagusuwei.*

In the event that a community member goes contrary to the local law, the matter is handled at the lower organ such as the youth or women group and whoever is found guilty is punished according to the gravity of the offence. While smaller offenses could attract paying of fines according to its nature and seriousness, serious cases lead to meting out severe punishment. Any matter is not resolved at the community level is handed over to the police, especially so where a criminal case is in question.

4.6.9: Occupation/Employment and Income Generating Activities

Responses from survey analysis and focus group discussions (FGDs) revealed that the inhabitants of the community are mostly fishermen/women, farmers, palm wine tappers and lumber workers. Traditional white-collar jobs holders like civil servants, traders, business men, contractors, artisans to some extent form part of the economic activities of the adult population.

Survey analysis shows the following occupational distribution: farming 19.6%, fishing 26.2% and trading 13.1%. These make up the primary occupation of the people. Also, 10.6% of the population work as technicians/artisans.

While businessmen and contractors are not represented in the job distribution, unemployment stands at 15.2%. 4.3% of the sampled populations are civil servants, 8.6% are students/apprentice, industrial workers are unrepresented even as others take up 2.3%.

The 15.2% unemployment rate shows that employment issues are of serious concern in the host community of VTT LNG project. (***See Figure 4.33)***

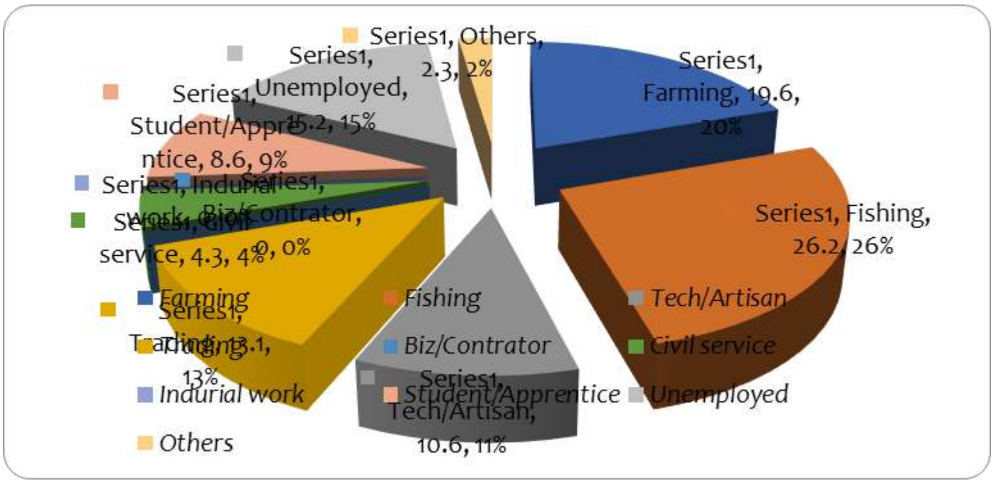


Figure 4.33: Respondents Occupation

4.6.10: Land Use and Management

Land Ownership/Access and Tenure System Generally, land is regarded as Nigeria's most important long-term resource base and in areas where this finite resource is in short supply, it can be very contentious. Consequently, Nigerians see land as a common denominator wherein lies most of their hopes and most of their problems. Land means many things to many people, and the manner in which it is acquired, owned, used and transferred is referred to as ***land tenure*** (Igbozurike, 1978).

Before rights can be exercised over land, it has to be acquired in one of the six principal methods of land acquisition. These are inheritance, purchase, lease, pledge, exchange and gift.

Land is the base for all human activities, including agricultural and industrial development. And as may be evident, land is a finite resource. In other words, it is fixed in supply. So with a fast growing population as is the case in both Edo State and its constituent council areas, land for all kinds of uses has become smaller with each passing year or even day. By providence, however, land resource is available in large abundant supply in the host community of the proposed gas plant project. This is because land is not being overwhelmingly influenced by hydrology as is the situation in the core riverine areas where very limited land space is available either for habitation or cultivation.

Nevertheless, even with the abundant supply of land, a typical Ijaw man values land highly and as such does not take lightly anything involving land. Of course, since land on which oil wells and related facilities are located gives huge benefits to the individual owner, family or community, they can go to any length to protect it.

Oil exploration is going on in practically every part of the Niger Delta. With people believing that their land could be harbouring oil when explored, they consider their land as a huge source of financial reward in waiting. Land is therefore highly esteemed in the area.

Land in Nigeria falls under four broad ownership classes and this is regardless of who the law says holds the land in trust for whom. There are individually owned, family-owned, communally owned, and government-owned lands. Two forms of landownership are common in the studied community, namely, family inheritance and communal land ownership. According to narratives, land in the community is owned by the founding families and the power over it is vested in the hands of the oldest man in the family. There are portions that are collectively owned by the entire community.

This implies that land is passed down the generations and acquired through family inheritance. In recent times, however, with the fast urbanisation of villages and towns, private ownership of land is increasingly becoming common. Indigenes now sell portions of their lands to non-indigenes for personal development.

Parcels of land made available to government and oil corporations for major public projects/utilities like schools, hospitals/clinics, civic center/town hall, markets, schools and places of worship are taken out of communally owned land.

In the studied area, arable land is used for cropping for between 2 and 5 years. The land is thereafter allowed to lie fallow so it could naturally regain its nutrients and fertility. During this fallow period, farming is carried out on a different piece of land. This is called shifting cultivation. Virgin land is cleared during the dry season for the cultivation of cassava, yam, plantain, maize, melon, pepper and cocoa yam in a mixed farming system.

It has been discovered, however, that the bush fallow system in which the farmer allows his field to revitalize for half a decade before returning to it is on the decline. These days, land is hardly left to fallow beyond three years due the increase in population and other economic activities that compete with agriculture such as oil and gas projects, power plants and urban development. This is why land taken up for oil and gas pipelines, oil wells, gas projects, power plant and processing facilities *can* and *do have* substantial effects on cultivable land. ***Figure 4.34*** shows that 69.5% of lands are owned through family inheritance, 15.2% through purchase, 13.1% is rented or leased, 2.2% is obtained through sundry means and 0% is owned through sharecropping.

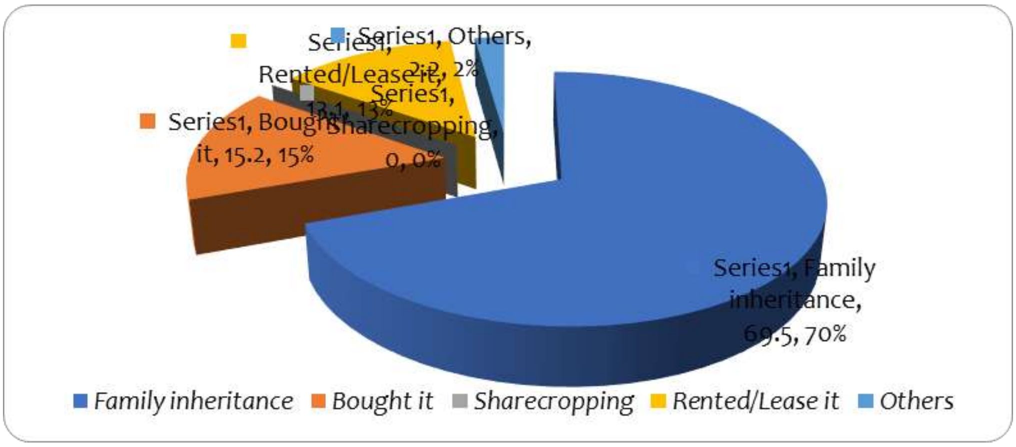


Figure 4.34: Land ownership system

4.6.11: Agricultural Produce and Productivity

Agriculture is the main occupation of the resident population of the proposed VTT LNG project host community. Crops grown in the area include yam, plantain, cassava, oil palm, banana, maize, melon, pepper and vegetables.

It is claimed that agricultural yield in Gelegele-gbene community has reduced over the years with oil exploration activities in the area blamed for this reduction. However, according to analysis of respondents surveyed, 19.5% blame the decline in agricultural yield on insufficient land, 52.2% attribute the problem to inadequate capital, 19.5% say poor technology is to blame, 6.5% believe insufficient labour is the culprit and 2.2% attribute the problem to the reduction in farm production. (***See Figure 4.35***)

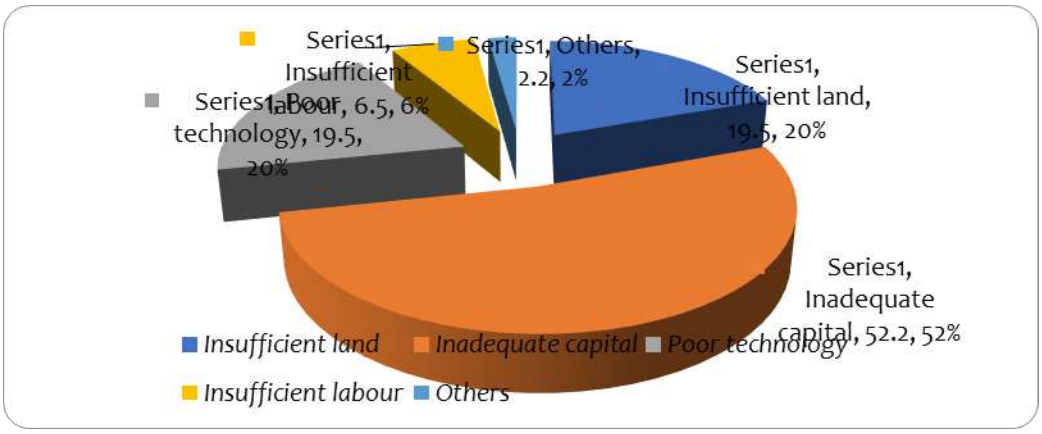


Figure 4.35: Farmer constraints

Plate 4.16: Showing harvested corn being prepared for eating; palm fruit undergoing processing and harvested plantain displayed for sale.

4.6.12: Income Sources and Levels

Income is an important variable that influences socio-economic status of individuals. Income distribution pattern, therefore, has the potential of influencing other demographic variables. Be that as it may, personal income levels of self-employed rural households are always difficult to determine. Why? Because most people do not keep records and as such, are uncertain of the gross or net amount actually earned from private endeavours.

Many household members also engage in several income-generating activities; however, the respective contributions of other economic activities cannot be accounted for. Consequently, the income figures of household members in the community are not reliable.

Although the income calculation of the studied community was difficult to obtain, the survey analysis of the community, even though subject to some uncertainties, could suffice. The income levels were found to be meager and variable. 0% had earnings of less than NGN5,000 in a month, 6.5% of the population had income in the bracket of NGN5001-10,000 and 0% earn in the range of NGN10001-15000. Also, 15.3% and 13.2% earn in the range of NGN15001-NGN20000 and NGN20001-NGN25000 respectively. 10.7% earn in the range of NGN25001-NGN30000, 13.1% NGN31001-NGN35000, 15.3% between NGN35001-NGN40000, 10.7% between NGN40001-45000 and 8.6% NGN450001-NGN50000. Finally, 6.5% of respondents earn N50000 and above per month, ***Figure 4.36***.

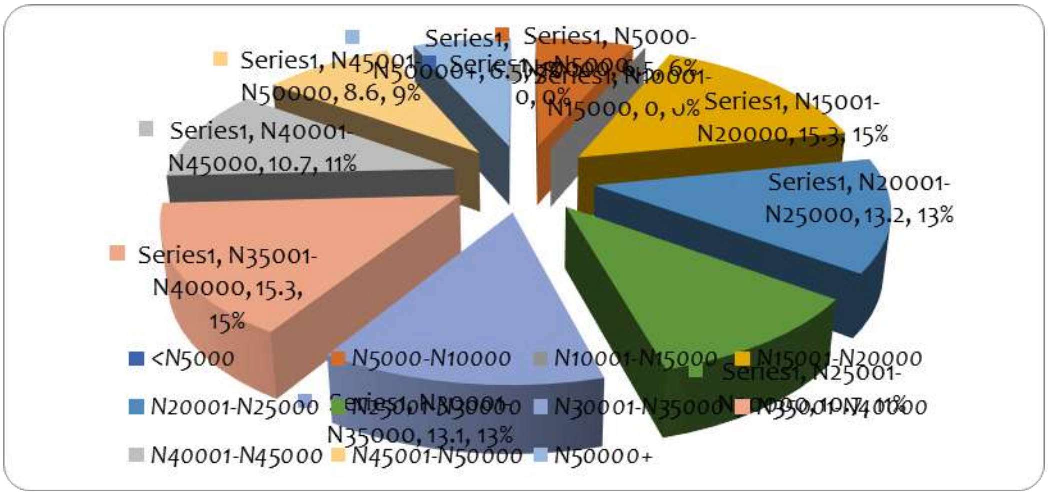


Figure 4.36: Estimated income/month

4.6.13: Social Structure and Quality of Life

The level of functional social amenities available in any given community often has direct relationship with the quality of life in the community and the willingness of the people to live and remain there. Social facilities available also influence other socio-cultural and economic variables in a community. The field study shows that the host community of the proposed VTT LNG project generally has access to some basic social amenities like borehole water which was provided by the Amnesty Office and Niger Delta Development Commission (NDDC) as shown in ***Table 4.18***.

It is also worthy of note, that some other basic amenities are lacking in the community. For example, although there is power installations in the community, electricity supply is not constant. Consequently, most of the community relies on individual generating sets for electricity. This has hindered business establishment and expansion in Gelegele-gbene as a whole.

***Table 4.18*: Social Amenities in the Community, Provider/Donors and their State**

S/no	Community	Type of infrastructure	Provider/Donor	Status
1	Gelegele-gbene	Borehole water	Amnesty Office and NDDC	Amnesty borehole still functions while the one provided by NDDC is not functional
2		Joseph Amusu Town Hall	Community	In use
3		Heath Care Centre	Edo State government	Functional
4		Primary and Secondary School	Edo State government	Functional
5		Amnesty Skill Acquisition Centre	Amnesty Office	Project under construction

(a) Educational Facilities

The host community has government owned primary and secondary schools. The available primary and secondary schools serve the community and its constituent communities. The schools have decent classroom blocks, however there are no chairs in the classrooms. In addition, inadequate teachers in both primary and secondary school have affected enrolment of pupils and students. Parents, it was gathered, prefer enrolling their children and wards in the private school outside the community where it is believed their children's studies will not be affected by lack of teachers in the school.

It was also gathered that teachers posted to both primary and secondary school always find their way to more suitable places, increasing the problem of lack of teachers.

As an intervention, there should be incentives to teachers posted to remote areas like this to encourage them to stay.

Plate 4.17: Showing primary and secondary school respectively in the community

(b) Electricity Supply

The host community of the proposed VTT LNG gas project visited was connected to the national power grid. Be that as it may, power supply like in every other part of the country is not stable. This has made most of the community members to depend more on power generating sets as alternative means of power supply.

Survey analysis shows that Gelegele-gbene residents rely on various forms of energy. 17.4% use electricity, 4.3% gas, 50% wood fuel. Further, 26.1% depends on petroleum products and 2.2% on other sources.

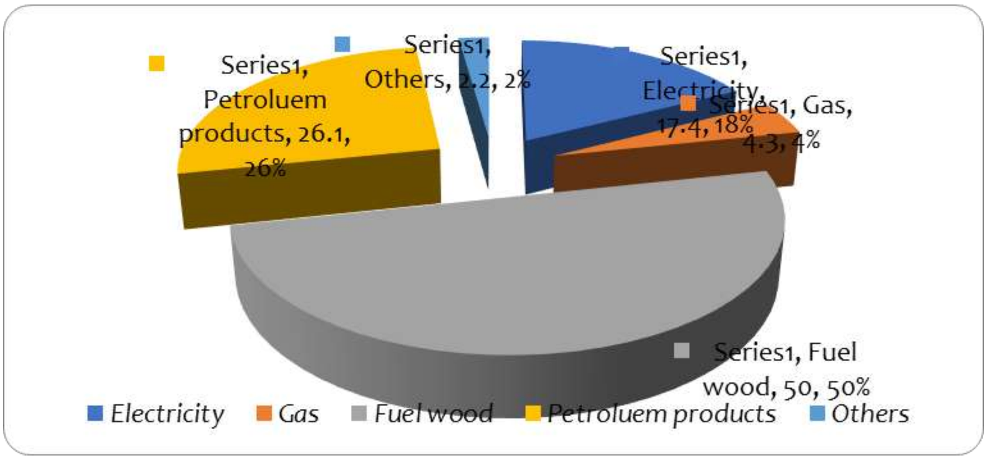


Figure 4.37: Cooking fuel usage

(c) Transportation and Communication

The population is served by a mix of transportation modes—cars, trucks, buses, foot, bicycles. Motorcycle, popularly known as *okada,* has been an established means of transportation while the tricycle, or *keke,* is a recent introduction. These transport means are used either by individuals or groups to carry out personal businesses and to transport a variety of goods from points of production to the market during market days. These transportation modes are instrumental in connecting neighbouring populations beyond the confines of the immediate community.

Access to public communication like the mobile telecommunication is available, even though the service fluctuates in the host community. Network connectivity is hardly possible in some areas due to signal strength, although this varies with the subscribers' location and their network providers. The available telecommunication base station in the community is Airtel.

Plate 4.19: Airtel mast serving Gelegele-gbene community and environs; cars parked as means of transport in the community

(d) Water Supply and Sanitation Facilities

Available data from the National Bureau of Statistics reveals that water in the majority of Niger Delta states comes from unsafe supply sources. This includes rivers, lakes, ponds, unprotected wells and boreholes. The Bureau, however, classifies available sources of potable water for household use as pipe borne, untreated pipe, borehole, protected well, unprotected well, river/lake/pond, vendor trucks and other categories.

There are water supply facilities in Gelegele-gbene community. These facilities were provided by the Niger Delta Development Commission (NDDC) and the Amnesty Office.

But it should be noted that NDDC-provided borehole is no longer functional causing the people to rely heavily on the functional Amnesty Office borehole.

Some members of the community also rely on private boreholes in their own houses. The situation in the community is in line with the revelation of the study that a safe and reliable water supply is currently available to only a small proportion 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 center, while only 3% of the population in rural villages are actually served safe water.

Plate 4.19: Showing functional Amnesty borehole water and non-functional Niger Delta Development Commission (NDDC) borehole water respectively

Moreover, from the surveyed analysis 6.5% collect rain water for use, 15.3% depends on rivers/stream, 19.5% uses manually dug wells, 0% access public piped/tap, 10.8% enjoy privately piped water, 43.5% depend on the community borehole, and 0% buys water from vendors or privately-owned borehole and 4.3% obtain water from other sources according to ***Figure 4.38***.

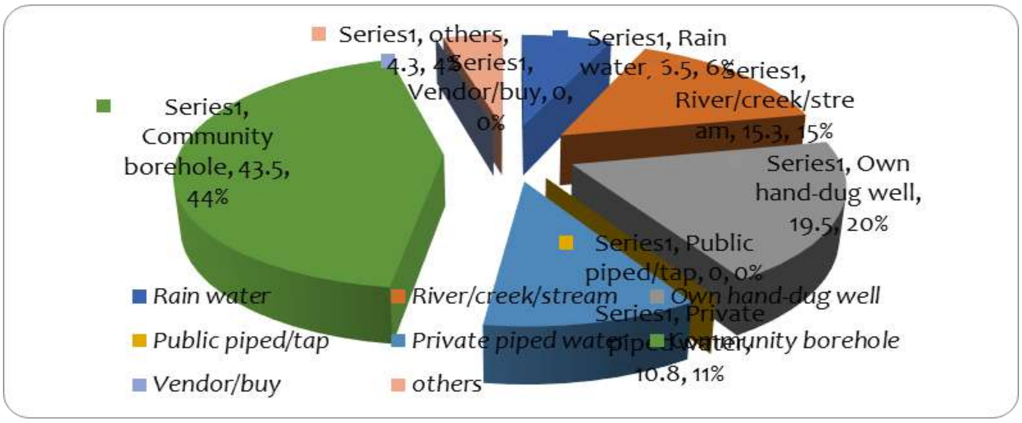


Figure 4.38: Domestic source of water

(e) Housing Types and Ownership

As shown in ***Plate 4.20***, the housing pattern, types and structure within the host community are often a reflection of its environmental setting. In the more rural settlements, old housing stocks are intermixed with emergent modern types while in the semi-urban community, there is the predominance of the modern housing types with better quality stock.

Plate 4.20 presents the key attributes of the typical houses found in the Gelegele-gbene and its constituent communities. Majority of the houses are of the rooming type with walls made of concrete blocks. Roofing materials are corrugated iron sheets. There are a sizeable number of houses constructed of wattle and mud daub, some of which are finished with cement plaster.

Plate 4.20: Housing type and quality in the Gelegele-gbene community is typical of rural area; houses constructed of the concrete blocks, mud and zinc roof are common

Survey analysis shows 2.2% of the housing type in the host community to be constructed with mud and thatch roof, mud houses with zinc roof make up 10.8%, wood/plank houses with zinc roof have a share of 4.4%, zinc house with zinc roof amount to 8.6% and concrete houses with zinc roof make up the of the houses in the community with 71.7%. Others house types account for about 2.2%. Meanwhile, the most common house plan in the community is flat rooms.

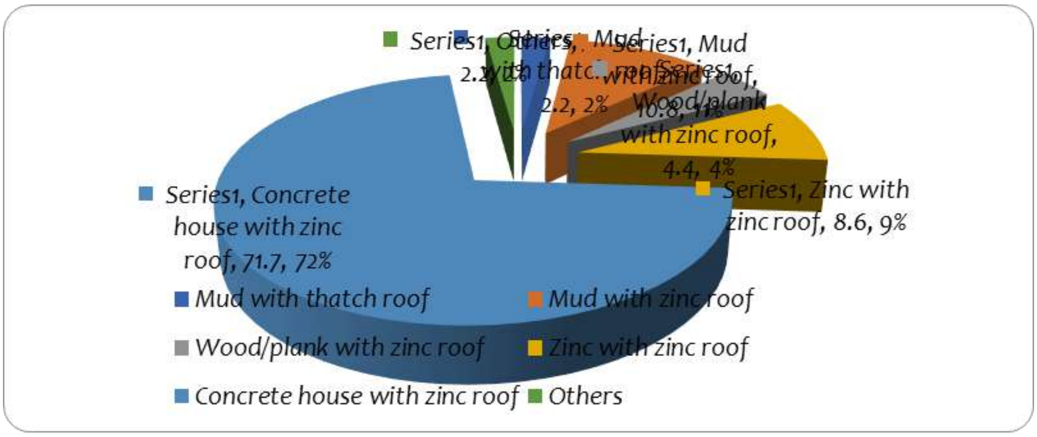


Figure 4.39: Housing type

4.7: Findings of the Focus Groups

The focus group discussion revealed that the host community of the proposed VTT LNG project is made up of peace-loving people and they are not in any way opposed to the proposed project. They are friendly and are ready to welcome and work harmoniously with VTT LNG, the project proponent. They also have been yearning for development and see the proposed gas project and its subsequent operation as a real opportunity which they believe will attract more development to the area.

However, the various groups in the community like the elderly group, women group and youth group have numerous expectations numerous but prominent among them, in particular order, are:

1) Creating of employment opportunities
2) Construction of internal roads
3) Construction of landing jetty
4) Cottage hospital
5) Scholarship awards for the children and ward from secondary school to tertiary institutions

Other notable demands in no particular are:

- Skill acquisition/human capital development centre
- Farming implements e.g. a tractor
- Improved seedlings and fertilizer

The fulfilment of any promises and terms as may be contained in an MoU when entered into is regarded as very vital in improving the company's relations with the host community.

4.7.1: Socio-economic Sensitivity and Attitude Toward the Project

The community members expressed some concerns on the proposed gas plant in the area, chief among which are:

- Gas explosion
- Spills which could result in environmental degradation
- Influx of people leading to overcrowding
- Insecurity
- Likelihood of fire outbreak

However, the project proponent assured the community that the best available technology will be deployed in the construction of the gas plant. Further, they will forestall any form of sabotage through the provision of surveillance equipment.

On the issue of influx of people to the community, VTT LNG assured the people that a significant percentage of the workforce shall be recruited within community to forestall pressure on the existing social infrastructures.

4.7.2: Perceptions of the Proposed VTT Gas Plant Project by the Population

The general population in the studied community has a mixed feeling on the proposed gas operations in their area. A good number of those sampled and responses from focus group discussion and key informants' interviews revealed that, although they are fully in support of the gas project and its operation, the community dwellers fear that such a project is not without its negative impacts. Therefore, adequate measures should be put in place to mitigate whatever negative impacts it might have on the people and the community as a whole. This, according to the community members, will help to enhance whatever positive impacts the projects will bring to the community.

4.7.3: Expectations and Social Needs of the Population

Community consultations focus group discussion and responses from the administered questionnaires indicate that the resident populations are not in any way against the proposed gas project and its operation in the host community. Fulfilment of promises and terms as may contained in a future MoU when entered into is regarded as very vital in improving the company's relations with the project host community. These demands which will affect VTT's relationship in years to come are outlined in section **4.9** above.

It is important to point out here that one of the causes of the unrest that has bedevilled the whole Niger Delta Region is unemployment; although unemployment is becoming a global issue. Others are youth delinquency, land dispute, chieftaincy tussle, inter-family problems, inter-village conflicts, alcoholism and prostitution. Youth delinquency and unemployment are identified to be chief among the social problems in the area with a share of 27.4% and 19.3% respectively. Land disputes account for 12.9%, alcoholism and prostitution 16.2%, chieftaincy tussle 8.1%, inter-family problems 9.6% and inter-village conflicts 6.5%.

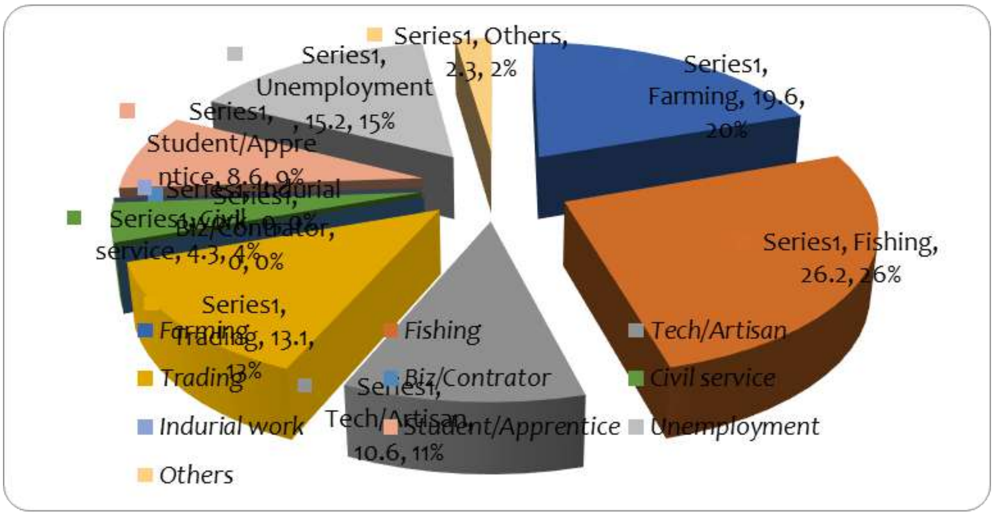


Figure 4.40: Social problems

Some of the recommendations by the community members to mitigate some of these social problems are obvious. Emphasis was particularly placed on the need to engage host community members who are qualified and are ready to work, provision of vocational/technical training for the youths, award of scholarship, provision of health care centres and equipping of the existing ones and stable power supply.

Most importantly, transparency in dealing with the project host community is greatly recommended. It is believed that these concerns once addressed could go a long way in mitigating the identified social problems as well as help the company, VTT LNG, to enjoy a smooth operation in Gelegele-gbene community.

4.7.4: Health Data

(a) Sources of drinking water of community members

Access to drinkable water is one of the Millennium Development Goals (MDGs). Meanwhile, the major source of drinking water in the community is mainly from borehole and streams. There exists public borehole by Amnesty Office and Niger Delta Development Commission (NDDC). The one provided by the Amnesty Office is functional while that of NDDC is not functional.

A bag of sachet water is sold for ₦120 (one hundred and twenty naira).

Water bodies around the village are another source of water for the people. In addition, rainwater is channelled from the roof into containers during rainy season as a source of water for the community dwellers.

(b) Access to sanitation facility

About 25% of community's members do not have a toilet facility within the ideal 50m distance from their houses, even though most of the toilets sighted were the pit type. Open defecation is a practice, which often contaminates surface water. The use of these methods to manage human waste—pit toilets and open defecation—is really a threat to the community member's health as admitted by the respondents. Some have reported collecting water with fresh human waste, but inability to afford an ideal toilet facility in their individual household and a safe source of clean water has rendered them helpless.

(c) Energy for cooking

The use of firewood and charcoal as a source of fuel for domestic cooking was observed among some members of the community. Processing garri, roasting plantain (*bole*) and smoking of fish to preserve it are other chief reasons to source for fuel. To perform these tasks, the locals collect firewood and charcoal notwithstanding the health implications.

Plate 4.21: A community member processing garri. Another is boiling freshly harvested corn. Wood fuel is a common source of energy in the community

(d) Waste management

Wastes generated in the community are mainly garbage and other domestic wastes. These wastes were usually dumped near residential buildings in the backyard. Even though these wastes can become a source of contamination of the water bodies, community members practice this habit freely.

(e) Alcohol usage and cigarette smoking

Smoking is common in the community. A significant number of the young males in the community smoke cigarette. An average smoker smokes at most three sticks of cigarette a day. Women in the community rarely smoke cigarette even though female smokers could be spotted in the community at night. These are mostly commercial sex workers.

(f) Sexual behaviour

Sexual behaviour is directly related to the incidence of sexually transmissible infections and diseases, including HIV/AIDS. The two key safe sexual behaviours useful in public health are to limit the number of sexual partners and to use condoms.

Majority of Gelegele-gbene community members claim to have only one sex partner while a few admitted to having more than one. The purchase of condoms from the drug stores was used as proxy to measure the behaviour of the people with regards to preventive measures relating to unwanted pregnancies and sexually transmitted infections. Condom purchase was relatively low.

The knowledge of the existence of HIV/AIDS is high in the community. The methods of STIs transmission such as needles, razor blade and sexual contact is also well known in the community. The 2003 NDHS reported that 70.6% of female youths in the South-South reported having high risk or unprotected sex in past one year, a statistic higher than the national average of 29.4%. However, the HIV/AIDS Reproductive Health Survey showed figures for South West females and males to be 69.3% and 68.6% respectively (FMOH, Nigeria 2005). This shows a slight decline but is still higher than the national average of 67% for females and 63% for males from the same report.

This risky sexual behaviour increases vulnerability to both STIs and HIV/AIDS. HIV zero-prevalence in Nigeria has not been increasing but the level is still worrisome. The factors that drive increase in HIV/AIDS prevalence such as industrialisation, promiscuity, low condom use is prevalent in the study area of Gelegele-gbene. The high prevalence rate of HIV/AIDS in an area is sustained by several factors including project-induced influx of workers who have a higher income level than locals, migration of commercial sex workers due to the economic attraction of workers, risky sexual behaviours, high sexual activities, early sexual exposures, etc.

(g) Housing

The housing pattern in the studied community is a combination of houses with concrete/block wall with zinc roofs. Mud houses with corrugated iron sheet roofing and brick houses with corrugated iron sheet are popular options. Inadequate housing has both direct and indirect effects on mental and physical health. The nature of the physical structure would determine to a large extent the capacity of the building to protect from heat, cold, dampness, mould, indoor air pollution, overcrowding, disease vectors and parasites.

(h) Knowledge of HIV/AIDS

Most respondents during the focus group discussions in the community are familiar with HIV/AIDS but knowledge of how it is usually contracted was observed to be very low. There is need to carry out awareness campaign to educate members of the community on HIV/AIDS.

Another plague that has dominated public health discussions recently is Ebola. Although this was widely publicised nationwide, a few respondents still claimed ignorance of the subject. There is a need to keep educating the public on the preventive measure of these deadly diseases.

(i) Household Food

Common foods eaten by the people of Gelegele-gbene community include garri, plantain, *loiloi*, rice and yam. Other foods consumed in low quantity include fish, vegetables, beans, milk, eggs and meat. Malnutrition is a major health problem in Nigeria, and this paints an overall picture of the health status of the population. Children who are malnourished are at a greater risk of falling sick and dying than children who are not malnourished.

Three standard indices of child growth used to describe nutritional status are **stunting** which means height-for-age, **wasting** which means weight-for-height and **underweight** which means weight-for-age. To ensure that the results obtained in this study are comparable on an international scale, they are expressed in terms of Z scores. The Z score gives indication in units of standard deviation how of far from the reference value a given value lies. The standard used here is based on the National Center for Health Statistics (NCHS) growth references as recommended by the World Health Organisation (WHO).

An assessment of the nutritional status of 190 children in the surveyed community, aged 0-5 years, was carried out as shown in ***Table 4.19***. The indices of malnutrition recorded shows that 26.7% are underweight, 32% stunted and 13.4% are wasted. A child with a significantly low height-for-age ratio is considered to be stunted or short for his age. This is generally the result of a failure to receive adequate nutrition over an extended period of time. This can also be caused by recurrent episodes of chronic illness. Children whose weight-for-height ratio is significantly low are defined as wasted or thin for their age. One in seven surveyed children was classed as wasted.

Stunting and wasting are most severe in the second year of life. These conditions is likely to be due to poor weaning diets, as breast milk offers significant protection and nutrition in the first year. Added to this is acute diarrhoea mainly in the second, third and fourth years of life. This is caused by using contaminated water as discussed in (**d**) above.

Table 4.19: Weight and height for age of pre-school children in the studied community

Age (months)	Mean Weight (kg)	Mean Height (m)	Weight for age (Normal range) kg
0 – 11	6.73	0.54	3.5 – 9.4
12 – 23	9.17	0.76	9.5 – 12.4
24 – 35	11.45	0.91	12.5 – 14.4
36 – 47	12.60	0.94	14.5 – 17.4
48 – 60	13.98	1.02	17.5 – 19.4

(j) Mortality Rate

The mortality figures from questionnaire survey are grossly unreliable. The indigenes tend to give exaggerated values when asked about mortality cases. This may be to lend credence for their demand for more government presence. Inadequate records on mortality rates from the local government level where cases of death are supposed to be registered were also noted. The common causes of mortality in the project area especially in children includes diarrhoea, malnutrition, malaria, respiratory tract infections, measles and other vaccine preventable diseases. These illnesses were prevalent in the area from the hospital records.

(k) Morbidity Rate

Mortality rates between the ages of 0 and 5 and maternal mortality rates are said to be low in Gelegele-gbene community. This was observed during the focus group discussion with the community. It was reported that although women die during pregnancy and childbirth this does not happen often, with the rate estimated at once in five years. The causes of the maternal deaths that happened in the community in the last five years were attributed to prolonged labour and abortion, according to respondents.

(l) Health system

There is functional public primary health center in the project community. Immunization aimed at protecting children aged 0-5 years against polio and other deadly child diseases is also carried out from time to time in the community.

(m) Traditional and Herbal Medicine Practices

Traditional medicine is available in the community. This practice involves the use of extracts derived from medicinal plants. Several medicinal plants abound in the area as listed under the vegetation section. Some of the medicinal plants used in the traditional medical practice in this study area and their uses are given in **Table 4.20**.

Table 4.20: Common Medicinal Plants and their Uses in the Area

Common/local names	**Botanical Names**	**Medicinal Uses**
Pawpaw leaves	*Carica papaya*	Treatment of malaria
Alligator pepper plant	*Afromomum melegueta*	Galactogogue, purgative, sore throat, malaria, consulting oracles
Lemon	*Citrus aurantium*	Abdominal upset, tincture for other herbs in treatment of malaria
Cashew fruit, leaf and bark	*Anarcadium occidentale*	Treatment of diarrhoea and menstrual problems
Mango leaves and bark	*Mangifera indica*	Treatment of malaria
Banana plant	*Musa spp*	Treatment of fever
Guava tree leaves and bark	*Psidium guajava*	Treatment of malaria, diarrhoea and menstrual disorders

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Introduction

An assessment was carried out to identify and qualify the potential impacts associated with the development of the proposed Gas Processing Facility with an LNG Plant . This was achieved through the public participation process, environmental assessment practitioners (EAPs) and biophysical specialists' assessment. The impacts cover all the proposed project phases which include construction, operation, maintenance and decommissioning. Also, the impacts' likelihood of occurrence, magnitude and significance were evaluated for the screening exercise. Emphasis was placed on the valued ecosystem, social components, and resources in and around the proposed project.

This section identifies and characterizes all the associated and environmental impacts or effects that will be caused by **VTT LNG West Africa Limited's** proposed Gas Processing Facility with an LNG Plant in Gilli-Gilli, Edo State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

5.2 Summary Of Environmental Impact Indicators

The environmental impact indicators are easily observable parameters that will indicate change/deviation, which can be used to monitor the various environmental components. Those considered in this study are as summarized in **Table 5.1.**

Project Activities

The activities anticipated in the proposed project cover phases including construction, operation/maintenance and decommissioning. The anticipated activities of each of these phases include:

A. Pre-Construction phase activities

- Mobilisation (transport) to site (equipment, personnel and construction modules).

- Energy requirements (provision of energy for pre-construction activities).
- Site Preparation and excavation of land area.
- Labour requirements.

Table 5.1: Environmental Components and Potential Impact Indicators

S/No	Environmental Components	Impact Indicators
1	Air Quality and Noise	SPM, NO_X, SO_2, CO, VOCs, NH_3, H_2S and Noise
2	Soil/Agriculture	Soil type, Soil pH, TOC, Soil nutrients, Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer; topography
3	Surface Water Quality	Dissolved and suspended solids, pH, BOD, COD, turbidity, toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg.and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
4	Groundwater quality	Dissolved and Suspended Solids, Turbidity, pH, BOD, COD, Toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg. and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
5	Socio-economic/Health	Needs and concern of host communities/third party concerns; opportunities for employment; income level; health risks; waste streams, Handling, Treatment, and disposal; access to household water; access to roads; access to transport; opportunities for contracting and procurement; respect for labour rights; respect for human rights;

B. Construction phase activities

- Transportation.
- Excavation.
- Piling.
- Construction of interconnecting spurline.
- Platform construction.

- Site fabrication (welding) and coating.
- Radiographic testing and Pressure testing.
- Backfilling.
- Interconnecting Pipeline commissioning.
- Demobilization

C. The operational phase activities are

- Liquified Natural Gas Plant Operations/ maintenance (normal)
- Liquified Natural Gas Plant Operations/maintenance (abnormal)

D. The decommissioning activities include

- Dismantling of the entire plant
- Removal of interconnecting pipeline, storage tanks, gantry equipment e.t.c, for relocation or sale

5.3 Impact Identification and Evaluation

To adhere strictly to general guidelines for an Environmental and Social Impact Assessment (ESIA) process, the following basic steps were adopted for identification and evaluation of impacts in this study:

- Impact identification;
- Impact qualification;
- Impact rating; and
- Impact description.

5.3.1 Impact Identification

The aim of impact identification is to account for the entire potential and associated biophysical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. The identified potential impacts during the different phases of the proposed project areas listed in **Table 5.2.**

Table 5.2: Identified Project Impacts of the Proposed Project

Impacts	Phase		
	Pre-Construction and Construction	Operation & Maintenance	Decommissioning
Acceleration of erosion	√		
Acidification of soil and water	√		√
Alteration of local topography	√		
Alteration of soil profile	√		√
Blockage of drainage pattern	√		√
Blockage of roads/motorways	√		√
Burns/injuries from welding sparks	√	√	√
Change in land use	√	√	√
Change in water quality	√		√
Contamination of groundwater	√	√	√
Damage to communication cables	√		
Exposure to heat and light	√		√
Exposure to radioactive emissions	√	√	
Exposure to welding flash	√	√	√
Impairment of air quality	√	√	√
Improved natural gas supply to customers		√	
Improved livelihood	√	√	√
Increased demand for social infrastructure	√	√	√
Increase in incidence of STI's including HIV	√		√
Increase in income	√	√	
Increase in price of locally sourced materials	√		
Increase in social vices	√		√
Increased opportunity for business and employment	√	√	√
Influx of migrant workers and camp-followers	√		√
Interference with road and water transportation	√		√

Impacts	Phase		
	Pre-Construction and Construction	**Operation & Maintenance**	**Decommissioning**
Legal issues	√	√	√
Loss of land	√	√	
Loss of employment/ income			√
Noise and vibration nuisance	√	√	√
Road traffic accidents	√	√	√
Worksite accidents	√	√	√

5.3.2 Impact Qualification

The identified impacts of the project were qualified using four criteria including:

- Positive or negative
- Short-term or long-term
- Reversible or irreversible
- Direct or indirect

Negative impacts are those that adversely affect the biophysical, health, and social environments, while positive impacts are those which enhance the quality of the environment. For this study, short-term means a period of time less than three months while any period greater than three months was considered long term. Reversible/irreversible meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated.

5.3.3 Impact Rating

This stage involves evaluation of the impact to determine whether or not it is significant. The quantification scale of 0, 1, 3 and 5 was used. The ratings are as adapted from the International

Organization for Standardization (ISO) 14001– Environmental Management System Approach. The criteria and weighting scale used in evaluating significance are:

- Legal/regulatory requirements (L).
- Risk factor (R).
- Frequency of occurrence of impact (F).
- Importance of impact on affected environmental components (I).
- Public perception/interest (P).

5.3.3.1 Legal /Regulatory Requirements (L)

This asks the question 'is there a legal/regulatory requirement or a permit required?' The scoring is as follows:

0= There is no legal/regulatory requirement
3= There is legal/regulatory requirement
5= There is a legal/regulatory requirement and permit required

The legal/regulatory requirements were identified based on national laws/guidelines/standards (FMEnv, DPR, Edo state Ministry of Environment, etc) relating to the project activity.

5.3.3.2 Risk (R)

This uses a matrix based on the interaction of the probability of occurrence of the impact **(Table 5.3)** against consequences **(Table 5.4).** The matrix **(Figure 5.1)** is referred to as the Risk Assessment Matrix (RAM). Five probability categories interacted with four groups of consequences. The resultant outcomes were given scores with colour-coding. High-risk categories are red; intermediate risk, yellow and low risk, green as follows:

1=Low risk (green)
3=Intermediate risk (yellow)
5=High risk (red)

5.3.3.3 Frequency of Impact (F)

The frequency of impact refers to the number of occurrence of the impact. The frequency of impact was determined using historical records of occurrence of impacts, and consultation with experts and local communities. The criteria for rating the frequency of impacts are outlined in **Table 5.5.**

5.3.3.4 Importance of Affected Environmental Component and Impact (I)

The importance of the affected environmental components was determined through consultation and consensus of opinions.

This was also further facilitated by information on experiences on the impacts of already existing facilities in the proposed project area.

The rating of the importance of impacts is summarized in **Table 5.6.**

Table 5.3: Probability of Occurrence

Probability Category	Definition
A	Possibility of Repeated Incidents
B	Possibility of Isolated Incidents
C	Possibility of Occurring Sometime
D	Not Likely to Occur
E	Practically Impossible

Table 5.4: Consequence Categories

Consequence Category	Considerations			
	Safety / Health	Public Disruption	Environmental Aspects	Financial Implications
I	Fatalities / Serious Impact on Public	Large Community	Major/Extended Duration/Full-Scale Response	High
II	Serious Injury to Personnel / Limited Impact on Public	Small Community	Serious / Significant Resource Commitment	Medium
III	Medical Treatment for Personnel / No Impact on Public	Minor	Moderate / Limited Response to Short Duration	Low

IV	Minor Impact on Personnel	Minimal to None	Minor / Little or No Response Needed	None

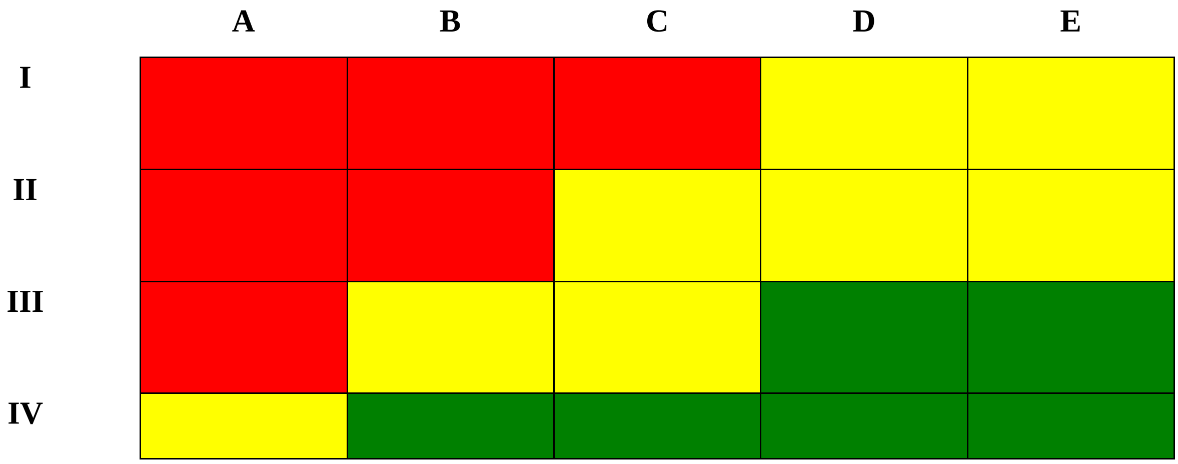


Figure 5.1: Risk Assessment Matrix

5.3.3.5 Public Perception (P)

The consensus of opinions among the project stakeholders was used to determine the public perception of the potential impacts and the criteria applied are as summarized in **Table 5.7**. The combination of the five impact rating weights formed the basis for judging the level of significance of each impact.

The final ratings of the identified impacts are presented in **Table 5.8 .** In this study, medium and highly significant negative impacts were judged to require mitigation, and all positive impacts required enhancement.

Table 5.5: Frequency Rating and Criteria

Frequency	Rating	Criteria
Low	1	Rare, not likely to happen within project lifespan
Medium	3	Likely to happen ≥ 5 years
High	5	Very likely to happen throughout the project lifespan

Table 5.6: Importance Criteria

Importance	Rating	Criteria

Low	1	• Imperceptible outcome • Insignificant alteration in value, function or service of impacted resource • Within compliance, no controls required
Medium	3	• Negative outcome • Measurable reduction or disruption in value, function or service of impacted resource • Potential for non-compliance
High	5	• Highly undesirable outcome (e.g., impairment of endangered species and protected habitat) • Detrimental, extended animal behavioural change (breeding, spawning, moulting) • Major reduction or disruption in value, function or service of impacted valued ecosystem resource • Impact during environmentally sensitive period • Continuous non-compliance with existing statutes

Table 5.7: Public Perception Criteria

Public Perception	**Rating**	**Criteria**
Low	1	• No risk to human health, acute and/or chronic • No possibility of life endangerment for residents, associated communities • Minor reduction in social, cultural, economic values • Unlikely adverse perception among population
Medium	3	• Limited incremental risk to human health, acute and/or chronic • Unlikely life endangerment for residents, abutting communities • Some reduction in social, cultural, economic value • The possibility of adverse perception among the population • Potential for non-compliance
High	5	• Elevated incremental risk to human health, acute and/or chronic • Possibility of life endangerment for residents, abutting

		communities • Major reduction in social, cultural, economic value • Continuous non-compliance with statute • Any major public concern among population in study area

Table 5.8: Impact Value and Rating Colour Code

Impact value	**Cut off values**	**Impact Rating**
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	High
F + I	>6	
P	= 5	
Positive		Positive

Table 5.9: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phases ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Mobilisation (transport) to site (equipment, personnel and construction modules)	Road traffic accidents		√	√		√	√	√		3	3	3	3	3	15	10	H
		Noise nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Loss of biodiversity		√	√		√		√		3	3	1	1	1	9	2	M
	Energy consumption (provision of energy for pre-construction activities)	Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Noise and vibration nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Increased opportunity for business and employment	√		√		√		√		-	-	-	-	-	-	-	P
		Contamination of soil by waste oil		√	√		√		√		3	1	3	1	1	9	4	M
	Site Preparation –	Acceleration of erosion		√	√		√		√		3	1	3	1	1	9	4	M

	clearing, excavation and landscaping of the interconnecting pipeline landing	Alteration of local topography		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of soil profile		√	√	√	√		√		0	1	1	1	1	4	2	L
		Blockage of drainage pattern		√	√	√	√		√		0	1	1	1	1	4	2	L
		Contamination of soil by run-offs		√	√	√	√		√		3	1	1	1	1	4	2	L
		Impairment of air quality		√	√	√	√		√		3	1	3	1	1	11	4	M
		Noise and vibration nuisance		√	√		√		√		3	1	3	1	1	9	4	M
		Worksite accidents		√		√		√	√	√	0	5	3	5	5	18	8	H
		Security/artificial light at night		√	√		√		√		0	1	3	1	1	6	4	L
		Habitat alteration		√	√			√		√	0	5	5	5	5	20	10	H

Table 5.10: Potential and Associated Impacts of the Proposed Project – Construction Phases- ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Transport activities during construction	Road traffic accidents		√	√		√		√		3	5	5	5	5	23	10	H
		Noise nuisance from steaming engines/ heavy vehicles		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality – emission from Heavy vehicles		√	√		√		√		3	1	1	1	3	9	2	M
	Excavation of land area	Loss of vegetal cover with possible impact on biodiversity loss		√	√	√	√	√	√		3	3	3	3	3	15	6	H
		Noise and vibration nuisance		√	√		√		√		3	5	3	1	3	15	4	H
		Waste generation from excavated materials		√	√		√		√		3	1	3	1	1	9	4	M
		Impairment of air quality		√	√	√	√		√		3	5	3	3	1	15	6	H
		Contamination in the event of oil		√	√			√	√		5	3	3	5	1	17	8	H

		spills from equipment and machinery																
		Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		√	√		√		√		5	1	1	3	1	11	4	M
	Construction of InterconnectingPipeline	Burns/injuries from welding sparks		√	√			√	√		3	5	3	5	1	17	8	H
		Exposure to welding flash		√	√		√		√		3	5	3	5	1	17	8	H
		Kidnapping of workers		√	√			√		√	3	5	5	5	5	23	10	H
	Water utilization	Changes in surface hydrology		√	√		√		√		0	1	1	1	1	4	2	L

	for concrete-weight	from water utilization for construction																
	Coating	Contamination of soil by paints and coating as a result of spillage		√	√		√		√		3	5	3	5	1	17	8	H
		Hazardous waste generation from coating operations such as metals			√	√		√		√	3	5	3	5	1	17	8	H
	Construction of LNG plant	Waste water management from construction Inapproprite waste management can lead to contamination of groundwater		√	√		√		√		3	1	1	1	3	9	2	M
	Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity			√	√		√		√	3	5	3	5	1	17	8	H
		Changes in surface hydrology from water utilization for construction		√	√		√		√		2	1	1	1	1	7	2	L
	Commissioning – Radiography	Discharge of hydrotest water from hydrostatic testing of equipment		√	√			√	√		3	5	3	5	1	17	8	**H**

	and hydrotesting	and interconnecting pipeline with water.																
	Site demobilization	Road traffic accidents		√	√			√		√	0	3	2	3	3	11	5	M

Table 5.11: Impacts of the Proposed Project –Operation (Normal)

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Operation/ Maintenance	Mini-LNG Plant operations and maintenance	Air Pollution (1) Fugitive emissions from natural gas processing facilities are associated with leaks in the tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump,and compressor seals; gas conveyance systems, pressure		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		relief valves, tanks or open pits /containment, and loading and unloading operations of hydrocarbons.																
		Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation		√	√			√		√	0	5	5	5	5	20	10	H
		Air Pollution (3) from Venting, flaring and greenhouse gases emission from the release of unburnt methane		√	√			√		√	0	5	5	5	5	20	10	H
		Processing wastewater to include		√	√		√		√		5	3	3	5	3	19	8	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		stormwater and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents																
		Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during depressurisation		√	√		√		√		3	3	3	3	3	15	6	H
		Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination		√			√	√		√	0	3	3	1	3	10	4	M

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water. Chemical additives, oxygen scavenger, dye and corrosion inhibitor may be added to the interconnecting pipeline for protection.	√		√		√		√		3	3	3	3	3	15	6	H
		Condensate spills or leaks from interconnecting pipeline operation		√			√	√		√	0	5	3	5	5	18	8	H
		Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as a nuisance. Non Hazardous waste will mainly		√	√	√	√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		come from discarded packaging materials such as metal cuttings, paper cartons, and empty plastic containers. Although the impact of this waste is expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.																
		The threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		processing facility.																
		Air emission during Maintenance/servicing of production equipment and ancillaries		√	√	√	√		√		3	1	1	3	1	9	4	M
	Transport activities during operation	Road traffic accidents		√	√			√		√	0	5	5	5	5	20	10	H

Table 5.12: Impacts of the Proposed Project –Operation (Abnormal)

Project Phase	Emergencies	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	

		Air Pollution Loss of containment of gas due to interconnecting pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution		√	√			√		√	0	5	5	5	5	20	10	H
		Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		√	√			√		√	0	5	5	5	5	20	10	H
		Fire leading to impact on fish and fishing activities as well as the benthic ecosystem		√	√			√		√	0	5	5	5	5	20	10	H
		Health and Safety Fire and explosion incident resulting in injury and fatalities		√			√	√		√	0	5	5	3	5	18	8	H

Table 5.13: Impacts of the Proposed Project –Decommissioning

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Decommissioning	Demolition and Evacuation	Revegetation	√		√		√		√		-	-	-	-	-	-	-	P
		Interference with road transportation		√	√		√		√		3	3	3	1	3	13	4	M
		Noise and vibration nuisance		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality		√	√	√	√		√		3	3	3	3	3	15	6	H
		Contamination of groundwater		√	√	√	√		√		3	1	3	3	1	11	6	M
		Contamination of soil		√	√	√	√		√		3	1	3	3	1	11	6	M
		Solid waste generation and impact on disposal facility		√	√	√	√		√		3	3	3	3	3	15	6	H
		Loss of job		√	√			√		√	0	5	5	5	5	20	10	H
		Kidnapping of workers		√	√			√		√	0	5	5	5	5	20	10	H
		Injury/fatalities in workforce		√	√	√	√		√		3	1	3	3	1	11	6	

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		/communities																M
		Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.		√	√	√	√		√		3	1	3	3	1	11	6	M

5.4 Description of Associated and Potential Impacts

The potential positive and negative impacts rated either high or medium are further herein described as arguments underlying the assessment.

5.4.1 Pre-Construction and Construction Phases

The negative medium impacts in this phase are: change in land and water usage, while during Mobilisation (transport) to the site (equipment, personnel, and construction modules) there will be noise nuisance and interference with road transportation. Energy requirements (provision of energy for construction) will result in negative medium impacts from impairment of air quality and noise and vibration nuisance with labour requirements activity resulting in negative medium impacts from an increase in the incidence of STI's/ HIV, increased demand on social infrastructure and influx of migrant workers/followers.

The site preparation (vegetation and land clearing), excavation of land area, interconnecting pipeline construction / lowering and backfilling activities will lead to high impacts from the acceleration of erosion, alteration of local oceanography and sea hydrology, exposure to heat, light and radiation, impairment of air quality, and noise/vibration nuisance. Exposure to welding flash is the only anticipated negative medium impacts from site fabrication (welding), with exposure to radioactive emissions from radioactive testing. During the installation of LNG plant, the medium and high impacts anticipated are impairment of air quality, noise and vibration nuisance, and exposure to heat, light, and radiation. Interference with road transportation will be the only from demobilization.

The phase impacts with high negative significant ratings include road accidents from mobilisation, injuries and death from falling objects and work site accidents from the site preparation, during the installation of the gas plant, from the excavation of land areaand from backfilling. Burns/injuries from welding sparks will be a high negative rating impact from site fabrication.

The phase's positive impacts are increasing in income from mobilisation; increased opportunity for business and employment from energy requirements; increased opportunity for business and employment, increase in income and improved livelihood from labour requirements; an increase in income from demobilization.

5.4.1.1 Construction of temporary on site facility

During the construction phase, there will be a need for temporary on site facility. The temporary on site facility will be for the mobilization, transfer and logistics. Equipmets shall be transferred from this location.. The effect is expected to be short term, negative and reversible therefore low

5.4.1.2 Loss of land usage

The land that shall be used for the project shall not be available for any other possible project in the entire lifespan of the proposed plant so as to maintain the plant integrity. The non-availability of this land and the change in its use due to the proposed project is of direct impact on land availability in the host area and to last the entire life of the proposed plant anticipated to be about 30 years thus qualified the impacts to be rated long term. However, this land can be returned to the owner after the life-span of the project if so desired thus the impacts are rated reversible. Application of the impacts quantification elements qualified it to be rated medium. No impact is anticipated on sea usage.

5.4.1.3 Blockage of road access to other users

Movement of materials, equipment, and personnel in preparation for the proposed project is anticipated to result in increased road traffic volume on the road leading in and out of the area thus may worsen traffic situation around the area. However, these impacts are expected to last the period of mobilization to the site, storage of construction materials, site preparation for plant construction and installation activities. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.1.4 Impairment of air quality/ Noise and vibration nuisance

Operations and activities of mobile and stationary plants to be involved in transportation of construction materials, energy requirements, site preparation, onsite construction and installation, land excavation for interconnecting pipeline, backfilling, completion of the project and commissioning, and demobilization project activities may generate noise and vibration while emissions from the plants and associated dust suspensions may cause impaired air quality. All these are direct, with negative impact to last the period of construction activities thus the short term. Though they are reversible, their level of impacts caused them to be rated medium. Table 5.14 shows the air emission per day per fleet. Heavy duty equipment and other related large machinery may produce noise levels as high as 91 decibels weighted to 'A' scale (dBA). Table 5.15 shows the typical construction equipment and their associated noise level.

Table 5.14: Air emission per day per fleet

Compound	Weight (metric tons)
Carbon dioxide	1.05
Carbon monoxide	0.458
Hydrocarbons	0.35
Nitrogen oxides	0.126
Particulates	.17
Sulphur oxides	.727

Source of emission factors

http//:www.epa.gov/region09/air/marine vessel/pfds/tanimar/pdf

Table 5.15: Construction Equipment Noise level

Equipment Type	Noise Level at 50feet (dBA)
Backhoe	85
Tractor	80
Truck	91
Chipper	85
Chainsaw	76

5.4.1.5 Road traffic accidents

Increase in traffic volume anticipated on the major road leading to the facility during the mobilization, demobilization, plant construction and operation of the project which shall include transportation of the LNG from the plant to customer locations across the country but mostly in the Northern region may increase the chances of road accident especially when heavy equipment is to be moved. There is the possibility of traffic accidents involving **VTT LNG West Africa Limited** vehicles alone or **VTT LNG West Africa Limited** engaged contractors and third party vehicles during mobilization and demobilization and operation phases. Since some of these accidents may result in death which is negative, direct and irreversible, they are rated high.

5.4.1.6 Injuries and death/worksite accidents

During site preparation, onsite construction and installation of the gas plant as well as land excavation, there can be worksite accidents and injuries/death from falling objects on site. Some of these accidents may result in the death of victims which is negative, direct and irreversible, thus rated high.

5.4.1.7 Employment/contracting and increase in income

Procurement of construction materials, their transportation, labour requirements, and installation of the plant and the compressor activities will create employment/contracting as well as an increase in income opportunities thus improving the economic power of the people in the proposed host environment. This impact is a positive rating.

5.4.1.8 Increased opportunity for business and employment

During energy provision, labor engagement, and installation of plant, several business opportunities will be created for the indigenous people while some people will be employed in the immediate environment of the proposed site. These impacts are also of positive ratings.

5.4.1.9 Improved natural gas supply to customers

The major aim of this proposed project is the provision of natural gas supply for customers spread all over the country. If the project is successfully completed, it is expected that this aim will be completely achieved. Improved natural gas supply to be obtained as a result of this. This impact is of a positive rating.

5.4.2 Operation/Maintenance Phase

Generally, the impact of compressor failure, explosion and fire in the operation phase during maintenance is rated moderate severity. Impact could occur infrequently during normal operations, but given a breakdown of the safeguards and controls (i.e. lack of maintenance for a protecting device) it could occur more readily.

This phase of the proposed plant is anticipated to have medium ratings negative impacts including Noise and vibration nuisance as well as impairment of air quality. The positive impacts ratings in the phase include improved natural gas supply to customers, increased opportunity for business and employment and increase in income and improved livelihood. However, the activities of the operation phase shall include transportation of the LNG from the plant to customer locations across the country via moving tankers and this may increase the chances of road accident especially when these tankers are to be moved. There is the possibility of traffic accidents involving **VTT LNG West Africa Limited** vehicles alone or **VTT LNG West Africa**

Limited engaged contractors and third party vehicles during mobilization and demobilization and operation phases. Since some of these accidents may result in death which is negative, direct and irreversible, they are rated high.

5.4.2.1 Impairment of air quality

Normal operations and activities of the proposed project during this phase may be sources of air pollution from the supporting equipment including gas flares and compressors. This may result in air emission of suspended particulates matters (SPM), carbon monoxide (CO), oxides of nitrogen ($NO_{X)}$, hydrocarbons (HC), and sulphur dioxide (SO_2). Though the quantities of these emissions will be determined by emission inventory with ground level concentrations to be quantified using emission dispersion modeling, the volume of gas to be handles made them rated medium in the preliminary investigations.

However during abnormal conditions arising from loss of containment there is possibility of fire and explosion leading to severe air pollution. In the event of such an occurrence environment may be affected.

5.4.2.2 Discharge of Gas Processing Effluent

At the gas processing station, the operation wastewater which may include stormwater and cooling water at the treatment plant may contain condensate, biocides and anti-fouling agent. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.2.3 Noise and Vibration

Operations and activities of the proposed project during this phase may be sources of noise from the supporting equipment including gas flares and compressors. Though the levels of noise to be released from these supporting facilities will be determined by Noise Map, a noise dispersion modeling tool, the volume of gas to be handles made them rated medium in the preliminary investigations like the ambient air quality status.

5.4.2.4 Discharge of hydrotest water

The commissioning and operation of the gas line will require regular integrity test. The hydrotest water will also contain other additive and chemicals like oxygen scavenger, dye and corrosion inhibitor which may be added to interconnecting pipeline for protection. The impacts are short-term, negative, reversible, with the direct impact thus rated medium.

5.4.2.5 Condensate Spill

With change in temperature and pressure conditions along the interconnecting pipeline, the likelihood of the formation of condensates exist. This impact is short term, negative, reversible.

5.4.2.6 Waste generation

It is expected that during the construction of the LNG plant, the construction activities could result in the generation of both hazardous and non-hazardous wastes. The potential effects will be of aesthetics as well as a nuisance. Non-hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons, and empty plastic containers. Although the impact of this waste is expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature. The impact will be short term, negative and irreversible, so considered medium.

5.4.3 Decommissioning Phase

At the end of this project which is anticipated to be 30 years by design, there will be decommissioning. In this phase, interference with road transportation and impairment of air quality are the two medium ratings anticipated while kidnapping of workers and visitors on site is a high rating negative impact.

5.4.3.1 Impairment of air quality

Dismantling, removal and site clean-up at the end of the proposed project may require the use of heavy machinery with activities that may open the soil surface. Operations and activities of the mobile plants to be involved at this stage may generate emissions and associated dust suspensions may cause impaired air quality. These were identified as direct which will last the period of decommissioning activities. Though they were considered reversible, their levels caused them to be of medium ranking.

5.4.3.2 Kidnapping of workers and visitors on site

The kidnapping of workers and visitors on site are among the major security concerns in Nigeria now. During movements as required in decommissioning, personnel and company contractor may be victims of kidnappers. Some of these attacks may result in the death of victims which is negative, direct and irreversible, thus rated high.

5.4.3.3 Solid, Liquid and Hazardous Waste Management

Decommissioning activities will generate wastes such as excavated soils and debris wood piles, fuels, lube oils, chemicals and solid wastes from the demolition camp. Leaching from waste oil could result in groundwater contamination. The solid and hazardous waste generated during the decommissioning activities will be managed using the best management practices. The impact from the hazardous waste management will be negative, short-term, localized, reversible and medium.

5.4.3.4 Increased opportunity for employment and contracting resulting in increased income level.

The process of decommissioning will involve the repair of damaged roads, removal of structures, and restoration of the campsite. These activities could increase opportunities for employment and contract. The impact was rated as direct, positive, short-term, local and reversible.

5.4.3.5 Nuisance (Noise, emission, Vibration etc) from heavy machinery.

The process of decommissioning could also result in the generation of noise, vibration etc. from heavy equipment. The impact was rated as direct, negative, short-term, local, reversible, and medium.

5.4.3.6 Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.

As plant activities come to an end, there could be agitation by the third parties from loss of employment and contracting opportunities. The impact was direct, negative, short-term, local, and reversible, with the medium rating.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The basis for impact quantification and significance rating has earlier been discussed in **Chapter Five**. The results indicate that various components would be impacted positively or negatively. In order to preserve the present integrity of the environment, certain steps have been recommended to mitigate or control the medium and high ratings negative impacts identified. The control/mitigation measures have been based on the baseline conditions with regard to the biophysical environment, socio-economic and health status of the host community. Also considered were the project activities and their envisaged impacts, the concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities.

The actions and measures that **the VTT LNG West Africa Limited** intends to take to reduce (or eliminate) negative impacts and promote positive environmental, social and health impacts of the proposed project are therefore presented in this chapter. In this mitigation measures, emphasis are placed on those negative impacts rated as significantly medium and high. These measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of the Health, Safety and Environment (HSE) policies put in place during the different phases of the project.

The mitigation measures proposed are in keeping with the following:

- Environmental laws at national, regional and internal levels;
- FMEnv (formerly FEPA, 1991) regulations on Natural Gas Plant facilities and their waste management;
- DPR regulations on Natural Gas Pipeline facilities and their waste management (EGASPIN, 2002);
- Edo State Ministry of Environment policies;
- Best Available Technology for Sustainable Development;

- Social wellbeing; and
- Concerns of stakeholders.

To define mitigation measures for the identified associated and potential impacts, the following criteria were used:

Prevention – Exclude significant potential impacts and risks by design and management measures.

Reduction – Minimise the effects or consequences of those significant associated and potential impacts that cannot be prevented to a level as low as reasonably possible by implementing operational and management measures.

Control – Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practicable.

6.2 Highlights of Mitigation and Enhancement Measures

Summarized in **Tables 6.1 and 6.2** are the detailed mitigation and enhancement measures identified and recommendations to ameliorate all the significant associated and potential negative impacts identified in the gas Proposed Project activities.

Table 6.1: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phase

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
Mobilisation (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	VTT LNG West Africa Limited shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • Involve VTT LNG West Africa Limited security in traffic control in traffic management • Defensive driving course for VTT LNG West Africa Limited and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	
	Noise nuisance	M	VTT LNG West Africa Limited shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality	M	VTT LNG West Africa Limited shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practise on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil	L

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
			▪ Limiting activities in erodable soil	
Energy consumption (provision of energy for pre-construction activities)**)**	Impairment of air quality	M	VTT LNG West Africa Limited shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L
	Noise and vibration nuisance	M	VTT LNG West Africa Limited shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Increased opportunity for business and employment	P	VTT LNG West Africa Limited shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P
	Contamination of soil	M	VTT LNG West Africa Limited shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practise on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L
Site Preparation – clearing,	Acceleration of erosion	H	VTT LNG West Africa Limited shall: • Stabilize soil within the well location and campsite mechanically	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
excavation and landscaping			using compactors to reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion • Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodable soil	
	Alteration of local topography	M	VTT LNG West Africa Limited shall: • re-grading the sites, then replacing the layer of top soil that was previously put. • restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic • restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way	L
	Alteration of soil profile	M	VTT LNG West Africa Limited shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			species from adjoining forest after activities • stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	
	Blockage of drainage pattern	M	VTT LNG West Africa Limited shall ensure that: • trict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	L
	Contamination of soil	M	VTT LNG West Africa Limited shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practise on-site. • Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimises perturbation to aquatic environment. • Avoid spills prohibiting refuelling near waterway	L
	Impairment of air quality	M	VTT LNG West Africa Limited shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled;	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• equipment engines are turned off when not in use • all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • it provide and enforce the use of PPE (e.g. nose masks and ear muffs) • it construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;	
	Noise and vibration nuisance	M	VTT LNG West Africa Limited shall ensure that: • equipment are fitted with effective silencers;	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			• there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	
	Work site accidents	H	VTT LNG West Africa Limited shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	M
	Security/artificial light at night	L	VTT LNG West Africa Limited shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged	L
	Habitat Alteration	H	VTT LNG West Africa Limited shall: ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			restoring vegetation at the end of the work	

Table 6.2: Potential and Associated Impacts of the Proposed Project– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Transport activities during construction	Road traffic accidents	H	VTT LNG West Africa Limited shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods	M

			• Involve VTT LNG West Africa Limited security in traffic control in traffic management • Defensive driving course for VTT LNG West Africa Limited and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	
	Noise nuisance	M	VTT LNG West Africa Limited shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality – emission from trucks	M	VTT LNG West Africa Limited shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation	L

			• Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust	
Excavation of land area	Loss of vegetal cover with possible impact on biodiversity loss	H	VTT LNG West Africa Limited shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers. ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by	L

			restoring vegetation at the end of the work	
	Impairment of air quality	H	VTT LNG West Africa Limited shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;	L
	Noise and vibration nuisance	H	VTT LNG West Africa Limited shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged	L

			• vibration containment shall be made for generators and machines	
	Waste generation from excavated materials	M	VTT LNG West Africa Limited shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work.	L

			• safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws.	
	Burns/injuries from welding sparks	H	VTT LNG West Africa Limited shall ensure: • that workers and visitors are properly kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet international standards	L
Construction of Interconnecti	Exposure to welding flash	H	• VTT LNG West Africa Limited shall ensure that workers and visitors are properly kitted (appropriate PPEs are used)	L

ng Pipeline				
Lowering of Interconnecting Pipeline	Noise and vibration nuisance	M	VTT LNG West Africa Limited shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • generators are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs shall be encouraged	L

	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	VTT LNG West Africa Limited shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L

	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused	H	VTT LNG West Africa Limited shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;	L

Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L
	Habitat alteration	M	VTT LNG West Africa Limited shall: • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP. • ensure the use of appropriate PPEs • ensure that backfilling is followed by mechanical compaction so as to retain the original level.	L

			• re-vegetate the soils with indigenous grasses, sedges etc to check incidence of flooding	
	Kidnapping of workers and visitors on site	H	VTT LNG West Africa Limited shall ensure that: • both contractor and its personnel develop a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the VTT LNG West Africa Limited Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of these police to strengthen security in the area • a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, it supports government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	M
	Worksite accidents	H	VTT LNG West Africa Limited shall ensure that:	M

			• workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • VTT LNG West Africa Limited shall ensure immunization of workforce against as appropriate • Regular spraying of work sites. Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • VTT LNG West Africa Limited shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her	L

			stakeholders' engagement plan. • VTT LNG West Africa Limited shall ensure site clinic is provided to take care of minor illnesses for all construction workers	
Construction of Interconnecting Pipeline	Temporary change in land use but land will be returned to its original use after completion of works and subsequent sand filling	M	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • New structures such as signboards, bill boards for the project shall be removed after construction. Those required such as direction or warning signs shall be properly placed.	L
Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures.	L

			• Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills	
	Hazardous waste generation from coating operations such as metals	H	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv and DPR standard at an approved disposal sites	L
Construction of LNG plant	Waste water management from construction - Inappropriate management can lead to contamination of surface and groundwater	H	• Disposal of water and waste products arising from the sites via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance; • Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel; • Provide sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment.	L

			• Waste water shall be treated in line with an approved standard by FMEnv and DPR before of its release to the environment	
	Changes in surface hydrology from water utilization for construction	L	• Drilling of borehole for water utilization for construction of concrete-weight	L
Commissioning and Site Demobilisation	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.	H	VTT LNG West Africa Limited shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state.	L

			• Disposal in each case shall be monitored by the appropriate regulatory bodies and VTT LNG West Africa Limited	
	Road traffic accidents	M	VTT LNG West Africa Limited shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L

Table 6.3: Potential and Associated Impacts of the Proposed Project – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
operations and maintenance	Air Pollution (1) Fugitive emissions in natural gas processing facilities that are associated with leaks in	H	VTT LNG West Africa Limited shall ensure: • Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits / containments, and loading and unloading operations of hydrocarbons.		• Maintain stable tank pressure and vapor space by: ○ Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); ○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapor pressure of materials being stored. • Use of supply and return systems, vapor recovery hoses, and	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			vapor-tight trucks / railcars / vessels during loading and unloading of transport vehicles; • Use of bottom-loading truck / rail car filling systems; and • Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.	
	Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	VTT LNG West Africa Limited shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	Air Pollution (3) Venting, flaring and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure	H	VTT LNG West Africa Limited shall: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	L
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents	H	VTT LNG West Africa Limited shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and • Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids are handled, segregate contaminated and non-	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit	
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during depressurisation	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise • Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the	M

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding • Encourage the use PPEs	
	Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination	M	• Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections,	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Storing and handling of hazardous waste in accordance to approved WMP • Access to areas containing hazardous substances shall be restricted and controlled; • Hydrocarbon and hazardous materials shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv and DPR standard in an approved site; • solid hazardous waste shall not be burned;	
	Discharge of hydrotest water	H	VTT LNG West Africa Limited shall ensure:	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	from hydrostatic testing of equipment and interconnecting pipelines with water. Chemical addatives, oxygen scanvenger, dye and corrosion inhibitor may be added for pipeline protection		• Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations.;	
	Condensate spills or leaks from pipeline rupture	H	VTT LNG West Africa Limited shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and equipment; • Identification and location of existing gas and other buried utility infrastructure prior to excavation for installation or	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			repair of gas pipeline. Installation of visual marking of gas lines as part of installation, and updating as necessary on an ongoing basis; • Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of gas lines and components using sufficient separation distance and appropriate pipe protection layering to minimize potential interference with other underground infrastructure. Separation of plastic pipes from sources of heat; • Odorization of gas to facilitate detection of gas leakage; • Training of gas utility workers in procedures for emergency preparedness and response involving appropriate public	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			authorities, in addition to emergency shutdown and • Pressure reduction in the piping system.	
	Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is expected to be minimal,	H	VTT LNG West Africa Limited shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated • Nonhazardous wastes are segregated, stored and disposed	L

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
	poor disposal methods can lead to environmental problems due to their non-biodegradable nature.		through an approved state waste collector	
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	VTT LNG West Africa Limited shall ensure: • Provision of early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			segregation of process, storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the facility and adjacent buildings, provision of additional cooling water capacity for adjacent tanks, or other risk based management approaches; and • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved;	

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
			○ Designing the oily sewage system to avoid propagation of fire.	
	Air emission during maintenance/servicing of production equipment and ancillaries	M	VTT LNG West Africa Limited shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones • Experts and professional must always be used to handle any repairs of production equipment and ancillaries • VTT LNG West Africa Limited shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements • and best practice using approved contractors • VTT LNG West Africa Limited shall ensure that none of	L

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
			these wastes are disposed into any water body or on land	
	Road and traffic accidents as a result of transportation activities during facility operation	H	VTT LNG West Africa Limited shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	M

Table 6.4: Potential and Associated Impacts of the Proposed Project –Operation/Maintenance (Abnormal)

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**
Emergencies	Air Pollution Loss of containment of gas due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	• Gas plant components, in addition to general installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Testing of pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning. The system shall be gas tight when tested at a higher pressure than the normal maximum operation gas pressure; • Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken as indicated by detection results.	L

			• Typical urban testing sites include atmospheres in confined spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on streets and walkways. Areas of gas infrastructure subject to forces from heavy load traffic or physical land shifts shall also be periodically monitored for leaks and ruptures; • Comparisons of purchased and delivered gas amounts shall be periodically examined for discrepancies and unaccounted for gas which may be an indicator of excessive system leakage; • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults.	
	Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane,	H	VTT LNG West Africa Limited shall ensure that: • Optimize plant controls to increase the reaction conversion rates;	L

	flaring of methane as a result of emergency or equipment failure		• Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	
	Fire leading to impact on fish and fishing activities as well as the benthic ecosystem	H	• Providing early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Limiting the areas that may be potentially affected by	M

			accidental releases by: o Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; o Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; and o Designing the oily sewage system to avoid propagation of fire.	
	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	• Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. • The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present. • Provision of manual firefighting equipment that is easily	M

			accessible and simple to use • Fire and emergency alarm systems that are both audible and visible • Permit to work system (PTW) shall be enforced	

Table 6.5: Potential and Associated Impacts of the Proposed Project – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Demolition and Decommission	Interference with road transportation	M	• VTT LNG West Africa Limited shall monitor the no of trucks per day to know if there is need to create other accessible roads • VTT LNG West Africa Limited shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L
	Noise and vibration nuisance	M	VTT LNG West Africa Limited shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used	L
	Impairment of air quality	H	VTT LNG West Africa Limited shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site	L

			• that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	
	Contamination of surface and Groundwater & soil	M	VTT LNG West Africa Limited shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEV guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the to a condition in no way inferior to the condition prior to the commencement of work.	L
	Solid waste generation and impact on disposal facility	H	• VTT LNG West Africa Limited shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors • VTT LNG West Africa Limited shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures while disposing wastes • VTT LNG West Africa Limited shall keep all waste consignment, treatment and disposal records for regulatory verification	L

			• Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation of waste • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector	
	Loss of job	H	VTT LNG West Africa Limited shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L
	Injury / fatalities in workforce /communities	H	VTT LNG West Africa Limited shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced • ensure use of PPE	L

			• provide first aid and clinic on site	
	Kidnapping of workers and visitors on site	H	• VTT LNG West Africa Limited shall ensure that both contractor and its personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the VTT LNG West Africa Limited Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of its police to strengthen security in the area • VTT LNG West Africa Limited shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, VTT LNG West Africa Limited shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security VTT LNG West Africa Limited shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	M
	Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.	M	• Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L
	Revegetation	P	• Restoring vegetation after decommissioning of facility	P

6.3 Summary of Residual Impacts after Mitigation

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the mitigation measure implemented.

Overall, on balance, with the provision of the proposed mitigation measures as outlined in Tables 6.1 to 6.3, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project.

Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

An overall mitigation measure is to undertake a Job Hazard Analysis, to enable each worker assess the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

6.4 Wastes and Disposal Activities

Effective and responsible handling and disposal of wastes are key elements in environmental management system. Wastes refer to any material (solid, liquid, gaseous or mixture) that is surplus to requirements. Waste management for the project shall be carried out in line with VTT LNG West Africa Limited waste management policy and guidelines, as well as international best practices.

VTT LNG West Africa Limited shall take all practical and cost-effective measures to minimise the generation of wastes, by employing the four Rs (Reduce, Reuse, Recycle, and Recovery) through process of optimisation or redesign, efficient procedures and good housekeeping.

Waste shall be managed in the following ways:

- Inventorisation
- Classification
- Segregation

- Wastes quantification
- Wastes tracking; and
- Wastes disposal

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

7.1 Introduction

Environmental management is concerned with a planned, integrated programme aimed at ensuring that identified and unidentified impacts of a proposed project are contained and brought to an acceptable minimum. It provides confidence on the part of project planners that a reliable scheme will be put in place to deal with any contingency that may arise during all phases of development from preliminary study to abandonment. In keeping with the VTT LNG West Africa Limited's policy on the environment, consideration of the environmental implications of this project began from preliminary study, conceptual design, up to the present stage of ESIA. This ESIA report is intended to provide an environmental input into the planning and execution of the project as being addressed by environmental management plan.

Environmental and Social Management Plan (ESMP) is the tool for managing the predicted environmental impacts of a project. It provides the means whereby the mitigation measures developed for reducing the effects of moderate and major impacts to *as low as reasonably practicable* (ALARP) are implemented and monitored throughout the project lifecycle.

The ESMP shall be employed as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.

Environmental management activities of the proposed VTT LNG West Africa Limited project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

7.2 Objectives of the ESMP

This ESMP has the following specific long-term objectives:

- ensure compliance with legislation and Company policy;
- achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- integrate environment fully into the business;
- rationalise and streamline existing environmental activities to add value in efficiency and effectiveness;
- encourage and achieve the highest performance and response from individual employees and contractors;
- provide standards for overall planning, operation, audit and review;
- enable management to establish environmental priorities;
- be applicable throughout the organisation;
- hold early consultations with communities and regulating authorities to ensure hitch free operations;
- establish a structure that will ensure compliance by VTT LNG West Africa Limited and its Contractors with the ESMP.

In order to accomplish the above targets, the ESMP has considered each environmental, social and health impacts from the point of view of the Valued Ecosystem and Social Component(s) (VEC/VSC) to be monitored, as well as the parameters for their monitoring. It also specifies the responsible party/parties for each action.

For the development of this ESMP, VTT LNG West Africa Limited recognized that sound environmental management of the proposed project can only be guaranteed through the integration of the provisions of the plan as an integral part of business quality management. To this end VTT LNG West Africa Limited shall put in place measures to enforce compliance by the project team on a daily basis throughout the duration of the project.

7.3 Management Commitments and Responsibility

The Management commitment and responsibility of VTT LNG West Africa Limited are detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of VTT states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of VTT contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of VTT host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve VTT's assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;
- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate VTT's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the VTT's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and

- adequately resource health, safety and environment functions throughout the business.

7.3.1 Organisation Structure

VTT (the operator of the plant) has an organisation structure that describes the various departments, responsibilities and responsible parties that shall help achieve its overall environmental objective (**Figure 7.1**). The Environmental, Health, Safety, Security and Quality/Community Affairs (EHSSQ/CA) department is primarily responsible for environmental, safety, security and occupational health management. The VTT ESMP is administered by the EHSSQ department.

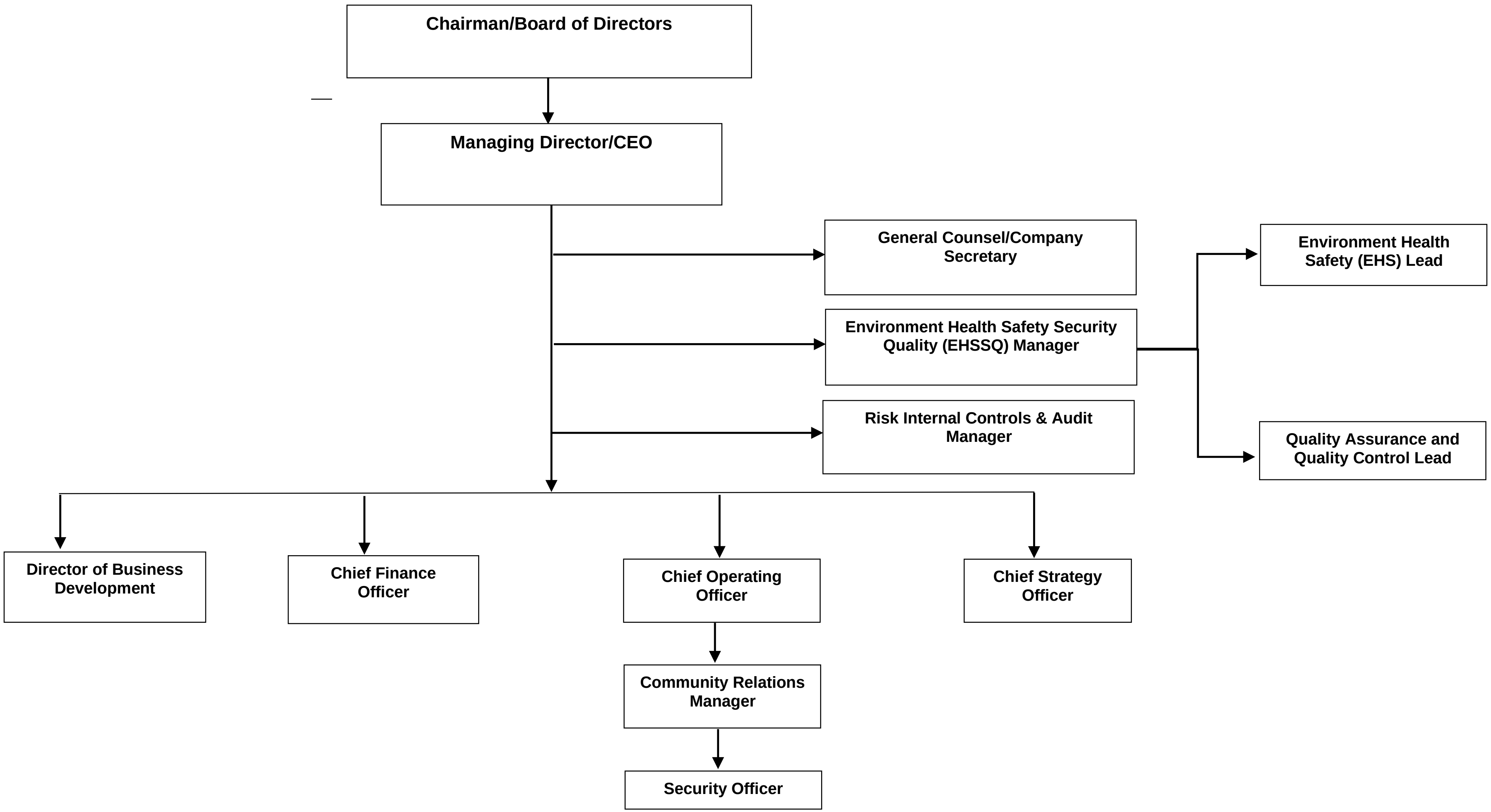


Figure 7.1: Organisation Organogram

7.3.2 Contractor Management Plan

VTT LNG West Africa Limited shall engage Contractors to carry out the various project activities. The Contractors are responsible for performing all work in compliance with relevant national and international HSE legislation and regulations, and with other requirements to which VTT subscribes; and in conformance with VTT's HSE MS requirements; and in accordance with VTT's technical and quality specifications.

VTT LNG West Africa Limited shall provide specifications for environmental compliance and performance and, as a contractual requirement, the contractor must develop and provide to the VTT LNG West Africa Limited its own specific management plans, incorporating:

- Health, Safety and Environment Policy Statements, Programs, and Management Systems;
- Health, Safety, and Environment Organization;
- Health, Safety, and Environment Responsibilities;
- HSE Procedures;
- Employee HSE Training Programs;
- Waste Management Plans;
- Emergency Response/Evacuation Plans;
- Transportation Safety Management System;
- Hazardous Materials Management Program;
- Industrial Hygiene and Medical Protection Plans.

The Contractors must also provide documentation detailing their plans for implementing the measures required in the ESMP; Local Content; Logistics; Security; and Community Relations. The Contractor's management plans must conform to the requirements of the VTT LNG West Africa Limited's overarching plans. Contractor's plans shall be reviewed

and approved by the VTT LNG West Africa Limited and incorporated into, and form part of, the VTT LNG West Africa Limited's overall ESMP. Contractors shall be required to self-monitor the implementation of their plan which shall be routinely monitored by the VTT LNG West Africa Limited directly or by third-parties and in conjunction with environmental regulators. Contractors shall be required to submit regular reports of monitoring activities and the VTT LNG West Africa Limited shall review these on a regular basis.

As a contractual requirement, the Contractor shall provide sufficient resources to manage HSE aspects of the work to be performed. This includes providing resources to ensure sub-contractor compliance and a process for emergency stop-work orders in response to monitoring triggers.

7.4 Implementation

7.4.1 Training

VTT LNG West Africa Limited shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact on the environment or social conditions. It recognizes that it is important that employees at each relevant function and level are aware of VTT's environmental, social, and health policy; potential impacts of their activities; roles and responsibilities in achieving conformance with the policy and procedures.

This shall be achieved through a formal training process. Employee training shall include awareness of and competency with respect to:

- environmental and social impacts that could potentially arise from their activities;
- necessity of conforming to the requirements of these ESIA and ESMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity

The EHSSQ Manager is responsible for coordinating the training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The EHSSQ Manager shall also periodically verify that staff are performing competently through discussion and observation. Employees responsible for performing site inspections shall receive training drawing on external resources as necessary. Training shall be coordinated by the EHSSQ Manager and/or Community Relations Manager prior to the beginning of field activities. Upon completion of training and once deemed competent in the requirements, staff shall be allowed to train other people.

Similarly, VTT LNG West Africa Limited shall require that each of the Contractors institute training for its personnel. Each Contractor is responsible for site HSE awareness training for personnel working on the job sites. The Contractor is also responsible for identification of any additional training requirements to maintain required competency levels.
The Contractor training program shall be subjected to approval by the VTT LNG West Africa Limited and it shall be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- Contractor has periodically verified that personnel perform competently after training

7.4.2 Documentation

The VTT LNG West Africa Limited shall control HSE documentation, including plans (e.g. the ESMP); associated procedures; and checklists, forms, and reports, through a formal company procedure. The document control procedure also describes the processes that the VTT LNG West Africa Limited and the Contractor shall employ for official communication of both hardcopy and electronic (through the intranet) document deliverables. In addition, it describes the requirement for electronic filing and posting and for assignment of a document tracking and control number (including revision codes).

The VTT LNG West Africa Limited Document Control Officer is responsible for maintaining a master listing of applicable documents, including HSE documents, and making sure that this list is communicated to the appropriate parties. The VTT LNG West Africa Limited HSE Manager is responsible for providing notice to the affected parties of changes or revisions to documents, for issuing revised copies and for checking that the information is communicated within that party's organization appropriately.

The Contractor shall be required to develop a system for maintaining and controlling its own HSE documentation and describe these systems in their respective HSE Plans and Site-Specific HSE Plans.

7.4.3 Operational Control Procedures

Each potentially significant impact identified in this ESMP shall have an operational control associated with its appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement, and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP.

Operating control procedures shall be reviewed and, where appropriate, amended to include instructions for planning and minimizing HSE impacts, or to at least reference relevant documents that address HSE impact avoidance and mitigation. To be comprehensive, suitable, adequate, and effective, the ESMP shall ensure that operational controls for avoiding and minimizing impacts are properly maintained for the project's life-cycle.

7.4.4 Emergency Preparedness and Response

The VTT LNG West Africa Limited has developed plans and procedures to identify the potential for and response to environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them. The Emergency Management Plan describes how detailed emergency response planning for foreseeable emergencies at all locations shall be planned, implemented, reviewed, improved. Individual Emergency Response Plans are written to provide additional detail for responding to incidents at specific locations. Emergency methods shall be reviewed by the VTT LNG West Africa Limited on an annual basis and after the occurrence of accidents or emergency situations.

7.5 Checking and Corrective Action

The objective of the inspection and monitoring activities described in this section is to verify compliance with the ESMP. The inspection and monitoring approach shall also be reflected in Contractor's HSE procedures. Contractors shall be responsible for implementing the VTT LNG West Africa Limited's environmental and social commitments in the field on a daily basis. Auditing of the monitoring and inspection activities by the Contractor and by the VTT LNG West Africa Limited provide the mechanism by which the VTT LNG West Africa Limited ensures that it remains compliant with regulatory commitments as well as its own HSE standards and policies.

The *inspection* activities described in this ESMP refer to qualitative monitoring, e.g., visual inspections. The *monitoring* activities described in this ESMP refer to empirical monitoring (e.g., measurements).

7.5.1 Inspection

Inspections shall be conducted by Staff, Contractor's HSE department on a daily basis. The results of the inspection and monitoring activities shall be made available to the VTT LNG West Africa Limited on a weekly basis or more frequently if requested by the VTT LNG West Africa Limited Head HSE.

7.5.2 Monitoring

Monitoring shall be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. With respect to the significant impacts identified in this ESIA, the VTT LNG West Africa Limited has developed a program to monitor the effectiveness of the mitigation measures. The program describes what effect is to be measured and the frequency.

In conjunction with monitoring of the effectiveness of specific mitigation measures, the VTT LNG West Africa Limited has developed a program to monitor for compliance with relevant regulatory standards. This program also ensures that staffs are meeting contractual obligations with respect to work practices and design specifications. Monitoring is carried out by the VTT LNG West Africa Limited HSE department and/or by Supervisors and Contractors pursuant to their contractual obligations.

7.6 VTT's Waste Management Policy

The waste management policy stipulates that:

- all practical and reasonable measures are taken to minimize the generation of solid, liquid and gaseous wastes;
- management and disposal of wastes in an environmentally responsible manner be observed; and
- tracking and maintenance of records of waste streams, and provision of verifiable trail of their management and disposal be maintained.

7.6.1 Waste and Hazardous Materials Management

The management of all wastes and hazardous materials that may be generated during the various activities of this gas plant project shall form an integral part of the overall HSE-MS (HSE Management System) and shall be based on a "cradle to grave" approach. The standard for the guideline includes the regulations of FMEnv, DPR and other National and International Agencies. These standards shall be binding on all staff and contractors involved in the project with respect to the:

- emission or release of pollutant, exhaust and/or fugitive gases;
- discharge or spill of effluent into the ecosystem; and
- discharge of solid wastes (including domestic waste).

7.6.2 Waste Handling

For proper handling and disposal, wastes shall be well defined at source and the definition transmitted along with the waste to the final disposal points. Contractor shall define and document all wastes generated in the course of work. Basic information that shall be provided, as a minimum, for adequate definition of wastes include:

- waste type identification;
- proper waste categorization;

- waste segregation information; and
- recommended waste management practices.

7.6.3 Waste Minimization

Waste minimization aims at a reduction of the volume of wastes to the greatest extent possible. The four principles of waste minimization process: recycle, reduce, reuse and recover shall be applied. A large proportion of excavated materials shall be used on site.

7.6.4 Waste Segregation

In order to ensure effective implementation of appropriate waste disposal methods, it is important that wastes are segregated at source. During construction, the types of wastes expected include off-cut metals, spent electrodes, cement slurry, spent lube oil, oil filters, cartridges, etc. These wastes shall be segregated into clearly designated bins at strategic locations with the waste bins located at the construction site.

7.6.5 Waste Disposal

All waste shall be disposed regularly in line with the VTT LNG West Africa Limited waste management manual. Instructions on a product's Material Safety Handling Sheet shall be strictly adhered to and this shall form the basis for the disposal of wastes related to such products. In line with the VTT LNG West Africa Limited, wastes in transit shall be accompanied and tracked by consignment notes.

7.6.6 Waste Tracking

In keeping with standard practice and regulatory requirements, the VTT LNG West Africa Limited shall maintain a standard waste tracking system (cradle to grave).

7.6.7 Operational Wastes and Disposal Methods

Waste management strategy for the envisaged wastes is as outlined in **Chapter Three**.

All wastes generated during the construction, operation and decommissioning phases shall be fully segregated and disposed of safely at designated locations by FMEnv, DPR and Edo State Ministry of Environments' accredited contractor in line with the VTT LNG West Africa Limited management procedure.

7.6.8 Hazardous Materials Handling

In keeping with the VTT LNG West Africa Limited HSE policy, this company shall ensure that:

- Material data sheets are readily available at site for all hazardous substances, including a short write up on ecological impacts (and mitigation) of accidental spills or incidents;
- Staff (including contractors' and casuals) handling hazardous materials shall be appropriately re-trained to be aware of the health and environmental implications.

7.7 Environmental Audit Programme

Prior to mobilization, an environmental audit shall be carried out and during project execution additional environmental audit shall be conducted. The environmental audit process shall be used to ensure that measures are put in place for ensuring sustainable development through enforcement of the necessary management procedures. The essence of the audit shall be to:

- determine compliance with regulatory requirements.
- inspect facility management systems, its operations, monitoring practices etc.
- identify current and potential environmental problems during the various phases of the project.
- ensure implementation of recommended practices and procedures.
- make recommendation(s) for the improvement of the management system of the project.

7.8 Implementation of the Mitigation Measures for Potential Impacts

Mitigation measures have been proposed for medium and high rated negative impacts. The measures represent VTT LNG West Africa Limited commitment to environmental protection and shall be incorporated into the project's HSE-MS document. The highlights of the mitigation measures proposed for the various expansion project activities are as discussed in **Chapter 6**.

7.9 Monitoring Programmes

In order to comply with regulatory requirements, monitoring programmes for biophysical, social and health aspects have been developed and these shall apply throughout the project lifecycle. Separate monitoring plans have been prepared for the associated potential impacts and cumulative impacts.

The monitoring of the ESMP implementation shall involve the other key statutory regulators (Edo State Ministry of Environment, the Department of Petroleum Resources and the Federal Ministry of Environment).

The environmental/social components and characteristics to be monitored are included in **Table 7.1.**

7.10 Environmental and Social Management Plan Implementation

In preparing this ESMP, VTT LNG West Africa Limited recognized that sound environmental management of the proposed project can only be guaranteed through the integration of provisions of the ESMP as an integral part of business quality management. To this end, the company shall enforce compliance by the project team on a daily basis throughout the duration of the project. The Project Manager shall be responsible for the implementation of the provisions of the ESMP while regular inspection of sites and facilities shall be undertaken by an Environmental Inspection Team (EIT) throughout the project duration.

Table 7.1: Environmental and Social Management Plan (ESMP) of the Mini-LNG Plant – Pre-Construction Phase

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
Mobilisation (transport) to site (equipment, personnel and construction modules)	Road and traffic accidents	H	VTT LNG WEST AFRICA LIMITED shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily	L	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • Involve VTT security in traffic control in traffic management • Defensive driving course for VTT and contractor drivers • First aid training of workforce and provision of first aid boxes				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	VTT LNG WEST AFRICA LIMITED shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction
	Impairment of air quality	M	VTT LNG WEST AFRICA LIMITED shall ensure: • Engine to comply with	L	Site inspection report Compliance	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.		monitoring report		
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practice on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodable soil				
Energy consumption	Impairment of air	M	VTT LNG WEST AFRICA LIMITED shall ensure that:	L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
(provision of energy for pre-construction activities))	quality		• there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used		Compliance monitoring report		
	Noise and vibration nuisance	M	VTT LNG WEST AFRICA LIMITED shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			in use; • soundproof electric power generators are engaged				
	Increased opportunity for business and employment	P	VTT LNG WEST AFRICA LIMITED shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P	Contract documents/ list of community members employed	VTT LNG West Africa Limited	Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
	Contamination of soil	M	VTT LNG WEST AFRICA LIMITED shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practise on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction
Site	Accelera	H		L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
Preparation – clearing, excavation and landscaping	tion of erosion		• VTT LNG WEST AFRICA LIMITED shall stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential • Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject		Compliance monitoring report		

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodible soil				
	Alteration of local topography	M	• Re-grading the sites, then replacing the layer of topsoil that was previously put. • Restoring the operational site by restoring the original profile of the topography and the soil • Strictly regulating heavy equipment traffic • Restricting the number of traffic lanes and limiting the	L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			movement of the machinery to the work site and to the marked access way				
	Alteration of soil profile	P	VTT LNG WEST AFRICA LIMITED shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the well	P	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			location and campsite mechanically using compactors to reduce erosion potential				
	Blockage of drainage pattern	M	VTT LNG WEST AFRICA LIMITED shall ensure that: • Strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction
	Contamination of soil	M	VTT LNG WEST AFRICA LIMITED shall: • Ensure that soil disturbance	L	Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			shall be kept to minimum required for operation and safety • Ensure that oil spill containment is provided to reduce oil spill from getting to the soil • Implement good housekeeping practice on-site. • Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimizes				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			perturbation to aquatic environment. • Avoid spills prohibiting refueling near waterway				
	Impairment of air quality	M	VTT LNG WEST AFRICA LIMITED shall ensure that: • only pre-mobbed equipment is used. • all equipment is controlled; • equipment engines are turned off when not in use • all construction equipment shall be in proper operating condition and fitted with factory standard silencing	L	Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			features if appropriate • it provides and enforces the use of PPE (e.g. nose masks and ear muffs) • it constructs sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			optimize the project's environmental performance. • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors. • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			and filtration equipment on conveyor transfer points to prevent the emission of dust;				
	Noise and vibration nuisance	M	VTT LNG WEST AFRICA LIMITED shall ensure that: • equipment is fitted with effective silencers; • there shall be regular maintenance of equipment. • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	Work site accidents	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	M			
	Security/ artificial light at night	L	VTT LNG WEST AFRICA LIMITED shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light.	L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged				
	Habitat Alteration	H	VTT LNG WEST AFRICA LIMITED shall: ▪ Use methods that minimizes perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway ▪ Minimize destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L	Site inspection report	VTT LNG West Africa Limited	During Pre-Construction

Table 7.2: Environmental and Social Management Plan (ESMP) of the Mini-LNG Plant– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Transport activities during construction	Road traffic accidents	H	VTT LNG WEST AFRICA LIMITED shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily	M	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	VTT LNG West Africa Limited/ FMEnv/Edo State Ministry of Environment/DPR	During Construction

			pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow-moving vehicles shall be scheduled during off peak periods • Involve VTT security in traffic control in traffic management • Defensive driving course for VTT and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles					

			• Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	VTT LNG WEST AFRICA LIMITED shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction
	Impairment of air quality – emission from trucks	M	VTT LNG WEST AFRICA LIMITED shall ensure: • Engine to comply with international standards for exhaust gases. • Maintenance of engines and exhaust gas check; Adoption of engine off policy at	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

			construction site • that nose masks and earmuffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance. • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the				

			generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust				
Excavation of land area	Loss of vegetal cover with possible impact on biodiversit	H	VTT LNG WEST AFRICA LIMITED shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

	y loss		▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refueling near waterway ▪ Minimize destruction or modification of the vegetation cover by ▪ Restoring vegetation at the end of the work				
	Impairment of air quality	H	VTT LNG WEST AFRICA LIMITED shall ensure: • there is regular maintenance of the engines. • engines are switched off when not in use • engines to comply with international standards for exhaust gases.	L	Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

			• Maintenance of engines and exhaust gas check; • that nose masks and earmuffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;				
	Noise and vibration nuisance	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • Machine engines are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DP	During Construction

			• regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines			R	
	Waste generation from excavated materials	M	VTT LNG WEST AFRICA LIMITED shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner.	L	Site inspection report Waste Management Policy/ tracking sheet report	VTT LNG West Africa Limited	During Construction

			• generation of all wastes are minimized as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion. • Reuse waste materials wherever possible and use designated disposal sites. • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and				

			construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided. • disposal of construction and related waste materials at designated and approved waste dump site. • waste management plan in road				

			planning and contract specifications is incorporated. • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws.				
	Burns/injuries from welding sparks	H	• VTT LNG WEST AFRICA LIMITED shall ensure that workers and visitors are properly kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet international standards	L	Site inspection report Daily Progress report	VTT LNG West Africa Limited	During Construction
	Exposure to welding flash	H	• VTT LNG WEST AFRICA LIMITED shall ensure that workers and visitors are properly kitted (appropriate	L	Site inspection report Daily Progress report	VTT LNG West Africa Limited	During Construction

			PPEs are used)				
	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Construction

	machinery		ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodible soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				
	Waste Management - The potential effects	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards,	L	Site inspection report Waste Management Policy/ Waste tracking sheet report	VTT LNG West Africa Limited	During Construction

	will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal		with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of wastewater and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full				

	methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		compliance with the national and local regulations. • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;				

Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilizing the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Construction

	Habitat alteration	M	VTT LNG WEST AFRICA LIMITED shall: • Implement good housekeeping practise on-site. • Store and handle hazardous waste in accordance to approved WMP. • VTT shall ensure the use of appropriate PPEs • VTT shall ensure that backfilling is followed by mechanical compaction so as to retain the original level and avoid alterations • VTT shall re-vegetate the soil with indigenous grasses, sedges etc to check incidence of flooding	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Construction

	Kidnapping of workers and visitors on site	H	• VTT LNG WEST AFRICA LIMITED shall ensure that both contractor and VTT personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the VTT Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of VTT police to strengthen security in the area • VTT shall ensure that a liaison to foster partnership with the community so as to	M	Daily/weekly security report	VTT LNG West Africa Limited	During Construction

			guarantee security for the project is established and sustained • In order to beef up security for the project, VTT shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • VTT shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized				
	Worksite accidents	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • workers and visitors are	M	Site inspection report	VTT LNG West Africa Limited	During Construction

			properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site				
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • VTT LNG WEST AFRICA LIMITED shall insure	L	Site inspection report	VTT LNG West Africa Limited	During Construction

			immunization of workforce against as appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • VTT LNG WEST AFRICA LIMITED shall assist the				

			activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan. • VTT LNG WEST AFRICA LIMITED shall ensure site clinic is provided to take care of minor illnesses for all construction workers				
Construction of interconnecting Pipeline	Temporary change in land use but land will be returned to its original use after completio	M	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

	n of works and subsequent sand filling		planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • New structures such as signboards, bill boards for the project shall be removed after construction. Those required such as direction or warning signs shall be properly placed.				
Water utilization for concrete-weight	Changes in surface hydrology from water utilization for	M	• Drilling of boreholes for water utilization for construction of concrete-weight	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

	construction						
Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Safe ventilation for storage of volatile materials shall be provided;	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

			• Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills				
	Hazardous waste generation from coating operations such as metals	H	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv and DPR standard at an approved disposal sites	L	Site inspection report Waste Management report Waste tracking records	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction
Construction of LNG	Waste water	H	• Disposal of water and waste products arising from the sites	L	Site inspection report	VTT LNG West Africa Limited/FMEnv/	During Construction

plant	management from construction - Inappropriate management can lead to contamination of surface and groundwater		via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance; • Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel; • Oil water separators and grease traps shall be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas. • Provide sanitation arrangements		Waste Management report Waste tracking records	Edo State Ministry of Environment/DPR	

			at work sites/facilities to avoid release of waste water and sewage to the environment. • Waste water shall be treated in line with an approved standard by DPR and FMEnv before of its release to the environment				
Commissioning and Site Demobilisation	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with	M	VTT LNG WEST AFRICA LIMITED shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline;	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Construction

	water.		and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state. • Disposal in each case shall be monitored by the appropriate regulatory bodies and VTT				
	Road	M	VTT LNG WEST AFRICA	L		VTT LNG West Africa Limited	Construction

	traffic accidents		LIMITED shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy		Inventory of approved journey management forms		

Table 7.3: Environmental and Social Management Plan (ESMP) of the Mini-LNG Plant – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigatio n	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Liquefied	Air Pollution (1)	H	VTT LNG WEST AFRICA LIMITED shall	L	Site inspection	VTT LNG	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Natural Gas operations and maintenance	Fugitive emissions in natural gas processing facilities are associated with leaks in tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits / containments, and		ensure: • Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: ○ Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during		report Compliance monitoring report Site inspection report	West Africa Limited/FM Env/Edo State Ministry of Environment /DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	loading and unloading operations of hydrocarbons.		filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); ○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			considering, for example, storage capacity and the vapor pressure of materials being stored. • Use of supply and return systems, vapor recovery hoses, and vapor-tight trucks / railcars / vessels during loading and unloading of transport vehicles; • Use of bottom-loading truck / rail car filling systems; and • Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.				
	Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Operation
	Air Pollution (3) Venting, flaring and greenhouse gases	H	VTT LNG WEST AFRICA LIMITED shall: • Optimize plant controls to increase the reaction conversion rates;	L	Site inspection report Compliance monitoring	VTT LNG West Africa Limited	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		• Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors and maintain the system to achieve high efficiency.		report		
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate, biocides	H	VTT LNG WEST AFRICA LIMITED shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also	L	Effluent report	VTT LNG West Africa Limited/FM Env/Edo State Ministry of Environment /DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	and anti-fouling agents		energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and • Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control				

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			plans, and route stormwater from process areas into the wastewater treatment unit				
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during depressurisation	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise • Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum	M	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Encourage the use PPEs				
	Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination	M	• Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			engineering measures. • Storing and handling of hazardous waste in accordance to approved WMP • Access to areas containing hazardous substances shall be restricted and controlled; • Hydrocarbon and hazardous materials shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv and DPR standard				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			in an approved site; • solid hazardous waste shall not be burned;				
	Discharge of hydrotest water from hydrostatic testing of equipment and pipeline with water. Chemical additives, oxygen scavenger, dye and corrosion inhibitor may be added for pipeline protection	H	VTT LNG WEST AFRICA LIMITED shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous	L	Site inspection report Compliance monitoring	VTT LNG West Africa Limited/FM Env/Edo State Ministry of	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations.;		report	Environment /DPR	
	Condensate spills or leaks from pipeline rupture	H	VTT LNG WEST AFRICA LIMITED shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and equipment; • Identification and location of existing gas and other buried utility infrastructure prior to excavation for	L	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			installation or repair of gas pipeline. Installation of visual marking of gas lines as part of installation, and updating as necessary on an ongoing basis; • Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of gas lines and components using sufficient separation distance and appropriate pipe protection layering to minimize potential interference with other				

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			underground infrastructure. Separation of plastic pipes from sources of heat; • Odorization of gas to facilitate detection of gas leakage; • Training of gas utility workers in procedures for emergency preparedness and response involving appropriate public authorities, in addition to emergency shutdown and • pressure reduction in the pipeline system.				
	Waste generation from the platform if they are to be manned. The	H	VTT LNG WEST AFRICA LIMITED shall ensure: • toilets are created at the site.	L	Site inspection report Compliance monitoring	VTT LNG West Africa Limited/FM Env/Edo State	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is expected to be minimal, poor disposal methods can lead to		• site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated		report Waste management report	Ministry of Environment /DPR	

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	environmental problems due to their non-biodegradable nature.		• Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector				
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	VTT LNG WEST AFRICA LIMITED shall ensure: • Provision of early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories;	M	Site inspection report Compliance monitoring report	VTT LNG West Africa Limited	During Operation

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
			• Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			facility and adjacent buildings, provision of additional cooling water capacity for adjacent tanks, or other risk based management approaches; and • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks;				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; ○ Designing the oily sewage system to avoid propagation of fire.				
	Air emission during Maintenance/servicing of production equipment and ancillaries	M	VTT LNG WEST AFRICA LIMITED shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones	L	Compliance monitoring report	VTT LNG West Africa Limited	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			• Experts and professional must always be used to handle any repairs of production equipment and ancillaries • VTT shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements and best practice using approved contractors • VTT LNG WEST AFRICA LIMITED shall ensure that none of these wastes are disposed into any water body or on land				
	Road and traffic				Compliance monitoring	VTT LNG	During

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	accidents as a result of transportation activities during facility operation	H	VTT LNG WEST AFRICA LIMITED shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	M	report	West Africa Limited/FM Env/Edo State Ministry of Environment /DPR	Operation

Table 7.4: Environmental and Social Management Plan (ESMP) of the Mini-LNG Plant –Operation/Maintenance (Abnormal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Emergencies	Air Pollution Loss of containment of gas due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	• Gas plant components, in addition to general installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Corrosion prevention of buried ferrous metal pipeline shall be undertaken using coating or cathodic protection techniques. For underground applications, the use of polyethylene pipe, which is not subject to corrosion, shall be	L	Compliance monitoring report/Emergency shut down	VTT LNG West Africa Limited/FMEnv/Edo State Ministry of Environment/DPR	During Operation

			considered as an alternative to ferrous metal pipeline materials; • Testing of interconnecting pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning. The system shall be gas tight when tested at a higher pressure than the normal maximum operation gas pressure; • Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken				

			as indicated by detection results. • Typical urban testing sites include atmospheres in confined spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on streets and walkways. Areas of gas infrastructure subject to forces from heavy load traffic or physical land shifts shall also be periodically monitored for leaks and ruptures; • Comparisons of purchased and delivered gas amounts shall be periodically examined for discrepancies and unaccounted for gas which may be an indicator				

			of excessive system leakage; • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults.				
	Air Pollution (2) Venting and greenhouse gases emission from the release of	H	VTT LNG WEST AFRICA LIMITED shall ensure that: • Optimize plant controls to increase the reaction conversion rates;	L	Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/Edo State Ministry of	During Operation

	unburnt methane, flaring of methane as a result of emergency or equipment failure		• Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors and maintain the system to achieve high efficiency.			Environment/DPR	
	Fire leading to impact on ecosystem	H	• Providing early release detection, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may	M	Facility inspection Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/Edo State Ministry of Environment/DPR	During Operation

			be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines). • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area				

			including secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; and ○ Designing the oily sewage system to avoid propagation of fire.				
	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	• Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. • The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the	M	Facility inspection Compliance monitoring report	VTT LNG West Africa Limited/FMEnv/Edo State Ministry of Environment/DPR	During Operation

			premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present. • Provision of manual firefighting equipment that is easily accessible and simple to use • Fire and emergency alarm systems that are both audible and visible • Permit to work system (PTW) shall be enforced				

Table 7.5: Environmental and Social Management Plan (ESMP) of the Mini-LNG Plant – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Demolition and Decommission	Interference with road transportation	M	• VTT shall monitor the no of trucks per day to know if there is need to create other accessible roads • VTT shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L	Inventory of approved journey management forms	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Decommissioning
	Noise and	M	VTT LNG WEST AFRICA LIMITED	L		VTT LNG West Africa Limited	During

	vibration nuisance		shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used		Compliance monitoring report	/FMEnv/Edo State Ministry of Environment/DPR	Decommissioning
	Impairment of air quality	H	VTT LNG WEST AFRICA LIMITED shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and earmuffs are	L	Compliance monitoring report	VTT LNG West Africa Limited /FMEnv/Edo State Ministry of Environment/DPR	During Decommissioning

			worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.				
	Contamination of surface and Groundwater & soil	M	VTT LNG WEST AFRICA LIMITED shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEV guidelines on waste management • Cleanup in compliance with relevant national and	L	Compliance monitoring report	VTT LNG West Africa Limited /FMEnv/Edo State Ministry of Environment/DPR	During Decommissioning

			international guidelines, involving the removal of the waste, etc • Restore the to a condition in no way inferior to the condition prior to the commencement of work.				
	Solid waste generation and impact on disposal facility	H	♦ VTT LNG WEST AFRICA LIMITED shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors ♦ VTT LNG WEST AFRICA LIMITED shall ensure that none of these wastes are disposed into any water body or on land ♦ follow safety measures while disposing wastes ♦ VTT LNG WEST AFRICA	L	Site inspection report Waste Management Policy/ tracking sheet	VTT LNG West Africa Limited /FMEnv/Edo State Ministry of Environment/DPR	During Decommissioning

			LIMITED shall keep all waste consignment, treatment and disposal records for regulatory verification ♦ Proper disposal of solid waste from labour camps; ♦ storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; ♦ sanitation arrangements at work sites/facilities to avoid release of waste water to the environment ♦ All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. ♦ There is minimum generation of waste				

			♦ Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; ♦ Reuse waste materials wherever possible ♦ Wastes shall be segregated, stored and disposed by an accredited state waste collector				
	Loss of job	H	VTT LNG WEST AFRICA LIMITED shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L	Contract documents/ list of community members employed	VTT LNG West Africa Limited /FMEnv/Edo State Ministry of Environment/DPR	During Decommissioning
	Injury/fatalities in workforce /communities	H	VTT LNG WEST AFRICA LIMITED shall • Ensure Safety awareness training for workforce	M	Progress/site inspection report	VTT LNG West Africa Limited	During Decommissioni

			• Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site			/FMEnv/Edo State Ministry of Environment/DPR	ng
	Third Party Agitation due to employment Issues and Loss of Benefits as Host Communities.	M	• Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L	Contract documents/ list of community members employed	VTT LNG West Africa Limited /FMEnv/Edo State Ministry of Environment/DPR	During Decommissioning
	Revegetation	P	• Restoring vegetation after decommissioning of facility	P	Site inspection and progress report	VTT LNG West Africa Limited/FMEnv/ Edo State Ministry of Environment/DPR	During Decommissioning

7.11 Environmental Monitoring Program and Auditing

In addition to the routine inspection, environmental monitoring and audits shall be carried out internally and externally by VTT LNG West Africa Limited to ensure compliance with regulatory requirements as well as its own HSE standards and policies. **Table 7.2** below presents the Monitoring Program. Audits to be conducted shall also cover the subcontractor. The audit shall be performed by competent persons and the results shall be communicated to the General Manager and management board of VTT LNG West Africa Limited. The audit shall include a review of compliance with the requirements of the ESMP and include, at minimum, the following:

- Completeness of HSE documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping. There shall be a cycle of audits into specific areas of the project such as waste management, and effectiveness of local content plans and discharge controls. The frequency of audits shall be risk based and shall vary with the stage of the project (more frequent during operation and in the early stages of the project and later part of the well life) and shall depend on the results of previous audits.

Table 7.6: Monitoring Program for the VTT LNG West Africa Limited Mini-LNG Plant

Monitoring Type	Monitoring Parameter	Measuring Frequency	Responsibility
Effluents and wastewater	pH, cations, anions, heavy metals, TDS, temperature, THC, BTEX, TPH, PAH, etc.	Weekly	HSE
Surface water	pH, Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*	Monthly	HSE
Ground water	Temperature, pH, Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol,	Monthly	HSE

Monitoring Type	Monitoring Parameter	Measuring Frequency	Responsibility
	Heavy metals, Total coliform and Faecal Coliform bacteria		
Rainwater	Volume, pH, TDS, acidity, alkalinity, colour, hardness, etc.	Monthly	
Sanitary sewage	Residual chlorine, pH, TSS, DO, BOD5, Total Coliform and Faecal coliform	During evacuation	HSE
Air quality	Particulate matter, C_XH_Y, SO_x, CO, VOC, NO_x, Noise, H_2S, NH_3.	Weekly	HSE
Biodiversity (Vegetation and wildlife)	Abundance and diversity of native plant and animal species, presence of exotic plant species.	2 year audit	HSE
Soil	Permeability, porosity, bulk density, texture (grain size), colour, pH, Anion, Cation and cation exchange capacity (CEC), THC, heavy metals, Soil capability, Total heterotrophic bacteria, fungi, Total hydrocarbon bacteria and fungi.	2 year audit	HSE
Demography	Population size and distribution, population density, dependency and sex ratio), marital status, educational attainment.	2 year audit	HSE/ CLO
Livelihood	Income distribution and consumption patterns, employment status, occupation, occupational mobility and adjustment, poverty profile, land use and tenure system, and other economic activities.	2 year audit	HSE/ CLO
Traffic	Vehicular volume count, origin and destination survey	2 year audit	HSE/ Logistics

Monitoring Type	Monitoring Parameter	Measuring Frequency	Responsibility
Healthcare facilities	Inventory of existing healthcare facilities and the types/ quality of services rendered; health programs available and their providers etc. Qualifications, experience and competence of local health professionals; availability of Medical Emergency Response Facilities	2 year audit	HSE/ Medic
Environmental health factors	Water supply, sanitation, housing, waste management practices and levels of radioactivity, pest/vector control	2 year audit	HSE/ CLO

7.11.1 Reporting

VTT LNG West Africa Limited shall keep regulatory authorities informed of the project performance with respect to HSE matters by way of written status reports and face-to-face meetings throughout the project. the VTT LNG West Africa Limited shall prepare a monthly report on environmental and social performance and submit same to relevant regulators. In addition to regular reporting, official notification shall be made to the government for any of the following:

- Significant modifications to this ESMP or the ESIA;
- Significant design, routing or implementation changes;
- Results of environmental monitoring;
- Community incidents; and
- Safety incidents or accidents.

VTT LNG West Africa Limited shall make accessible to government authorities, or provide upon request appropriate documentation of HSE related activities, including internal inspection records, training records, and reports. Subcontractors are also required to provide HSE performance reporting to the VTT LNG West Africa Limited on a regular basis through weekly and monthly reports.

7.11.2 Regulatory Oversight

Communications between the VTT LNG West Africa Limited management and government regulatory agencies shall be instituted through a variety of mechanisms, including written reports and memos, as well as informal and formal meetings. Meetings shall include regularly scheduled sessions as well as consultations. At the field level, formal meetings with government regulatory agency representatives shall be held as needed to discuss scheduling/planning issues, current areas of concern, and emerging HSE and socioeconomic issues.

At the management level, formal meetings are expected to be held, but on a less frequent basis. Informal meetings and communications shall also be held as necessary. With respect to formal meetings, the HSE Manager shall meet with government regulatory agency representatives to review HSE and socioeconomic performance based on the analysis of internal HS-EMS and field reports. These meetings can be expected to include discussion of upcoming work plans and coordination issues and resolution of problems that could not be adequately addressed at the field level. At the field level, government regulatory agency field representatives shall inform appropriate the VTT LNG West Africa Limited representatives if compliance concerns arise. At the management level, regularly scheduled meetings shall be held between HSE Mangers and the appropriate government regulatory agency representative to review HSE performance, areas of concern, and emerging issues.

7.12 Fiscal Plan for the EMP

To effectively implement the environmental management measures suggested as part of the EMP, estimated budget has been made as detailed in ***Table 7.7*** below.

Table 7.7: Budget for the EMP

Component	**Type**	**Monitoring Parameter**
Emissions	Flue gases, gas flaring	Carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and particulate matter (PM), Hydrogen sulphide (H_2S)
	Fugitive emission	H; CH_4; VOCs, PAHs; NH_3, CO, CO_2, SO_2 and SO_3,

Component	Type	Monitoring Parameter
		NOx, MTBE, ETBE, TAME, HF, and H_2S.
Budget	***₦4,500,000.00***	
Wastewater (Influent and effluent)	Process wastewater	Quantity, pH, Temperature, Heavy metals, TDS, Hydrocarbons (BTEX, TPH, PAH, THC), H_2S, NH_3, organic sulfur compounds (R-S-H mercaptans), organic acids, and phenol.
	Hydrostatic test fluid	Inhibitor, Ferrous, TDS, pH
	Sanitary sewage	Residual chlorine, pH, TSS, DO, BOD_5, Total Coliform and Faecal coliform
Budget	***₦3,500,000.00***	
Air quality and Nuisance	Nuisances	Noise level, odour, vibration, radiation
	Ambient air quality	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3, etc.
Budget	***₦1,500,000.00***	
Surface water	Rivers, streams, seasonal ponds, etc	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*
Ground water	Boreholes	Temperature, hydrocarbons (BTEX, TPH, PAH, THC), pH, Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.
Budget	***₦3,500,000.00***	

Component	Type	Monitoring Parameter
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey
Budget	***₦2,500,000.00***	
Safety and health		
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.
	Community health	Fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards
Budget	***₦7,000,000.00***	

CHAPTER EIGHT

DECOMMISSIONING AND ABANDONMENT PLANS

8.1 Introduction

Projects are usually designed with an expected lifespan and so, no matter how long the design life, all projects eventually close out. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. Appropriate provisions shall be made to cover the cost of decommissioning right from operational phase before the life span of the proposed plant.

The longevity of any development project is primarily dependent on a number of factors including:

- Availability of equipment and the servicing parts
- Durability of equipment and machinery
- Profitability of the project
- Usefulness and acceptability of end-product

The gas plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. **VTT LNG West Africa Limited** would need to decommission the entire system when this situation arises. While this is not expected to occur within the **next thirty years**, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment program

8.2 Decommissioning/ Abandonment Plan

VTT LNG West Africa Limited will follow the widely accepted decommissioning/abandonment process for Gas plant facilities as illustrated in **Figure 8.1.** Before abandonment, **VTT LNG West Africa Limited** will develop decommissioning plans for:

- Facilities to be abandoned or removed.
- Environmental aspects of the decommissioning activity.
- Methods for facility re-use, recycling, disposal, removal or abandonment.
- Proper consultation with all stakeholders (communities, other land users and regulators).
- Efforts to mitigate negative environmental impacts and appropriately rehabilitate the site.
- Programs for restoring the environment in accordance with national (FMEnv amd DPR) and international best-practices and regulatory requirements.
- Scope of work to assess possible residual impacts of the facility on the environment; specifically, any future restrictions on other activities.

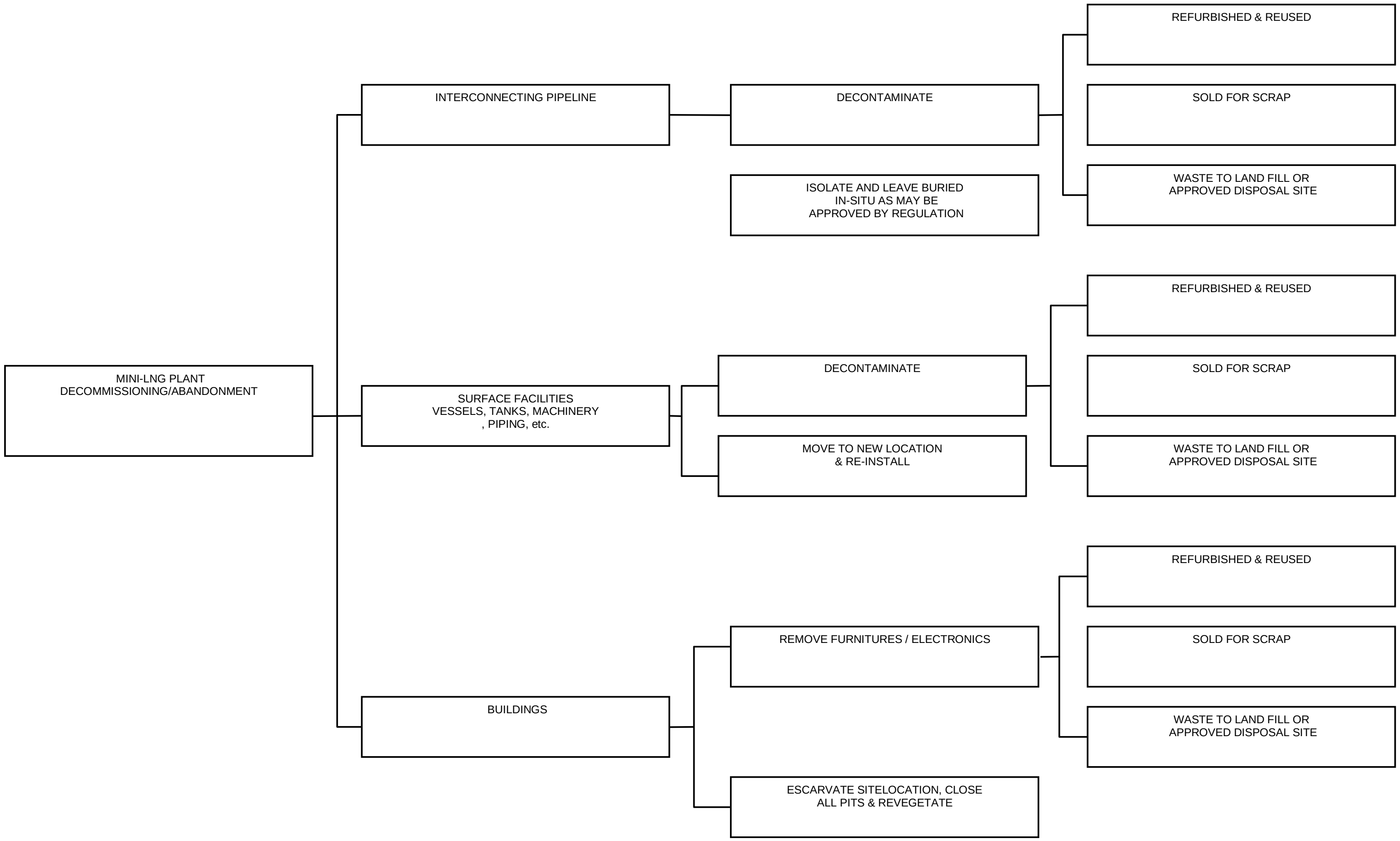


Figure 8.1: Typical Gas Plant Decommissioning/Abandonment Decision Tree

The content of the plan will take into consideration the extent of the decommissioning (temporary or permanent, partial or complete shutdown), plans for future use of the site, and the condition of the site and environment at the time of decommissioning. A detailed post-operational study of the impact of the project on the environment will be conducted to determine appropriate restoration and remedial measures.

At this stage, only preliminary plans exist for decommissioning and abandonment. In addition and upon commencement of production part of the revenue from the production will be set aside in an Escrow account to cover the cost of decommissioning and abandonment. Additional details will be developed as the project progresses. In general, however, decommissioning activities will be conducted in compliance with applicable regulations and guidelines, including FMEnv guidelines and DPR EGASPIN, Section VIII-G "Decommissioning of Oil and Gas Facilities", or any other regulations that are in force at the time of decommissioning. The plans will also include regulations and a risk and cost analysis of the various options. The abandonment plan will consider all facilities associated with the Project.

8.3 Decommissioning/ Abandonment Process

At the end of the facilities' utility, the facilities will be decommissioned as follows:

- Tanks, interconnecting pipeline, vessels, etc will be drained using a standard process for draining and entering of tanks, vessels, etc. As much liquid as possible would be pumped from the tanks and the remainder removed by vaporization. Re-entry of liquids into tanks will be achieved by isolating them.
- Interconnecting pipeline would also be isolated and purged, and the power supply for all motors and instrumentation locked out. Additionally, tanks may be warmed to prevent condensation on the tank surfaces and insulation and then purged with inert gas.
- All installed facilities on project sites will be adequately dismantled and removed to allow for proper remediation of the project site.
- The developer's Health Safety and Environmental Management Systems will be implemented to assure safety of personnel and the public during decommissioning as

well as minimize negative environmental impacts. Particular attention will be paid to the following:

- Protection from air pollutant emissions.
- Protection from noise.
- Waste handling.
- Spill containment and management.

- Once the facility has been properly and safely decommissioned, water and power supply lines would be disconnected and removed.
- All surface buildings and structures would be dismantled and removed from the site.
- Disturbed areas on the facility site will be identified and restored using appropriate plant species.
- All facility components that can be used or recycled will be identified and quantified.
- Buildings will either be sold or converted to other uses. Alternatively, the buildings may be donated to host communities.
- Vehicles and other facilities will be scrapped and/or moved to other locations.
- Cleared locations will be re-vegetated using fast growing native species.
- Contaminated environmental component attributable to project activities will be restored.

8.4 Remediation

This will entail:

1) A survey of the decommissioned site for contamination as part of a Conceptual Site Model and Strategy Plan;
2) Initial conclusions on the hydrology and geology;
3) Preparation of a Site Assessment Action Process Flow Sheet to be approved by FMEnv and also DPR as provided in ***Fig. VIII-F1 in EGASPIN;*** and
4) Interim action or remediation designed to confirm applicability and feasibility of one or more potential remedial options: such as application of dispersants or biological treatment using petroleum degrading bacteria or by aeration process.

Finally, the site shall be monitored for compliance and performance to confirm effectiveness to remedial measures. At the end of the site abandonment, the following useful documentations shall be reviewed:

1) The initial abandonment plan
2) The abandonment operations conducted in the project area, along with changes to plan necessitated by field conditions.
3) Toxicity test report carried out on all decommissioned items.

8.5 Reporting

As required by regulations, a post decommissioning report (PDR) will be prepared and submitted to the FMEnv and DPR. The report will provide the following details:

- Overview of decommissioned facilities.
- Details of methods used for decommissioning.
- Nature of decommissioning (partial or whole).
- Record of consultation meetings.
- Details of recyclable/reusable materials/facility components.
- Decontaminated facilities.
- Decommissioning Schedule.
- State of the surrounding environment.
- Waste Management Plan.
- Plans for restoration/remediation where necessary.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and ESMP that has been presented in earlier sections of this ESIA, it is therefore concluded that:

- The technology, equipment and facilities that is proposed to be employed in the proposed project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria;

- The comprehensive effluent and waste water treatment plants incorporated into the design of the Gas Plant system will ensure the complete treatment of effluent to regulatory requirements before discharging into the nearby stream or river.

- Apart from the buffer zone that shall be created in between the Gas Turbines and the other buildings, the engine rooms shall be adequately sound proofed to reduce noise in the office environment.

- The project will be attended with a number of positive impacts such as employment opportunities, increased power and gas supply and utilization, reduced cost of production, increase in income etc.

- A number of negative impacts have also been identified to be associated with the projects. Such impacts include, potential pollution of ambient air, water and soil, soil erosion, increase in noise, pressure on limited infrastructures, potential proliferation of STDs, potential etc. However, the mitigation measures recommended for this project if judiciously implemented will reduce some of the significant negative impacts to minor and negligible.

- The project will ensure more efficient utilization of natural gas, much of which is currently flared. Consequently, leading to reduction in health and environmental challenges associated with gas flaring.

- The ultimate success of this project and full actualization of improved power and gas supply to stakeholders around the project area and Nigeria in general is partly dependent on the desire to protect the power and gas supply facilities from possible vandals.

The ESIA report highlights the potential and associated adverse impacts of the project on the environment. With good management practice, the residual impacts shall be short-term, mostly localized and reversible on the environment. Also, some aspects of the project are expected to produce positive impacts on the socioeconomic environment. Measures to enhance the positive impacts were also recommended. Mitigation and enhancement measures were proffered for the identified negative and impacts of the project respectively. Also, an Environmental and Social Management Plan (ESMP) was developed to ensure that the identified potential impacts are reduced to “as low as reasonably practicable” (ALARP). Monitoring and audit programmes were recommended throughout the life span. This is to ensure that all impact indicators for the various environmental components are within statutory limits.

The ESIA shows that there is no potentially significant negative impact following application of mitigation measures. To this end, VTT LNG West Africa Limited hereby solicits approval of the project by FMEnv and DPR, while appropriate mitigation measures and post ESIA monitoring will be carried out following implementation.

9.2 Recommendations

VTT LNG West Africa Limited, has shown strong commitment to implementing this project in an environmentally friendly manner that will reduce associated negative impacts. Their reputation of having good relationship with the host communities anywhere and the best available technology the proponent is poised to deploy will no doubt enhance the successful implementation of the proposed gas plant project. Given the aforementioned, it is therefore recommended that:

- All project activities from the planning, construction to operational phases are carried out under the overall monitoring of the relevant environmental regulatory agencies.

- VTT LNG West Africa Limited, ensures its strict adherence to all specifications and standards for design and construction, mitigation measures and recommended ESMP in its implementation of this project.

- VTT LNG West Africa Limited maintains continuous consultations with all relevant stakeholders including the host communities.

- Mitigation measures prescribed in the report should be strictly followed by the proponent and all its contractors, while complying with regulatory guidelines and standards throughout the implementation of the proposed project.

- VTT LNG West Africa Limited should strictly implement and enforce all safety programs mentioned in this report especially as it relates to workers at all phases of the proposed project.

- Continuous implementation and improvement of the emergency response procedures should be strictly adhered to throughout the life cycle of the proposed project. As this one of the assured ways of entrenching best practices throughout the plants lifecycle.

- The Environmental and Social Management Plan (ESMP) designed for the project shall be implemented through the project life through construction, operation and decommissioning.

- The waste management plan shall be appropriately implemented, all personnel assigned to respective responsibilities shall also duly carry out their duties.

- An environmental-auditing of the site shall be carried out by competent third party in line with regulatory requirement when due.

- Environmental monitoring plan proposed in this report shall be implemented.

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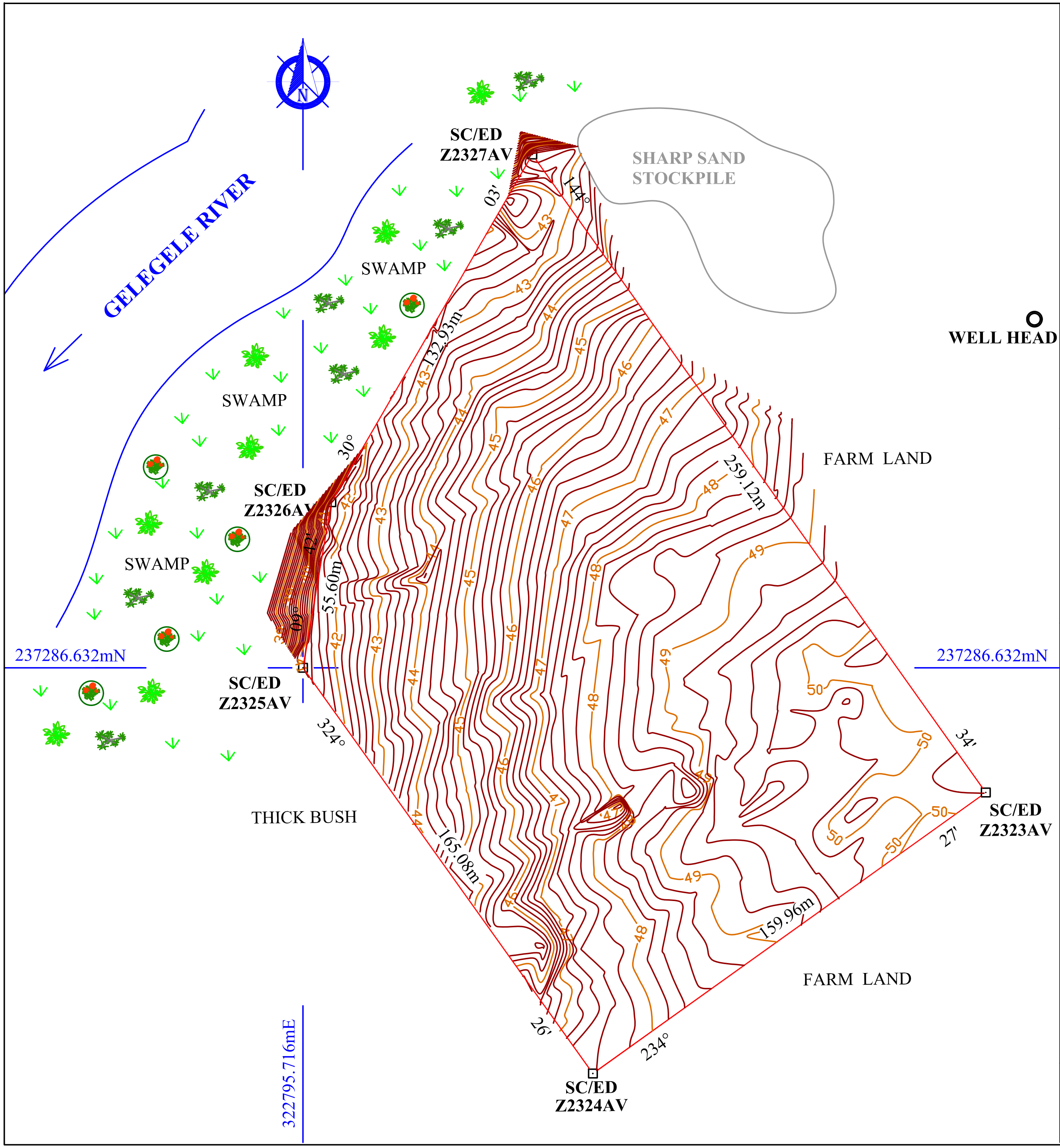
APPENDICES



PLAN SHEWING LANDED PROPERTY OF

VTT LNG WEST AFRICA LTD

AT GELEGELEGBENE COMMUNITY AREA
OVIA NORTH EAST LOCAL GOVERNMENT AREA
BENIN CITY, EDO STATE

ORIGIN : NATIONAL
AREA : 3.526 Hectare
SCALE 1:2000

40m 0 40 80m

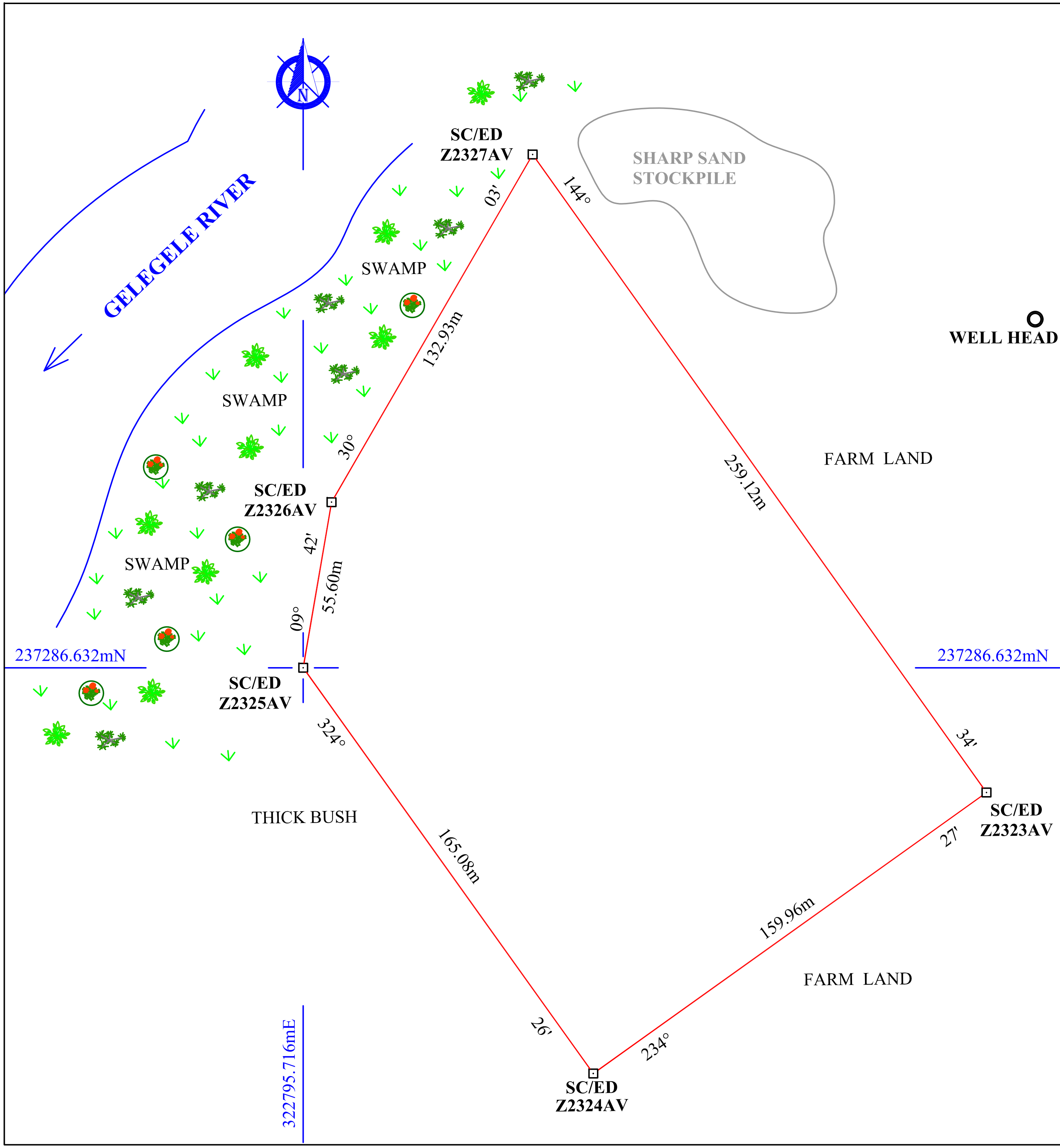
CONTOUR DRAWING

Total Points Used = 224
Minimum Elevation = 37.102
Maximum elevation = 50.373
Contour Intervals = 0.20m

CERTIFIED TRUE COPY 0F ORIGINAL
PLAN MADE BY ME ON 30/08/2019

....
SURV. VICTOR OKOROAFOR (MNIS, MSc.)
RAWDATA GEOGLOBAL SERVICES LTD
KM 2.5, EBO-ARUOGBA ROAD,
BY EBO SCHOOL ROAD JUNCTION, IYEKOGBA
BENIN CITY, EDO STATE.
E-MAIL: rawdatageo@gmail.com
Tel: 08035965509, 08084184767

PLAN No.: RAW / ED / 044C /19



PLAN SHEWING LANDED PROPERTY OF

VTT LNG WEST AFRICA LTD

AT GELEGELEGBENE COMMUNITY AREA
OVIA NORTH EAST LOCAL GOVERNMENT AREA
BENIN CITY, EDO STATE
ORIGIN : NATIONAL
AREA : 3.526 Hectare
SCALE 1:2000

PLAN DRAWING

CERTIFIED TRUE COPY 0F ORIGINAL
PLAN MADE BY ME ON 30/08/2019

....

SURV. VICTOR OKOROAFOR (MNIS, MSc.)
RAWDATA GEOGLOBAL SERVICES LTD
KM 2.5, EBO-ARUOGBA ROAD,
BY EBO SCHOOL ROAD JUNCTION, IYEKOGBA
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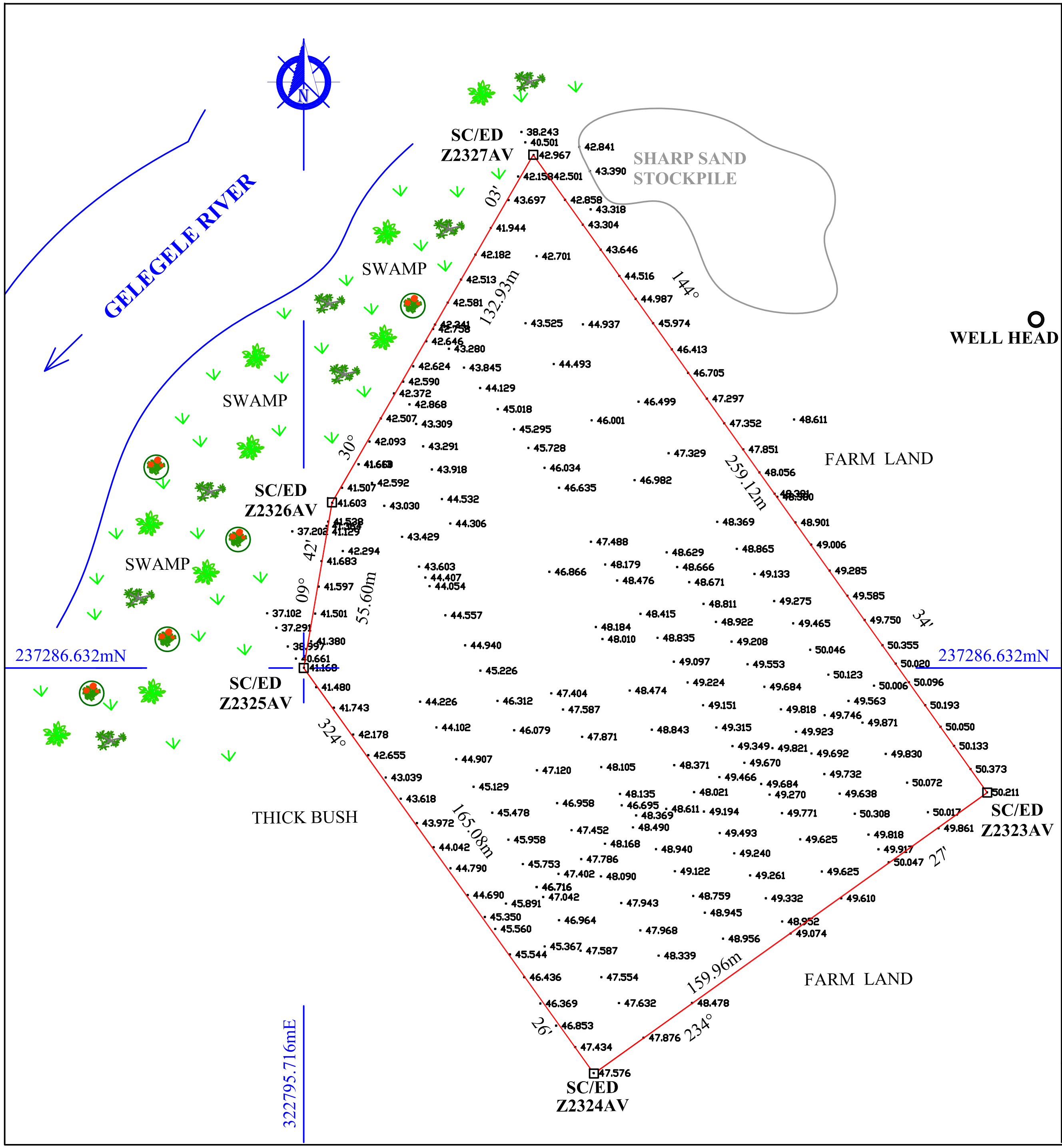
E-MAIL: rawdatageo@gmail.com
Tel: 08035965509, 08084184767

PLAN No.: RAW / ED / 044A /19



PLAN SHEWING LANDED PROPERTY OF

VTT LNG WEST AFRICA LTD

AT GELEGELEGBENE COMMUNITY AREA
OVIA NORTH EAST LOCAL GOVERNMENT AREA
BENIN CITY, EDO STATE
ORIGIN : NATIONAL
AREA : 3.526 Hectare
SCALE 1:2000

40m 0 40 80m

SPOT HEIGHT DRAWING

Total Points Used = 224
Minimum Elevation = 37.102
Maximum elevation = 50.373

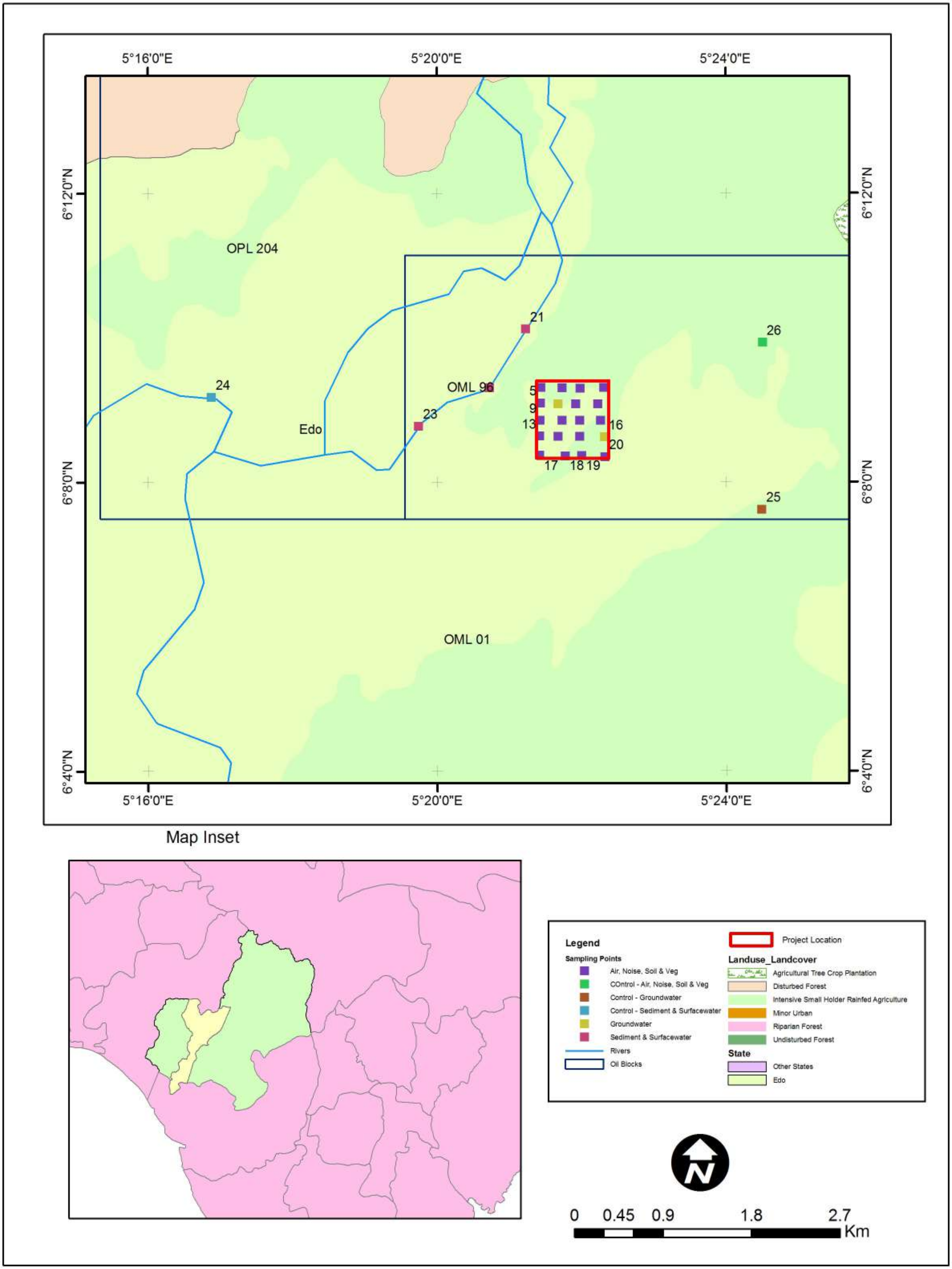
CERTIFIED TRUE COPY 0F ORIGINAL
PLAN MADE BY ME ON 30/08/2019

....

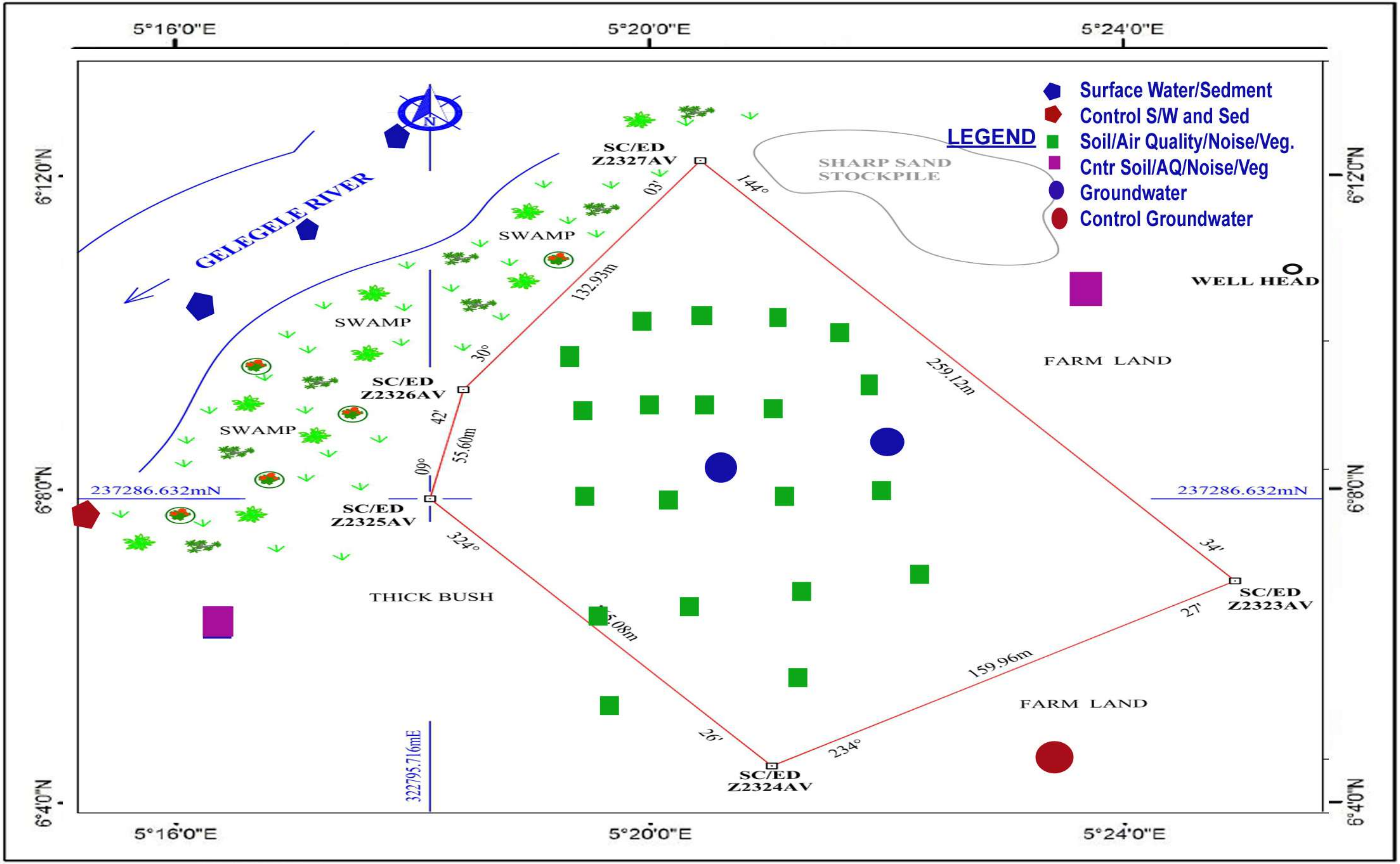
SURV. VICTOR OKOROAFOR (MNIS, MSc.)
RAWDATA GEOGLOBAL SERVICES LTD
KM 2.5, EBO-ARUOGBA ROAD,
BY EBO SCHOOL ROAD JUNCTION, IYEKOGBA
BENIN CITY, EDO STATE.
E-MAIL: rawdatageo@gmail.com
Tel: 08035965509, 08084184767

PLAN No.: RAW / ED / 044B /19

Appendix 4.1a-Sampling Map 1

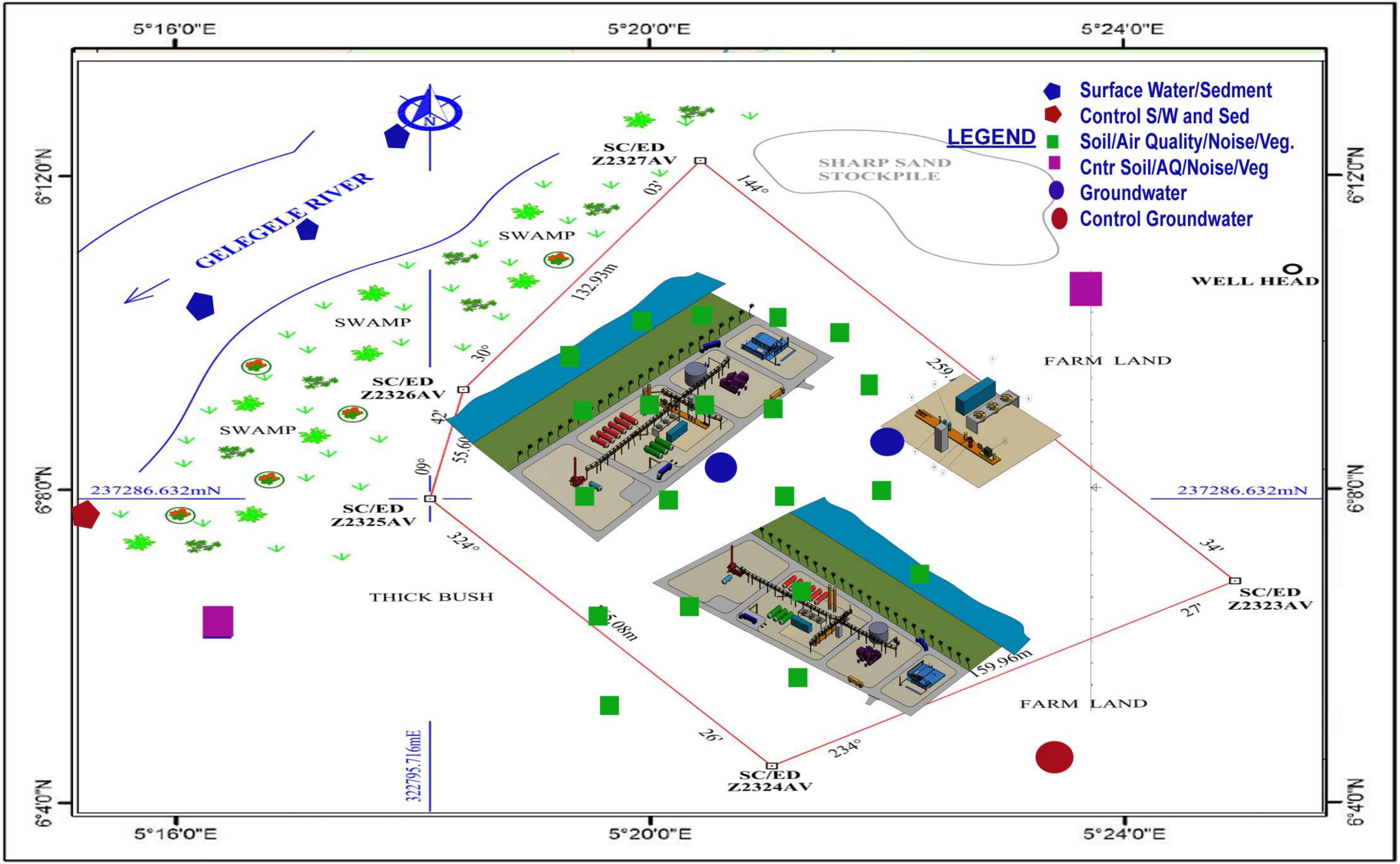

5°16'0"E
5°20'0"E
5°24'0"E
6°12'0"N
6°8'0"N
6°4'0"N
OPL 204
OML 96
Edo
OML 01
21
23
24
25
26
5
9
13
16
17
18
19
20
Map Inset
Legend
Sampling Points
Air, Noise, Soil & Veg
COntrol - Air, Noise, Soil & Veg
Control - Groundwater
Control - Sediment & Surfacewater
Groundwater
Sediment & Surfacewater
Rivers
Oil Blocks
Project Location
Landuse_Landcover
Agricultural Tree Crop Plantation
Disturbed Forest
Intensive Small Holder Rainfed Agriculture
Minor Urban
Riparian Forest
Undisturbed Forest
State
Other States
Edo
N
0
0.45
0.9
1.8
2.7
Km

Appendix 4.1B-Sampling Map 2



5°16'0"E
5°20'0"E
5°24'0"E
6°12'0"N
6°8'0"N
6°4'0"N
LEGEND
Surface Water/Sedment
Control S/W and Sed
Soil/Air Quality/Noise/Veg.
Cntr Soil/AQ/Noise/Veg
Groundwater
Control Groundwater
GELEGELE RIVER
SWAMP
SWAMP
SWAMP
SHARP SAND STOCKPILE
WELL HEAD
FARM LAND
FARM LAND
THICK BUSH
SC/ED Z2327AV
SC/ED Z2326AV
SC/ED Z2325AV
SC/ED Z2324AV
SC/ED Z2323AV
132.93m
55.60m
259.12m
159.96m
237286.632mN
237286.632mN
322795.716mE
144°
324°
234°

Appendix 4.1C-Sampling Map 3


5°16'0"E
5°20'0"E
5°24'0"E
6°12'0"N
6°8'0"N
6°4'0"N
LEGEND
Surface Water/Sedment
Control S/W and Sed
Soil/Air Quality/Noise/Veg.
Cntr Soil/AQ/Noise/Veg
Groundwater
Control Groundwater
GELEGELE RIVER
SWAMP
SWAMP
SWAMP
SHARP SAND STOCKPILE
WELL HEAD
FARM LAND
FARM LAND
THICK BUSH
SC/ED Z2327AV
SC/ED Z2326AV
SC/ED Z2325AV
SC/ED Z2324AV
SC/ED Z2323AV
132.93m
55.60
159.96m
144°
324°
234°
237286.632mN
237286.632mN
322795.716mE

APPENDIX 4.2A

AIR QUALITY, NOISE LEVEL AND MACROCLIMATIC CONDIRION OF VTT PROPOSED LNG FACILITY (DRY SEASON)

S/N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates										Noise dB(A)		Microclimates			
		N	E	SOx (ppm)	VOC (ppm)	NOx (ppm	NH_3 (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	CO_3 (ppm)	SPM $_{(10)}$ (ug/dm^3	SPM $_{(2.5)}$ (ug/dm^3)	Min	Max	Temp (ºC)	RH (%)	WS (m/s)	WD
1	AQ1	6.14742	5.3329	0.0	315	0.00		0.6	0.0		0.05	78.9	67.2	41.1	63.2	33.4	64.2	0.0	
2	AQ2	6.14751	5.33347	0.0	359	0.012		0.3	0.0		0.05	95.3	81.0	43.1	72.4	32.8	60.8	0.0	
3	AQ3	6.14771	5.33291	0.0	267	0.00		0.5	0.0		0.05	136.1	83.0	52.0	69.3	31.7	64.5	0.0	
4	AQ4	6.14722	5.33296	0.0	234	0.00		0.5	0.0		0.06	102.1	82.9	44.6	71.3	32.9	63.2	1.0	
5	AQ5	6.14745	5.33229	0.0	333	0.00		0.7	0.0		0.05	94.0	69.3	43.2	70.9	36.4	50.2	0.0	
6	AQ6	6.14773	5.33263	0.0	193	0.014		0.5	0.0		0.03	82.6	70.0	50.2	76.8	37.9	43.3	0.0	
7	AQ7	6.14724	5.33282	0.0	205	0.00		0.3	0.0		0.05	85.5	76.7	33.1	72.5	36.6	48.9	0.0	
8	AQ8	6.14690	5.33299	0.0	211	0.016		65	0.0		0.06	89.8	64.8	39.8	66/8	35.1	52.5	1.7	
9	AQ9	6.14772	5.33621	0.0	227	0.00		0.6	0.0		0.03	91.3	69.5	45.3	75.9	35.3	49.4	1.8	
10	AQ10	6.14693	5.33897	0.0	273	0.012		05	0.0		0.05	112.2	88.6	39.3	72.8	35.1	49.1	0.0	
11	AQ11	6.14742	5.33233	0.0	265	0.00		0.5	0.0		0.05	75.7	62.4	42.7	69.6	35.7	47.6	2.5	
12	AQ12	6.14769	5.33388	0.0	285	0.014		0.3	0.0		0.03	85.8	68.3	55.3	72.8	35.4	48.2	1.8	
13	AQ13	6.14788	5.33205	0.0	293	0.012		0.6	0.0		0.05	100.8	64.3	42.5	63.8	36.8	45.6	0.0	
14	AQ14	6.14756	5.33296	0.0	276	0.00		0.5	0.0		0.05	98.2	66.0	40.4	72.4	37.6	45.0	0.0	
15	AQ15	6.14789	5.33182	0.0	237	0.00		0.7	0.0		0.06	78.0	63.6	45.8	64.5	38.7	43.6	1.8	
16	AQ16	6.14762	5.33206	0.0	241	0.0		0.1	0.0		0.05	109.8	66.7	54.8	61.4	39.0	40.0	0.0	
17	AQ17	6.14747	5.33199	0.0	235	0.0		0.0	0.0		0.07	77.6	66.4	38.1	75.0	39.2	40.7	0.0	
18	AQ18	6.14774	5.33178	0.0	226	0.0		0.3	0.0		0.05	100.9	70.7	44.3	62.6	37.0	46.2	1.5	
19	AQ19	6.14782	5.33224	0.0	256	0.0		0.3	0.0		0.05	102.4	68.3	39.8	67.5	37.3	46.4	1.8	
20	AQ20	6.14697	5.33336	0.0	226	0.0		0.0	0.0		0.06	66.4	60.9	41.5	67.8	36.4	44.4	2.3	

S/N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates										Noise dB(A)		Microclimates			
21	AQ21	6.14673	5.33382	0.0	238	0.0		0.1	0.0		0.03	77.7	67.7	46.2	73.6	34.8	54.3	0.0	
22	AQ22	6.14653	5.33303	0.0	231	0.0		0.5	0.0		0.05	86.9	69.1	48.0	64.1	35.1	53.1	0.0	
23	CTRL1	6.15578	5.34489	0.0	308	0.0		0.5	0.0		0.03	137.7	73.9	49.2	67.8	37.7	41.6	2.6	
24	CTRL2	6.15578	5.34243	0.0	217	0.0		0.2	0.0		0.04	85.7	68.1	46.7	80.2	37.4	39.4	2.0	
25	CTRL3	6.15026	5.34243	0.0	191	0.0		0.2	0.0		0.07	86.3	67.1	43.5	67.6	37.3	40.5	0.2	
26																			
27																			
28																			
29																			
30																			

APPENDIX 4.2B

AIR QUALITY, NOISE LEVEL AND MACROCLIMATIC CONDIRION OF VTT PROPOSED LNG FACILITY (WET SEASON)

S/ N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates										Noise dB(A)		Microclimates			
		N	E	SO2 (ppm)	VOC (ppm)	NOx (ppm	NH_3 (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	CO_3 (ppm)	SPM $_{(10)}$ (ug/dm^3	SPM $_{(2.5)}$ (ug/dm^3)	Min	Max	Temp (ºC)	RH (%)	WS (m/s)	WD
1	AQ1	6..15599	5.33156	0.3	435	0.093		0.0	0.0		0.05	17.8	18.3	54.7		38.2	500.6	0.0	
2	AQ2	6.14769	5.3316	0.1	323	0.081		0.0	2.0		0.05	20.1	20.7	35.9		36.3	60.8	0.0	
3	AQ3	6.14735	5.3365	0.1	195	0.063		0.0	0.90		0.05	21.6	22.4	44.2		36.6	57.1	0.0	
4	AQ4	6.1489	5.3396	0.1	311	0.064		0.0	0.0		0.06	20.8	28.7	44.8		36.1	63.3	0.8	
5	AQ5	6.14764	5.3317	0.0	155	0.028		0.0	0.0		0.05	20.0	20.6	45.0		34.7	70.0	0.0	
6	AQ6	6.14730	5.33146	0.1	133	0.042		0.0	0.0		0.03	18.5	19.3	47.6		34.9	76.4	0.5	
7	AQ7	6.14736	5.3397	0.0	217	0.049		0.0	0.0		0.05	17.9	18.6	42.6		34.8	71.2	0.3	
8	AQ8	6.14737	5.3447	0.0	115	0.031		0.0	0.0		0.06	19.5	25.1	38.2		33.3	74.1	0.0	
9	AQ9	6.1398	5.3314	0.0	101	0.046		0.0	0.7		0.03	18.9	19.7	46.1		33.8	70.8	0.5	
10	AQ10	6.1397	5.3365	0.1	92	0.092		0.0	0.0		0.05	20.5	21.3	44.6		34.2	76.2	0.0	
11	AQ11	6.1398	5.3406	0.0	121	0..047		0.0	0.9		0.05	20.3	28.9	39.7		33.5	71.6	0.0	
12	AQ12	6.1392	5.3453	0.0	113	0.031		0.0	0.0		0.03	21.4	22.8	39.3		37.2	77.4	0.2	
13	AQ13	6.1362	5.3313	0.1	110	0.057		0.0	0.0		0.05	20.3	24.3	42.2		35.4	70.6	0.0	
14	AQ14	6.1361	5.3355	0.1	106	0,065		0.0	0.0		0.05	20.8	21.7	46.1		35.8	65.2	0.1	
15	AQ15	6.1361	5.3406	0.0	92	0.083		0.0	0.0		0.06	18.8	24.1	57.1		34.9	49.2	0.7	
16	AQ16	6.1360	5.3463	0.0	110	0.123		0.0	0.0			21.3	33.8	33.2	51.3	34.9	70.2	0.0	
17	AQ17	6.1318	5.3313	0.0	115	0.110		0.1	0.0			23.4	52.1	46.1	53.7	34.8	71.3	0.1	
18	AQ18	6.14677	5.33379	0.1	118	0.020		0.0	0.0			20.1	25.6	20.7	25.2	35.1	70.5	0.4	
19	AQ19	6.1316	5.3410	0.0	112	0.114		0.0	0.0			22.3	28.9	38.1	50.7	34.9	71.6	0.3	
20	AQ20	6.13142	5.3463	0.0	92	0.101		0.0	0.0			21.5	24.8	42.5	53.9	34.7	70.8	0.1	

S/N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates										Noise dB(A)		Microclimates			
21	AQ21	6.15403	5.3454	0.1	110	0.121		0.1	0.0			20.3	23.6	40.3	56.1	35.2	71.4	0.2	
22	AQ22	6.15018	5.3352	0.0	108	0.085		0.0	0.0			18.8	20.6	41.2	62.8	36.9	58.7	0.1	
23	AQ32	6.17194	5.3328	0.0	108	0.094		0.0	0.0			21.8	27.6	43.0	51.5	34.2	62.8	0.1	
24	Ctrl1	6.15011	5.312333	0.1	100	0.111		0.0	0.0			17.6	18.0	39.7	58.8	32.4	64.5	0.4	
25	Ctrl2	6.17194	5.3577	0.0	110	0.120		0.0	0.0			18.1	18.8	40.1	46.7	32.7	58.6	1.5	
26																			
27																			
28																			
29																			
30																			
31																			
32																			

Appendix 4.3-Wet Season VTT Result

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE FIELD
DATE OF SAMPLE RECEIVED: 16/11/2019
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *SURFACE WATER*
NUMBER OF SAMPLE: *5*

FIELD CODE	pH	E/COND (µS/cm)	Temp. (^oC)	Redox Potential (mV)	TDS (mg/l)	Colour (Pt-Co)	Alkalinity (mg/L as $CaCO_3$)
Surface Water 1 /UPSTREAM	6.76	137	26.20	202	75.35	12	20.0
Surface Water 2 /MIDSTREAM	6.71	136	26.70	145	74.80	9	12.0
Surface Water 3 /DOWNSTREAM	6.62	133	26.30	177	73.15	14	10.0
Surface Water C1	7.00	134	26.80	193	73.70	6	8.0
Surface Water C2	6.78	138	26.50	213	75.90	8	12.0

HEAVY METALS

FIELD CODE	Fe (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Cu (mg/l)	Hg (mg/l)	Ni (mg/l)
Surface Water 1 /UPSTREAM	0.776	<0.001	<0.001	0.550	0.012	<0.001	<0.001
Surface Water 2 /MIDSTREAM	0.680	<0.001	0.002	0.510	0.009	<0.001	<0.001
Surface Water 3 /DOWNSTREAM	0.324	0.006	0.004	0.560	0.015	<0.001	<0.001
Surface Water C1	0.608	0.013	<0.001	0.390	0.008	<0.001	<0.001
Surface Water C2	0.315	<0.001	<0.001	0.340	0.004	<0.001	<0.001

MICROBIOLOGY

FIELD CODE	THB (cfu/ml)	THF (cfu/ml)	HUB (cfu/ml)	HUF (cfu/ml)	Faecal Coliform MPN/100ml
Surface Water 1 /UPSTREAM	3.0×10^4	5.0×10^3	2.8×10^2	1.7×10^1	90
Surface Water 2 /MIDSTREAM	6.6×10^4	2.1×10^3	4.3×10^2	0.8×10^1	62
Surface Water 3 /DOWNSTREAM	5.6×10^4	1.8×10^3	1.4×10^2	2.0×10^1	82
Surface Water C1	6.4×10^4	1.2×10^2	1.2×10^2	0.5×10^1	60
Surface Water C2	5.0×10^4	1.3×10^3	1.0×10^2	1.0×10^1	72

The predomin
Bacillus, Pseu

Predominant
Penicillium a

SURFACE WATER HYDROCARBON RESULTS

COMPONENT	Surface water Upstream 1	Surface water Midstream 2	Surface water Downstream 3	Surface water Control 1	Surface water Control 2
TPH (mg/l)	0.791	0.682	0.955	0.385	0.221
PAH (mg/l)	BDL	BDL	BDL	BDL	BDL
Benzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Tolune (mg/l)	BDL	BDL	BDL	BDL	BDL
Ethylbenzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Xylene (mg/l)	BDL	BDL	BDL	BDL	BDL
BDL = Below Detection Limit					

OML 96

Chloride (mg/l)	TSS (mg/l)	Total Hardness (mg/L as $CaCO_3$)	DO (mg/l)	Turbidity (NTU)	BOD_5 (mg/l)	COD (mg/l)	O & G (mg/l)	THC (mg/l)	Carbonate (mg/l)
55.98	1.26	13.0	8.7	3.2	5.4	24.13	1.58	1.16	0.0
54.48	2.08	17.0	8.8	3.8	5.7	26.26	1.20	0.88	0.0
51.98	2.21	17.0	8.6	4.1	4.5	20.10	2.02	1.30	0.0
51.48	1.52	13.0	9.4	3.0	3.6	15.60	1.12	0.80	0.0
54.98	1.89	18.0	9.5	3.4	3.3	20.67	1.20	0.64	0.0

V (mg/l)	Zn (mg/l)	Ba (mg/l)	Mn (mg/l)
<0.001	0.122	<0.001	0.150
<0.001	0.126	<0.001	0.093
<0.001	0.103	<0.001	0.146
<0.001	0.129	<0.001	0.136
<0.001	0.102	<0.001	0.065

ıant genera of bacteria isolated from the surface water of the study area were ıdomonas, E.coli, coliforms and Staphylococcus.

fungal genera in surface water from the study area are ıd Aspergillus.

Phosphate (mg/l)	**Ammonium** (mg/l)	**Nitrate** (mg/l)	**Salinity** (ppt)	**Sulphate** (mg/l)	**Na** (mg/l)	**K** (mg/l)	**Mg** (mg/l)	**Ca** (mg/l)
0.10	0.08	0.23	0.07	4.256	19.90	0.44	2.02	5.83
0.11	0.08	0.21	0.07	3.655	18.74	0.20	1.94	6.30
0.15	0.10	0.18	0.06	4.256	18.28	0.31	1.48	5.55
0.10	0.05	0.16	0.06	4.737	15.93	0.18	2.35	5.93
0.11	0.06	0.14	0.07	4.136	18.00	0.47	1.50	6.03

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGEI
DATE OF SAMPLE RECEIVED: 16/11/2019
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *SEDIMENT*
NUMBER OF SAMPLE: *5*

PHYSICO-CHEMISTRY

S/N	FIELD CODE	pH	Electrical Conductivity µs/cm	Redox Potential mV	Chloride mg/kg	Sulphate mg/kg	TOC %
1	Sediment 1/ Upstream	6.72	413	72	88.63	92.71	4.68
2	Sediment 2/ Midstream	7.25	37	68	7.09	5.01	0.12
3	Sediment 3/ Downstream	6.82	130	57	17.73	20.96	0.35
4	Sediment Control 1	7.10	32	71	7.09	2.36	0.23
5	Sediment Control 2	6.99	338	72	70.90	71.45	6.32

HEAVY METALS

S/N	FIELD CODE	Fe mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Cr mg/kg	Hg mg/kg
1	Sediment 1/ Upstream	872	0.70	1.50	2.40	0.26	<0.001
2	Sediment 2/ Midstream	1048	1.05	1.20	3.65	0.32	<0.001
3	Sediment 3/ Downstream	1418	1.25	1.80	4.40	0.14	<0.001
4	Sediment Control 1	326	0.25	0.90	0.80	0.18	<0.001
5	Sediment Control 2	279	0.50	1.00	1.15	<0.001	<0.001

MICROBIOLOGY

S/N	FIELD CODE	THB (cfu/g)	THF (cfu/g)	HUB (cfu/g)	HUF (cfu/g)	SRB (cfu/g)
1	Sediment 1/ Upstream	10.3×10^4	6.8×10^3	5.3×10^2	1.0×10^2	Nil
2	Sediment 2/ Midstream	9.7×10^4	3.0×10^2	2.7×10^2	4.2×10^2	Nil
3	Sediment 3/ Downstream	12.2×10^4	7.9×10^3	4.1×10^2	2.0×10^2	Nil
4	Sediment Control 1	9.7×10^4	3.6×10^3	3.4×10^2	0.8×10^2	Nil
5	Sediment Control 2	3.8×10^4	2.0×10^3	1.3×10^2	0.5×10^2	Nil

The predominant genera of bacteria isolated from the sediment of the study area were
Bacillus spp, Pseudomonas spp., Enterobacter spp

Predominant fungal genera in sediment from the study area are
Mucor spp., Candida spp., Aspergillus spp., penicillium spp.

.E FIELD OML 96

Phenols mg/kg	Carbonate mg/kg	Nitrate mg/kg	THC mg/kg	Colour munsell color chart	PARTICLE SIZE % TOTAL SAND	% TOTAL SILT	% TOTAL CLAY	TEXTURE
<0.001	0.00	4.86	1.78	Dark Grey	45	34	21	LOAM
<0.001	0.00	2.21	0.43	Grey	95	0	5	SAND
<0.001	0.00	3.32	0.93	Grey	70	16	14	SANDY LOAM
<0.001	0.00	2.88	0.60	Grey	99	0	1	SAND
<0.001	0.00	5.53	2.12	Dark Grey	18	46	36	ILTY CLAY LOAN

Ni mg/kg	Mn mg/kg	V mg/kg	Zn mg/kg	Ba mg/kg	K meq/100g	Mg meq/100g	Ca meq/100g	Na meq/100g
1.23	16.28	<0.001	8.24	0.74	0.56	2.22	4.47	0.40
0.85	14.04	<0.001	10.20	0.32	0.38	1.43	2.07	0.74
0.94	55.80	<0.001	25.14	0.63	0.49	2.05	4.42	0.74
<0.001	4.36	<0.001	7.93	0.17	0.13	1.00	2.64	0.48
<0.001	6.200	<0.001	12.53	0.20	0.83	3.89	2.08	1.15

HYDROCARBONS

FIELD CODE	TPH (mg/kg)	PAH (mg/kg)	BTEX (mg/kg)
VTT/EIA/SS1T	1.341	0.06	BDL
VTT/EIA/SS1I	0.324	0.03	BDL
VTT/EIA/SS2T	0.502	0.11	BDL
VTT/EIA/SS2I	0.452	BDL	BDL
VTT/EIA/SS3T	1.097	0.04	BDL

BDL = Below Detection Limit of 0.01

NAME OF CLIENT: *VTT LNG*

PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE

DATE DATE OF SAMPLE RECEIVED: 16/11/2019

PERI(PERIOD OF ANALYSIS: *17th November - 16th December, 2019*

SAMPLE MATRIX: *SOIL*

NUMBER OF SAMPLE: *44*

PHYSICO-CHEMISTRY

S/N	FIELD CODE	pH	Electrical Conductivity µs/cm	Chloride mg/kg	Sulphate mg/kg	TOC %	Total Phosphorous %	Ammonium mg/kg
1	VTT/EIA/SS1T	6.52	265	53.18	71.45	4.37	0.013	3.36
2	VTT/EIA/SS1B	6.64	268	70.90	74.11	2.30	0.010	2.58
3	VTT/EIA/SS2T	6.43	43	3.55	2.36	0.74	0.009	2.06
4	VTT/EIA/SS2B	6.24	57	7.09	5.01	0.59	0.007	1.80
5	VTT/EIA/SS3T	6.37	72	10.64	7.67	1.01	0.010	2.84
6	VTT/EIA/SS3B	6.33	42	3.55	2.36	0.86	0.008	2.32
7	VTT/EIA/SS4T	6.25	206	35.45	60.82	1.95	0.016	4.12
8	VTT/EIA/SS4B	6.29	153	28.36	42.22	1.44	0.013	3.62
9	VTT/EIA/SS5T	6.35	163	31.91	58.16	1.52	0.011	3.10
10	VTT/EIA/SS5B	6.25	84	7.09	10.33	0.90	0.008	2.58
11	VTT/EIA/SS6T	6.22	38	3.55	2.36	1.64	0.016	4.12
12	VTT/EIA/SS6B	6.24	88	10.64	10.33	1.09	0.014	3.88
13	VTT/EIA/SS7T	6.42	242	35.45	68.79	3.35	0.018	4.64
14	VTT/EIA/SS7B	6.54	224	31.91	66.14	3.12	0.016	4.12
15	VTT/EIA/SS8T	6.65	292	70.90	76.77	1.21	0.009	2.58
16	VTT/EIA/SS8B	6.32	173	28.36	58.16	0.90	0.007	2.06
17	VTT/EIA/SS9T	6.92	326	88.63	87.40	2.73	0.013	3.36
18	VTT/EIA/SS9B	6.73	205	35.45	60.82	1.40	0.009	2.32
19	VTT/EIA/SS10T	6.50	282	70.90	76.77	2.65	0.012	3.62

20	VTT/EIA/SS10B	6.80	192	28.36	58.16	1.72	0.011	3.10
21	VTT/EIA/SS11T	6.10	35	3.55	2.36	0.66	0.008	2.58
22	VTT/EIA/SS11B	6.40	52	7.09	5.01	0.55	0.007	2.06
23	VTT/EIA/SS12T	6.50	41	3.55	2.36	0.20	0.006	1.80
24	VTT/EIA/SS12B	6.40	43	3.55	7.67	0.04	0.005	1.54
25	VTT/EIA/SS13T	6.50	70	7.09	5.01	1.17	0.010	2.84
26	VTT/EIA/SS13B	6.51	58	3.55	58.16	0.78	0.008	3.10
27	VTT/EIA/SS14T	6.49	215	28.36	10.33	2.22	0.016	3.88
28	VTT/EIA/SS14B	6.55	81	7.09	31.59	1.68	0.013	3.62
29	VTT/EIA/SS15T	6.71	127	24.82	10.33	1.40	0.009	2.84
30	VTT/EIA/SS15B	6.66	94	10.64	34.25	0.70	0.007	2.32
31	VTT/EIA/SS16T	6.72	145	24.82	10.33	1.76	0.008	2.58
32	VTT/EIA/SS16B	6.66	103	10.64	55.51	1.76	0.008	2.84
33	VTT/EIA/SS17T	6.60	163	28.36	34.25	2.46	0.014	3.88
34	VTT/EIA/SS17B	6.63	141	24.82	31.59	1.99	0.011	3.36
35	VTT/EIA/SS18T	6.60	133	21.27	10.33	2.38	0.009	3.10
36	VTT/EIA/SS18B	6.72	106	10.64	2.36	1.68	0.008	2.58
37	VTT/EIA/SS19T	7.20	48	3.55	68.79	1.09	0.011	3.36
38	VTT/EIA/SS19B	7.10	241	35.45	71.45	0.90	0.007	2.84
39	VTT/EIA/SS20T	7.12	250	53.18	66.14	2.22	0.011	3.62
40	VTT/EIA/SS20B	6.88	230	35.45	60.82	1.72	0.010	3.10
41	VTT/EIA/SSC1T	7.30	212	31.91	74.82	1.95	0.008	2.32
42	VTT/EIA/SSC1B	7.05	266	70.90	74.11	1.17	0.007	2.06
43	VTT/EIA/SSC2T	7.02	258	53.18	71.45	2.03	0.009	2.58
44	VTT/EIA/SSC2B	6.80	242	53.18	68.79	1.76	0.007	2.32

SOIL HEAVY METALS

S/N	FIELD CODE	Fe mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Cr mg/kg	Hg mg/kg	Ni mg/kg
1	VTT/EIA/SS1T	2312	<0.001	3.91	3.45	2.60	<0.001	2.30

2	VTT/EIA/SS1B	3493	0.65	1.02	1.25	4.70	<0.001	1.05
3	VTT/EIA/SS2T	2429	0.70	2.44	2.10	2.20	<0.001	3.10
4	VTT/EIA/SS2B	1666	0.60	3.66	0.80	1.00	<0.001	2.35
5	VTT/EIA/SS3T	2081	<0.001	1.82	1.15	1.20	<0.001	0.55
6	VTT/EIA/SS3B	1343	<0.001	1.00	2.00	0.50	<0.001	2.00
7	VTT/EIA/SS4T	1158	0.52	4.31	0.45	<0.001	<0.001	4.20
8	VTT/EIA/SS4B	1878	0.83	9.47	2.95	<0.001	<0.001	1.95
9	VTT/EIA/SS5T	1549	0.70	7.26	1.40	1.10	<0.001	1.60
10	VTT/EIA/SS5B	1652	<0.001	9.42	0.55	3.20	<0.001	0.40
11	VTT/EIA/SS6T	2294	<0.001	2.24	1.90	<0.001	<0.001	2.35
12	VTT/EIA/SS6B	1555	<0.001	4.61	2.10	0.70	<0.001	2.00
13	VTT/EIA/SS7T	2562	<0.001	1.78	1.15	1.40	<0.001	4.20
14	VTT/EIA/SS7B	1912	0.50	1.23	1.30	3.10	<0.001	1.30
15	VTT/EIA/SS8T	2307	0.80	7.02	4.95	<0.001	<0.001	0.50
16	VTT/EIA/SS8B	3558	<0.001	1.26	3.25	<0.001	<0.001	2.50
17	VTT/EIA/SS9T	1613	<0.001	0.91	1.50	2.60	<0.001	4.00
18	VTT/EIA/SS9B	2325	<0.001	1.14	3.50	0.50	<0.001	1.50
19	VTT/EIA/SS10T	2793	<0.001	5.00	4.55	<0.001	<0.001	2.40
20	VTT/EIA/SS10B	1971	<0.001	3.64	4.40	1.60	<0.001	0.30
21	VTT/EIA/SS11T	1230	<0.001	6.02	2.20	5.50	<0.001	0.45
22	VTT/EIA/SS11B	879	0.45	2.11	4.10	4.70	<0.001	0.55
23	VTT/EIA/SS12T	1163	0.95	0.88	4.15	<0.001	<0.001	0.80
24	VTT/EIA/SS12B	1449	<0.001	1.26	3.10	1.10	<0.001	0.65
25	VTT/EIA/SS13T	2000	0.60	1.45	4.50	3.20	<0.001	1.15
26	VTT/EIA/SS13B	1215	0.30	0.77	1.05	1.40	<0.001	0.90
27	VTT/EIA/SS14T	2418	<0.001	3.06	4.90	<0.001	<0.001	0.97
28	VTT/EIA/SS14B	1603	<0.001	1.81	2.30	2.10	<0.001	0.25
29	VTT/EIA/SS15T	772	<0.001	1.40	3.40	2.50	<0.001	0.20
30	VTT/EIA/SS15B	1131	<0.001	4.32	3.60	0.80	<0.001	0.40
31	VTT/EIA/SS16T	2426	0.55	5.08	1.20	1.90	<0.001	0.50
32	VTT/EIA/SS16B	1691	<0.001	1.74	1.50	1.40	<0.001	1.60
33	VTT/EIA/SS17T	1475	0.90	2.46	3.85	<0.001	<0.001	2.20
34	VTT/EIA/SS17B	1677	0.42	1.22	4.80	0.60	<0.001	0.55

35	VTT/EIA/SS18T	1942	<0.001	5.65	3.15	<0.001	<0.001	1.20
36	VTT/EIA/SS18B	3537	<0.001	3.80	1.50	3.60	<0.001	4.15
37	VTT/EIA/SS19T	2690	<0.001	2.01	2.10	0.90	<0.001	3.55
38	VTT/EIA/SS19B	2029	<0.001	1.38	1.65	1.30	<0.001	1.65
39	VTT/EIA/SS20T	3299	<0.001	7.04	4.40	<0.001	<0.001	1.05
40	VTT/EIA/SS20B	2929	<0.001	6.26	2.30	1.50	<0.001	1.15
41	VTT/EIA/SSC1T	3528	<0.001	0.90	4.75	1.90	<0.001	0.70
42	VTT/EIA/SSC1B	2529	<0.001	1.36	2.55	1.40	<0.001	0.40
43	VTT/EIA/SSC2T	2164	<0.001	0.81	1.30	<0.001	<0.001	0.20
44	VTT/EIA/SSC2B	2502	<0.001	0.94	2.65	0.70	<0.001	0.45

MICROBIOLOGY

S/N	FIELD CODE	THB (cfu/g)	THF (cfu/g)	HUB (cfu/g)	HUF (cfu/g)	SRB (cfu/g)	FIELD CODE
1	VTT/EIA/SS1T	8.5×10^4	4.3×10^3	3.2×10^2	1.0×10^2	Nil	VTT/EIA/SS1T
2	VTT/EIA/SS1B	6.6×10^4	1.2×10^3	1.8×10^2	0.7×10^2	Nil	VTT/EIA/SS1B
3	VTT/EIA/SS2T	7.6×10^4	3.3×10^3	2.1×10^2	1.3×10^2	Nil	VTT/EIA/SS2T
4	VTT/EIA/SS2B	10.2×10^4	2.8×10^3	0.9×10^2	Nil	Nil	VTT/EIA/SS2B
5	VTT/EIA/SS3T	9.7×10^4	3.2×10^3	1.7×10^2	1.2×10^2	Nil	VTT/EIA/SS3T
6	VTT/EIA/SS3B	7.2×10^4	5.1×10^3	3.0×10^2	1.8×10^2	Nil	VTT/EIA/SS3B
7	VTT/EIA/SS4T	3.8×10^4	1.2×10^3	1.0×10^2	0.5×10^2	Nil	VTT/EIA/SS4T
8	VTT/EIA/SS4B	5.2×10^4	3.4×10^3	0.3×10^2	Nil	Nil	VTT/EIA/SS4B
9	VTT/EIA/SS5T	2.4×10^4	8.0×10^3	1.2×10^2	0.8×10^2	Nil	VTT/EIA/SS5T
10	VTT/EIA/SS5B	3.0×10^4	6.3×10^3	1.8×10^2	1.0×10^2	Nil	VTT/EIA/SS5B
11	VTT/EIA/SS6T	4.2×10^4	3.0×10^3	2.0×10^2	1.5×10^2	Nil	VTT/EIA/SS6T
12	VTT/EIA/SS6B	10.1×10^4	1.2×10^3	2.2×10^2	1.2×10^2	Nil	VTT/EIA/SS6B
13	VTT/EIA/SS7T	12.8×10^4	1.6 x 103	6.0×10^2	2.2×10^2	Nil	VTT/EIA/SS7T
14	VTT/EIA/SS7B	6.4×10^4	1.2×10^3	4.2×10^2	1.2×10^2	Nil	VTT/EIA/SS7B

15	VTT/EIA/SS8T	6.6×10^{4}	1.3×10^{3}	1.0×10^{2}	2.0×10^{2}	Nil
16	VTT/EIA/SS8B	10.1×10^{4}	1.2×10^{3}	2.2×10^{2}	1.2×10^{2}	Nil
17	VTT/EIA/SS9T	10.1×10^{4}	1.2×10^{3}	2.2×10^{2}	1.2×10^{2}	Nil
18	VTT/EIA/SS9B	5.3×10^{4}	4.0×10^{3}	1.0×10^{2}	0.8×10^{2}	Nil
19	VTT/EIA/SS10T	2.8×10^{4}	1.6 x 103	2.0×10^{2}	1.8×10^{2}	Nil
20	VTT/EIA/SS10B	1.5×10^{4}	1.2×10^{3}	1.8×10^{2}	1.1×10^{2}	Nil
21	VTT/EIA/SS11T	1.5×10^{4}	1.3×10^{3}	1.0×10^{2}	Nil	Nil
22	VTT/EIA/SS11B	3.6×10^{4}	1.2×10^{3}	2.0×10^{2}	0.7×10^{2}	Nil
23	VTT/EIA/SS12T	4.4×10^{4}	3.7×10^{3}	3.0×10^{2}	1.4×10^{2}	Nil
24	VTT/EIA/SS12B	2.5×10^{4}	2.6×10^{3}	2.8×10^{2}	1.2×10^{2}	Nil
25	VTT/EIA/SS13T	1.2×10^{4}	4.8×10^{3}	1.0×10^{2}	Nil	Nil
26	VTT/EIA/SS13B	2.4×10^{4}	2.2×10^{3}	0.8×10^{2}	0.4×10^{2}	Nil
27	VTT/EIA/SS14T	3.7×10^{4}	1.6×10^{3}	2.8×10^{2}	1.2×10^{2}	Nil
28	VTT/EIA/SS14B	2.8×10^{4}	2.9×10^{3}	2.4×10^{2}	0.8×10^{2}	Nil
29	VTT/EIA/SS15T	3.1×10^{4}	6.0×10^{3}	Nil	Nil	Nil
30	VTT/EIA/SS15B	1.8×10^{4}	3.8×10^{3}	Nil	Nil	Nil
31	VTT/EIA/SS16T	4.0×10^{4}	11.2×10^{3}	3.2×10^{2}	1.2×10^{2}	Nil
32	VTT/EIA/SS16B	3.2×10^{4}	4.0×10^{3}	1.8×10^{2}	0.7×10^{2}	Nil
33	VTT/EIA/SS17T	3.8×10^{4}	1.6×10^{3}	2.0×10^{2}	1.2×10^{2}	Nil
34	VTT/EIA/SS17B	3.1×10^{4}	1.2×10^{3}	1.5×10^{2}	0.3×10^{2}	Nil
35	VTT/EIA/SS18T	2.8×10^{4}	5.0×10^{3}	2.9×10^{2}	0.5×10^{2}	Nil
36	VTT/EIA/SS18B	1.8×10^{4}	3.8×10^{3}	1.8×10^{2}	0.9×10^{2}	Nil
37	VTT/EIA/SS19T	2.9×10^{4}	8.0×10^{3}	2.8×10^{2}	0.7×10^{2}	Nil
38	VTT/EIA/SS19B	2.2×10^{4}	5.6×10^{3}	2.0×10^{2}	1.2×10^{2}	Nil
39	VTT/EIA/SS20T	2.6×10^{4}	4.0×10^{3}	Nil	Nil	Nil
40	VTT/EIA/SS20B	1.7×10^{4}	1.2×10^{3}	Nil	Nil	Nil
41	VTT/EIA/SSC1T	4.7×10^{4}	6.0×10^{3}	1.5×10^{2}	0.9×10^{2}	Nil

VTT/EIA/SS8T
VTT/EIA/SS8E
VTT/EIA/SS9T
VTT/EIA/SS9E
VTT/EIA/SS10
VTT/EIA/SS10
VTT/EIA/SS11
VTT/EIA/SS11
VTT/EIA/SS12
VTT/EIA/SS12
VTT/EIA/SS13
VTT/EIA/SS13
VTT/EIA/SS14
VTT/EIA/SS14
VTT/EIA/SS15
VTT/EIA/SS15
VTT/EIA/SS16
VTT/EIA/SS16
VTT/EIA/SS17
VTT/EIA/SS17
VTT/EIA/SS18
VTT/EIA/SS18
VTT/EIA/SS19
VTT/EIA/SS19
VTT/EIA/SS20
VTT/EIA/SS20
VTT/EIA/SSC1

42	VTT/EIA/SSC1B	2.6×10^4	3.8×10^3	1.4×10^2	1.0×10^2	Nil
43	VTT/EIA/SSC2T	5.0×10^4	1.6×10^3	1.8×10^2	0.4×10^2	Nil
44	VTT/EIA/SSC2B	1.8×10^4	1.2×10^3	1.2×10^2	0.7×10^2	Nil

VTT/EIA/SSC1
VTT/EIA/SSC2
VTT/EIA/SSC2

BDL

The predominant genera of bacteria isolated from the soil of the study area were Bacillus, Pseudomonas, Enterobacter, Micrococcus and Staphylococcus.

Predominant fungal genera in the study area are Mucor, Penicillium and Aspergillus.

FIELD OML 96

Nitrate mg/kg	Total Nitrogen %	THC mg/kg	Bulk Density g/cm^3	Porosity %	CEC (meq/100g)	Phenols mg/kg			*1mm* VCS
8.63	0.13	1.44	1.81	31.7	11.08	<0.001			6.82
6.63	0.10	1.10	1.46	47.20	13.37	<0.001			9.30
5.31	0.08	0.77	1.66	37.40	12.57	<0.001			7.08
4.64	0.07	0.43	2.62	31.10	12.06	<0.001			6.67
7.29	0.11	0.93	1.77	33.20	13.87	<0.001			10.20
5.97	0.09	0.77	2.52	34.90	12.79	<0.001			8.68
10.61	0.16	1.10	2.33	22.10	12.93	<0.001			5.81
9.29	0.14	0.93	2.22	16.20	12.71	<0.001			6.50
7.95	0.12	1.10	1.89	28.70	14.48	<0.001			9.81
6.63	0.10	0.77	1.51	44.10	15.09	<0.001			8.79
10.61	0.16	1.10	1.79	32.40	15.54	<0.001			3.02
9.95	0.15	0.93	1.62	46.2	11.67	<0.001			8.07
11.94	0.14	1.44	1.50	43.40	10.57	<0.001			9.81
10.61	0.18	1.27	2.05	42.60	9.67	<0.001			11.97
6.63	0.16	0.93	1.99	24.90	17.47	<0.001			12.39
5.31	0.10	0.77	2.59	22.30	12.51	<0.001			14.09
8.63	0.08	1.10	1.54	41.90	14.75	<0.001			10.07
5.97	0.13	0.93	2.55	23.80	11.26	<0.001			8.48
9.29	0.09	1.10	1.60	39.60	10.27	<0.001			9.64

7.95	0.14	0.93	1.65	40.30	14.03	<0.001			13.50
6.63	0.12	0.43	1.93	27.20	13.52	<0.001			8.81
5.31	0.10	1.43	2.18	26.40	10.95	<0.001			11.13
4.64	0.08	0.26	1.91	27.90	12.85	<0.001			10.75
3.98	0.07	0.09	1.97	25.70	11.79	<0.001			12.33
7.29	0.06	0.93	1.66	37.40	12.24	<0.001			7.42
7.95	0.11	0.60	1.80	32.10	12.47	<0.001			6.54
9.95	0.12	1.10	1.34	49.40	14.35	<0.001			6.96
9.29	0.15	0.93	1.61	39.20	14.85	<0.001			6.23
7.29	0.14	0.77	1.48	44.10	15.09	<0.001			6.69
5.97	0.11	0.60	1.74	34.30	11.35	<0.001			7.09
6.63	0.09	0.93	1.81	31.70	11.01	<0.001			5.30
7.29	0.10	0.93	1.56	41.10	10.53	<0.001			3.60
9.95	0.11	1.10	1.80	32.10	12.50	<0.001			7.44
8.63	0.15	0.77	2.00	24.50	13.68	<0.001			8.25
7.95	0.13	1.10	1.74	34.30	19.07	<0.001			7.73
6.63	0.12	0.93	1.74	34.30	16.46	<0.001			5.53
8.63	0.10	0.77	2.07	21.90	10.96	<0.001			3.42
7.29	0.13	0.60	2.00	24.50	11.90	<0.001			2.74
9.29	0.11	1.10	1.51	43.00	12.25	<0.001			4.03
7.95	0.14	0.77	1.59	40.00	11.05	<0.001			8.74
5.97	0.12	0.93	1.84	30.60	14.85	<0.001			3.90
5.31	0.09	0.93	2.00	24.50	13.82	<0.001			1.91
6.63	0.08	1.10	1.54	41.90	14.45	<0.001			3.75
5.97	0.10	0.93	1.42	46.40	13.69	<0.001			1.22

Mn mg/kg	**V mg/kg**	**Zn mg/kg**	**Ba mg/kg**	**As mg/kg**	**K meq/100g**	**Mg meq/100g**	**Ca meq/100g**	**Na meq/100g**
43.04	0.03	27.63	0.33	<0.001	0.56	3.59	4.31	0.77

32.12	0.04	23.78	0.29	<0.001	0.69	3.53	3.89	0.81
34.42	0.01	10.70	<0.001	<0.001	0.44	2.10	4.42	1.42
17.12	<0.001	7.13	0.16	<0.001	0.74	2.59	3.89	0.82
24.86	0.03	16.75	0.34	<0.001	0.50	2.69	5.16	0.89
40.12	<0.001	13.07	<0.001	<0.001	0.51	1.45	4.25	2.32
8.32	<0.001	11.01	<0.001	<0.001	0.52	1.89	4.03	2.17
8.12	0.09	10.00	<0.001	<0.001	0.90	0.73	5.05	1.79
10.28	0.05	6.32	0.38	<0.001	0.89	4.59	2.65	1.52
7.92	<0.001	6.45	0.60	<0.001	0.69	2.65	5.93	0.80
30.00	<0.001	11.21	0.24	<0.001	0.75	1.93	6.45	1.23
42.28	<0.001	12.53	<0.001	<0.001	0.92	2.10	3.86	0.91
37.80	<0.001	7.10	<0.001	<0.001	0.67	3.37	2.16	0.84
52.28	<0.001	18.10	<0.001	<0.001	0.63	2.74	1.93	1.15
64.54	<0.001	11.84	<0.001	<0.001	0.70	4.80	4.66	1.48
50.08	<0.001	17.96	<0.001	<0.001	0.73	2.60	4.00	1.02
47.32	<0.001	25.08	0.50	<0.001	0.71	4.57	4.06	0.49
58.82	<0.001	9.66	0.60	<0.001	0.58	2.93	3.13	0.87
75.84	<0.001	15.71	0.32	<0.001	0.53	1.41	2.69	2.22
50.04	<0.001	12.37	0.34	<0.001	0.50	1.54	5.01	2.31
43.36	<0.001	7.31	0.27	<0.001	0.54	1.43	6.18	0.86
39.00	0.05	11.51	0.12	<0.001	0.65	1.27	4.03	1.34
37.20	0.04	17.31	<0.001	<0.001	0.38	2.28	4.81	1.09
40.14	0.02	14.03	<0.001	<0.001	0.60	2.80	3.45	1.01
37.92	<0.001	16.08	0.34	<0.001	0.72	2.57	3.86	1.01
41.54	0.04	21.43	0.18	<0.001	0.52	2.92	3.49	1.38
73.98	<0.001	19.08	<0.001	<0.001	0.49	3.38	4.06	1.63
62.54	<0.001	16.69	0.19	<0.001	0.72	2.61	4.47	2.09
79.72	<0.001	11.08	<0.001	<0.001	0.39	3.26	5.05	1.35
42.22	0.03	9.93	<0.001	<0.001	0.70	3.28	2.20	1.39
43.78	0.06	21.81	0.35	<0.001	0.54	2.48	2.95	1.37
35.24	<0.001	21.04	0.11	<0.001	0.53	1.93	3.56	1.00
47.72	<0.001	19.56	0.40	<0.001	0.54	3.60	3.05	1.14
37.92	0.05	20.05	0.22	<0.001	0.52	3.26	3.59	1.74

107.52	<0.001	28.06	0.45	<0.001	1.32	2.07	7.16	2.16
107.14	<0.001	16.28	0.21	<0.001	1.10	2.59	6.06	1.21
35.20	<0.001	19.36	0.07	<0.001	1.28	2.70	1.99	1.34
46.40	<0.001	14.82	0.23	<0.001	0.60	1.82	3.56	1.96
29.00	<0.001	49.80	<0.001	<0.001	0.73	1.57	4.57	1.29
27.66	<0.001	9.54	<0.001	<0.001	0.87	2.94	2.86	0.70
31.88	<0.001	17.78	0.08	<0.001	0.70	5.14	3.01	1.05
24.74	<0.001	33.33	<0.001	<0.001	0.75	3.55	3.86	1.05
42.08	<0.001	35.15	<0.001	<0.001	0.91	2.80	4.46	1.46
27.36	<0.001	34.15	<0.001	<0.001	0.54	3.34	3.52	1.74

HYDROCARBONS

TPH (mg/kg)	PAH (mg/kg)	BTEX (mg/kg)
0.824	0.06	BDL
0.633	0.03	BDL
0.438	BDL	BDL
0.219	BDL	BDL
0.527	BDL	BDL
0.436	0.04	BDL
0.615	0.12	BDL
0.589	0.1	BDL
0.603	BDL	BDL
0.389	BDL	BDL
0.628	0.08	BDL
0.501	0.13	BDL
0.957	0.06	BDL
0.721	0.04	BDL

0.445	BDL	BDL
0.425	BDL	BDL
0.654	0.05	BDL
0.329	BDL	BDL
0.627	0.01	BDL
0.518	0.03	BDL
0.244	0.01	BDL
0.805	BDL	BDL
0.147	BDL	BDL
0.051	BDL	BDL
0.577	BDL	BDL
0.340	0.06	BDL
0.654	0.02	BDL
0.548	BDL	BDL
0.413	BDL	BDL
0.286	BDL	BDL
0.528	BDL	BDL
0.440	0.07	BDL
0.603	0.11	BDL
0.449	0.04	BDL
0.653	0.08	BDL
0.511	BDL	BDL
0.397	BDL	BDL
0.322	BDL	BDL
0.631	BDL	BDL
0.275	0.02	BDL
0.532	BDL	BDL

0.664	BDL	BDL
0.583	BDL	BDL
0.447	BDL	BDL

= Below Detection Limit of 0.01

PARTICLE SIZE							
				%	%	%	
0.5mm **CS**	***0.25mm*** **MS**	***0.106mm*** **FS**	***<0.106mm*** **VFS**	**TOTAL SAND**	**TOTAL SILT**	**TOTAL CLAY**	**TEXTURE**
16.52	18.22	14.28	0.53	56	12	32	SANDY CLAY LOAM
17.80	17.69	10.52	0.40	56	21	23	SANDY CLAY LOAM
19.39	17.35	28.31	0.68	73	11	16	SANDY LOAM
18.71	20.30	28.16	0.80	75	10	15	SANDY LOAM
19.24	24.20	19.92	0.78	74	10	16	SANDY LOAM
20.90	24.05	19.27	1.15	74	11	15	SANDY LOAM
23.62	21.39	23.72	0.97	76	12	12	SANDY LOAM
18.46	28.34	16.29	0.75	70	12	18	SANDY LOAM
23.06	23.36	19.73	0.49	76	12	12	SANDY LOAM
20.86	23.11	20.55	0.51	74	6	20	SANDY LOAM
14.81	24.50	26.51	0.73	70	12	18	SANDY LOAM
17.52	16.34	19.69	0.98	63	17	20	SANDY LOAM
22.00	23.45	17.05	1.24	74	12	14	SANDY LOAM
23.48	23.20	10.57	1.31	71	15	14	SANDY LOAM
21.83	20.61	11.98	0.71	68	22	10	SANDY LOAM
19.06	19.35	13.30	1.19	67	14	19	SANDY LOAM
28.00	23.30	13.81	0.58	76	13	11	SANDY LOAM
24.50	25.65	21.68	0.84	81	15	4	LOAM SAND
20.26	21.58	22.78	0.44	75	17	8	SANDY LOAM

20.87	22.10	16.37	0.31	73	19	8	SANDY LOAM
29.69	27.86	12.16	0.41	79	8	13	SANDY LOAM
23.40	17.45	12.92	0.19	65	16	19	SANDY LOAM
22.88	22.42	11.48	0.18	68	7	25	SANDY CLAY LOAM
19.29	19.89	16.81	0.40	69	8	23	SANDY CLAY LOAM
26.21	24.47	16.22	0.73	75	19	6	LOAM SAND
25.97	25.17	20.61	1.19	79	19	2	LOAM SAND
32.31	24.85	14.21	0.80	79	17	4	LOAM SAND
31.47	27.45	15.79	1.11	82	11	7	LOAM SAND
27.47	28.91	18.62	0.72	82	11	7	LOAM SAND
29.89	28.25	15.31	0.21	81	12	7	LOAM SAND
37.57	33.92	10.61	0.44	88	3	9	LOAM SAND
29.33	33.26	15.38	0.98	83	10	7	LOAM SAND
26.52	24.53	12.58	1.05	72	18	10	SANDY LOAM
25.68	23.38	12.21	1.25	71	19	10	SANDY LOAM
27.35	26.40	8.44	1.19	71	21	8	SANDY LOAM
25.09	26.58	13.50	1.28	72	21	7	SANDY LOAM
28.60	32.02	12.33	1.24	78	11	11	SANDY LOAM
10.47	34.15	17.07	1.42	66	23	11	SANDY LOAM
16.40	25.50	9.78	0.67	56	35	9	SANDY LOAM
20.90	27.72	17.38	0.75	75	15	10	SANDY LOAM
14.54	26.15	12.00	0.98	58	30	12	SANDY LOAM
10.03	37.61	18.15	0.70	68	21	11	SANDY LOAM
10.37	20.18	11.32	0.48	46	46	8	LOAM
5.77	20.15	10.38	0.61	38	51	11	SILTY LOAM

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE FIELD C
DATE OF SAMPLE RECEIVED: 16/11/2019
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *GROUND WATER*
NUMBER OF SAMPLE: *5*

FIELD CODE	pH	E/COND (µS/cm)	Temp. (^oC)	Redox Potential (mV)	TDS (mg/l)	Colour (Pt-Co)	Alkalinity (mg/L as	Chloride (mg/l)	TSS (mg/l)
Ground Water 1	6.71	116	25.7	117	63.80	7	24.0	34.49	7.48
Ground Water 2	6.84	346	25.9	98	190.30	5	22.0	102.97	7.21
Ground Water 3	6.60	188	25.4	124	103.40	7	30.0	60.98	7.40
Ground Water C1	6.34	52	26.0	109	28.60	1	12.0	18.00	0.94
Ground Water C2	6.36	45	25.8	134	24.75	1	2.0	17.49	0.86

HEAVY METALS

FIELD CODE	Fe (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Cu (mg/l)	Hg (mg/l)	Ni (mg/l)	V (mg/l)	Zn (mg/l)
Ground Water 1	1.950	0.013	<0.001	0.030	0.050	<0.001	<0.001	<0.001	0.329
Ground Water 2	2.078	0.060	<0.001	0.090	0.071	<0.001	<0.001	<0.001	0.182
Ground Water 3	0.201	<0.001	<0.001	<0.001	0.120	<0.001	<0.001	<0.001	0.177
Ground Water C1	<0.001	<0.001	<0.001	<0.001	0.031	<0.001	<0.001	<0.001	0.100
Ground Water C2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.134

MICROBIOLOGY

	THB	THF	HUB	HUF	aecal Coliform

FIELD CODE	(cfu/ml)	(cfu/ml)	(cfu/ml)	(cfu/ml)	MPN/100ml
Ground Water 1	2.0×10^3	1.4×10^2	Nil	Nil	Nil
Ground Water 2	2.1×10^3	1.2×10^2	Nil	Nil	Nil
Ground Water 3	1.8×10^3	0.6×10^2	Nil	Nil	Nil
Ground Water C1	0.7×10^3	0.2×10^2	Nil	Nil	Nil
Ground Water C2	0.9×10^3	Nil	Nil	Nil	Nil

The predominant genera of bac
Bacillus and Pseudomonas

GROUNDWATER HYDROCARBON RESULTS

COMPONENT	Ground water 1	Ground water 2	Ground water 3	Ground water Control 1	Ground water Control 2
TPH (mg/l)	0.105	0.074	BDL	BDL	BDL
PAH (mg/l)	BDL	BDL	BDL	BDL	BDL
Benzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Tolune (mg/l)	BDL	BDL	BDL	BDL	BDL
Ethylbenzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Xylene (mg/l)	BDL	BDL	BDL	BDL	BDL

BDL = Below Detection Limit of 0.01

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Total Hardness (mg/L as $CaCO_3$)	DO (mg/l)	Turbidity (NTU)	BOD_5 (mg/l)	COD (mg/l)	O & G (mg/l)	THC (mg/l)	Carbonate (mg/l)	Phosphate (mg/l)	Ammonium (mg/l)	Nitrate (mg/l)	Salinity (mg/l)
28.0	9.7	12.6	1.6	6.01	0.47	0.26	0.0	0.08	0.08	0.21	0.06
43.0	10.6	11.4	1.3	5.78	0.36	0.15	0.0	0.11	0.06	0.15	0.16
34.0	9.8	13.9	1.3	3.76	<0.01	<0.01	0.0	0.08	0.10	0.17	0.09
6.0	9.2	<0.1	<1.0	3.00	<0.01	<0.01	0.0	<0.01	0.08	0.13	0.03
8.0	8.3	<0.1	<1.0	2.41	<0.01	<0.01	0.0	<0.01	0.09	<0.01	0.02

Ba (mg/l)	Mn (mg/l)
<0.001	0.138
<0.001	0.268
<0.001	0.122
<0.001	0.117
<0.001	0.175

teria isolated from the ground water of the study area were

Sulphate (mg/l)	**Na (mg/l)**	**K (mg/l)**	**Mg (mg/l)**	**Ca (mg/l)**
2.93	17.40	0.50	2.51	7.02
22.28	58.39	1.02	3.16	8.04
6.66	34.18	0.73	1.21	3.60
2.09	9.45	0.25	0.67	1.29
1.61	8.19	0.10	0.75	1.88

Appendix 4.4-Dry Season VTT Result

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE FIELD
DATE OF SAMPLE RECEIVED: 16/1 *06/02/202*
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *SURFACE WATER*
NUMBER OF SAMPLE: *5*

FIELD CODE	pH	E/COND (µS/cm)	Temp. (^{o}C)	Redox Potential (mV)	TDS (mg/l)	Colour (Pt-Co)	Alkalinity (mg/L as $CaCO_3$)
Surface Water 1 /UPSTREAM	6.8	38	27.60	53	19.00	9	30.0
Surface Water 2 /MIDSTREAM	6.90	38	27.90	19	19.00	6	50.0
Surface Water 3 /DOWNSTREAM	7.90	48	27.20	171	20.00	11	40.0
Surface Water C1	7.50	40	27.50	38	20.00	7	40.0
Surface Water C2	8.90	48	27.40	15	22.00	6	20.0

HEAVY METALS

FIELD CODE	Fe (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Cu (mg/l)	Hg (mg/l)	Ni (mg/l)
Surface Water 1 /UPSTREAM	0.965	0.006	<0.001	0.456	0.015	<0.001	<0.001
Surface Water 2 /MIDSTREAM	0.724	0.005	0.004	0.626	0.008	<0.001	<0.001
Surface Water 3 /DOWNSTREAM	0.443	0.012	0.006	0.425	0.012	<0.001	<0.001
Surface Water C1	0.703	0.019	<0.001	0.316	0.009	<0.001	<0.001
Surface Water C2	0.456	<0.001	<0.001	0.456	0.003	<0.001	<0.001

MICROBIOLOGY

FIELD CODE	THB (cfu/ml)	THF (cfu/ml)	HUB (cfu/ml)	HUF (cfu/ml)	Faecal Coliform MPN/100ml
Surface Water 1 /UPSTREAM	2.3×10^{4}	2.1×10^{3}	1.8×1^{2}	1.3×10^{1}	43
Surface Water 2 /MIDSTREAM	3.5×10^{4}	3.0×10^{3}	2.6×10^{2}	0.5×10^{1}	52
Surface Water 3 /DOWNSTREAM	4.2×10^{4}	3.3×10^{3}	3.0×10^{2}	1.0×10^{1}	63
Surface Water C1	7.2×10^{4}	2.8×10^{2}	2.0×10^{2}	NILL	48
Surface Water C2	6.3×10^{4}	2.0×10^{3}	1.3×10^{2}	0.7×10^{1}	50

The predomin
Bacillus, Pseu

Predominant
Penicillium a

SURFACE WATER HYDROCARBON RESULTS

COMPONENT	Surface water Upstream 1	Surface water Midstream 2	Surface water Downstream 3	Surface water Control 1	Surface water Control 2
TPH (mg/l)	BDL	BDL	BDL	BDL	BDL
PAH (mg/l)	BDL	BDL	BDL	BDL	BDL
Benzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Tolune (mg/l)	BDL	BDL	BDL	BDL	BDL
Ethylbenzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Xylene (mg/l)	BDL	BDL	BDL	BDL	BDL
BDL = Below Detection Limit					

OML 96

Chloride (mg/l)	TSS (mg/l)	Total Hardness (mg/L as $CaCO_3$)	DO (mg/l)	Turbidity (NTU)	BOD_5 (mg/l)	COD (mg/l)	O & G (mg/l)	THC (mg/l)	Carbonate (mg/l)
11.50	2.31	10	8.5	3.4	6.30	42.67	0.66	<0.001	0.0
13.50	2.14	13	8.70	3.6	7.50	37.33	0.98	<0.001	0.0
12.50	2.11	8	7.5	3.3	6.60	40.53	0.34	<0.001	0.0
9.00	1.68	12	8.90	3.1	5.40	30.93	<0.001	<0.001	0.0
10.00	2	5	6.70	3.2	5.10	33.07	<0.001	<0.001	0.0

V (mg/l)	Zn (mg/l)	Ba (mg/l)	Mn (mg/l)
<0.001	0.139	<0.001	0.163
<0.001	0.126	<0.001	0.078
<0.001	0.116	<0.001	0.123
<0.001	0.124	<0.001	0.146
<0.001	0.108	<0.001	0.025

ıant genera of bacteria isolated from the surface water of the study area were ıdomonas, E.coli, coliforms and Staphylococcus.

fungal genera in surface water from the study area are nd Aspergillus.

Phosphate (mg/l)	Ammonium (mg/l)	Nitrate (mg/l)	Salinity (mg/l)	Sulphate (mg/l)	Na (mg/l)	K (mg/l)	Mg (mg/l)	Ca (mg/l)
0.02	0.08	0.193	20.78	6.66	9.63	0.25	0.96	2.25
0.01	0.01	0.241	24.39	6.78	9.03	0.14	0.86	3.24
0.03	0.06	0.218	22.58	5.818	8.45	0.16	0.45	3.14
0.01	0.04	0.049	16.26	3.535	6.24	0.21	1.13	2.02
0.02	0.07	0.036	18.07	2.934	9.05	0.28	0.84	2.36

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGEI
DATE OF SAMPLE RECEIVED: 16/11/2019
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *SEDIMENT*
NUMBER OF SAMPLE: *5*

PHYSICO-CHEMISTRY

S/N	FIELD CODE	pH	Electrical Conductivity µs/cm	Redox Potential mV	Chloride mg/kg	Sulphate mg/kg	TOC %
1	Sediment 1/ Upstream	5.60	152	82	53.18	58.60	0.02
2	Sediment 2/ Midstream	5.25	141	103	35.45	37.76	0.06
3	Sediment 3/ Downstream	5.20	165	106	53.18	61.58	0.10
4	Sediment Control 1	5.14	146	108	35.45	40.74	0.02
5	Sediment Control 2	4.30	251	169	70.90	76.47	0.00

HEAVY METALS

S/N	FIELD CODE	Fe mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Cr mg/kg	Hg mg/kg
1	Sediment 1/ Upstream	963	0.63	1.63	3.24	0.33	<0.001
2	Sediment 2/ Midstream	1125	0.96	1.32	4.83	0.39	<0.001
3	Sediment 3/ Downstream	1624	0.14	1.96	6.02	0.25	<0.001
4	Sediment Control 1	563	0.19	1.18	0.93	0.28	<0.001
5	Sediment Control 2	345	0.33	1.26	1.24	0.00	<0.001

MICROBIOLOGY

S/N	FIELD CODE	THB (cfu/g)	THF (cfu/g)	HUB (cfu/g)	HUF (cfu/g)	SRB (cfu/g)
1	Sediment 1/ Upstream	8.3×10^4	5.3×10^3	2.8×10^2	1.2×10^2	Nil
2	Sediment 2/ Midstream	9.0×10^4	3.7×10^3	2.1×10^2	2.8×10^2	Nil
3	Sediment 3/ Downstream	10.2×10^4	6.9×10^3	3.2×10^2	1.7×10^2	Nil
4	Sediment Control 1	6.9×10^4	4.2×10^3	2.7×10^2	0.6×10^2	Nil
5	Sediment Control 2	2.7×10^4	3.1×10^3	1.0×10^2	0.7×10^2	Nil

The predominant genera of bacteria isolated from the sediment of the study area were
Bacillus spp, Pseudomonas spp., Enterobacter spp

Predominant fungal genera in sediment from the study area are
Mucor spp., Candida spp., Aspergillus spp., penicillium spp.

.E FIELD OML 96

Phenols mg/kg	Carbonate mg/kg	Nitrate mg/kg	THC mg/kg	Colour munsell color chart	PARTICLE SIZE % TOTAL SAND	% TOTAL SILT	% TOTAL CLAY	TEXTURE
<0.001	0.00	0.309	0.24	Light brown	90	5	5	SAND
<0.001	0.00	0.265	0.45	Light brown	93	4	3	SAND
<0.001	0.00	0.354	0.45	Grey	80	5	15	SANDY LOAM
<0.001	0.00	0.221	0.24	Grey	82	7	11	SANDY LOAM
<0.001	0.00	0.265	0.02	Grey	79	9	12	SANDY LOAM

Ni mg/kg	Mn mg/kg	V mg/kg	Zn mg/kg	Ba mg/kg	K meq/100g	Mg meq/100g	Ca meq/100g	Na meq/100g
<0.001	19.25	<0.001	9.96	0.96	0.63	2.96	4.60	0.73
<0.001	15.08	<0.001	11.25	0.45	0.72	1.65	2.95	0.86
<0.001	63.24	<0.001	27.92	0.77	0.52	2.22	4.94	0.69
<0.001	5.34	<0.001	10.03	0.23	0.23	2.13	3.15	0.36
<0.001	7.050	<0.001	13.34	0.35	0.93	3.93	2.84	1.08

HYDROCARBONS

FIELD CODE	TPH (mg/kg)	PAH (mg/kg)	BTEX (mg/kg)
VTT/EIA/SS1T	0.096	0.02	BDL
VTT/EIA/SS1B	0.075	0.03	BDL
VTT/EIA/SS2T	0.063	0.03	BDL
VTT/EIA/SS2B	0.045	BDL	BDL
VTT/EIA/SS3T	0.096	BDL	BDL

BDL = Below Detection Limit of 0.01

NAME OF CLIENT: *VTT LNG*

PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE FI

DATE DATE OF SAMPLE RECEIVED: 16/11/2019

PERI(PERIOD OF ANALYSIS: *17th November - 16th December, 2019*

SAMPLE MATRIX: *SOIL*

NUMBER OF SAMPLE: *44*

PHYSICO-CHEMISTRY

S/N	FIELD CODE	pH	Electrical Conductivity µs/cm	Chloride mg/kg	Sulphate mg/kg	TOC %	Total Phosphorous %	Ammonium mg/kg
1	VTT/EIA/SS1T	5.70	473.00	106.35	133.04	5.11	0.003	0.142
2	VTT/EIA/SS1B	5.84	363.00	88.63	118.15	3.71	0.003	0.129
3	VTT/EIA/SS2T	5.87	289.00	70.90	97.31	2.61	0.002	0.103
4	VTT/EIA/SS2B	5.93	230.00	53.18	61.58	2.54	0.001	0.077
5	VTT/EIA/SS3T	5.44	201.00	37.22	49.67	2.50	0.005	0.168
6	VTT/EIA/SS3B	5.47	197.00	35.45	37.76	2.46	0.004	0.155
7	VTT/EIA/SS4T	6.30	268.00	70.90	94.33	3.35	0.004	0.142
8	VTT/EIA/SS4B	6.41	203.00	37.22	49.67	2.07	0.003	0.129
9	VTT/EIA/SS5T	5.96	222.00	38.29	52.65	1.44	0.002	0.116
10	VTT/EIA/SS5B	6.00	132.00	24.82	25.85	1.48	0.002	0.077
11	VTT/EIA/SS6T	6.08	261.00	70.90	91.35	4.25	0.004	0.142
12	VTT/EIA/SS6B	5.94	260.00	70.90	88.38	3.55	0.003	0.129
13	VTT/EIA/SS7T	6.36	334.00	88.63	109.22	3.67	0.005	0.155
14	VTT/EIA/SS7B	6.35	291.00	70.90	100.29	3.35	0.004	0.142
15	VTT/EIA/SS8T	6.79	250.00	53.18	82.42	2.54	0.005	0.155
16	VTT/EIA/SS8B	6.74	217.00	35.45	55.62	1.56	0.004	0.142
17	VTT/EIA/SS9T	5.85	230.00	53.18	61.58	4.80	0.003	0.129
18	VTT/EIA/SS9B	5.97	256.00	70.90	85.40	4.41	0.003	0.116
19	VTT/EIA/SS10T	5.96	299.00	88.63	103.26	4.76	0.005	0.168

20	VTT/EIA/SS10B	5.88	240.00	53.18	79.44	4.52	0.004	0.129
21	VTT/EIA/SS11T	5.78	292.00	70.90	103.26	2.77	0.006	0.206
22	VTT/EIA/SS11B	5.85	349.00	88.63	112.20	1.91	0.005	0.181
23	VTT/EIA/SS12T	5.95	212.00	35.45	52.65	2.46	0.003	0.142
24	VTT/EIA/SS12B	5.81	236.00	53.18	58.60	1.91	0.003	0.129
25	VTT/EIA/SS13T	5.29	184.00	35.45	37.76	1.13	0.005	0.168
26	VTT/EIA/SS13B	5.12	107.00	17.73	19.89	0.55	0.004	0.155
27	VTT/EIA/SS14T	5.23	258.00	70.90	85.40	0.82	0.003	0.103
28	VTT/EIA/SS14B	4.75	198.00	35.45	37.76	0.39	0.002	0.090
29	VTT/EIA/SS15T	6.55	367.00	88.63	121.13	2.15	0.003	0.129
30	VTT/EIA/SS15B	6.68	359.00	70.90	118.15	1.52	0.003	0.103
31	VTT/EIA/SS16T	6.50	407.00	106.35	127.08	2.65	0.005	0.181
32	VTT/EIA/SS16B	6.72	425.00	106.35	130.06	1.21	0.004	0.142
33	VTT/EIA/SS17T	6.26	215.00	35.45	52.65	0.39	0.003	0.116
34	VTT/EIA/SS17B	6.29	255.00	70.90	85.40	0.27	0.002	0.090
35	VTT/EIA/SS18T	6.39	347.00	88.63	112.20	0.70	0.003	0.129
36	VTT/EIA/SS18B	6.36	244.00	53.18	82.42	0.12	0.003	0.116
37	VTT/EIA/SS19T	6.11	309.00	70.90	103.26	1.56	0.005	0.168
38	VTT/EIA/SS19B	6.05	320.00	88.63	109.22	1.21	0.003	0.129
39	VTT/EIA/SS20T	6.10	488.00	124.08	138.99	1.64	0.004	0.142
40	VTT/EIA/SS20B	6.09	321.00	88.63	109.22	1.25	0.003	0.116
41	VTT/EIA/SS21T	5.60	274.00	70.90	94.33	1.60	0.002	0.103
42	VTT/EIA/SS21B	5.62	239.00	53.18	76.47	1.17	0.002	0.090
43	VTT/EIA/SS22T	5.66	282.00	70.90	100.29	1.13	0.003	0.129
44	VTT/EIA/SS22B	5.54	353.00	88.63	118.15	0.70	0.003	0.116
45	VTT/EIA/SSC1T	5.82	283.00	70.90	100.29	0.47	0.002	0.077
46	VTT/EIA/SSC1B	5.79	263.00	70.90	88.38	0.51	0.001	0.065
47	VTT/EIA/SSC2T	5.73	318.00	88.63	109.22	0.23	0.002	0.103
48	VTT/EIA/SSC2B	5.70	252.00	53.18	82.42	0.08	0.002	0.090
49	VTT/EIA/SSC3T	5.42	245.00	70.90	85.40	1.83	0.003	0.129
50	VTT/EIA/SSC3B	5.52	233.00	53.18	76.47	1.60	0.003	0.116

SOIL HEAVY METALS

S/N	FIELD CODE	Fe mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Cr mg/kg	Hg mg/kg	Ni mg/kg
1	VTT/EIA/SS1T	2634	0.26	4.22	4.02	1.40	<0.001	2.41
2	VTT/EIA/SS1B	3624	0.93	1.26	1.36	3.25	<0.001	1.06
3	VTT/EIA/SS2T	2563	0.96	3.28	2.60	1.19	<0.001	2.15
4	VTT/EIA/SS2B	1962	0.74	2.96	1.24	0.96	<0.001	2.22
5	VTT/EIA/SS3T	2125	<0.001	1.93	1.68	1.16	<0.001	0.63
6	VTT/EIA/SS3B	1569	<0.001	1.26	3.02	0.42	<0.001	2.19
7	VTT/EIA/SS4T	1635	<0.001	5.02	1.25	<0.001	<0.001	4.39
8	VTT/EIA/SS4B	1532	<0.001	10.25	2.58	<0.001	<0.001	2.11
9	VTT/EIA/SS5T	1663	<0.001	8.68	1.60	<0.001	<0.001	1.76
10	VTT/EIA/SS5B	1789	<0.001	5.04	0.42	<0.001	<0.001	0.49
11	VTT/EIA/SS6T	3536	0.12	3.24	1.89	<0.001	<0.001	2.46
12	VTT/EIA/SS6B	1982	0.26	5.48	1.96	<0.001	<0.001	2.68
13	VTT/EIA/SS7T	30245	<0.001	2.06	1.04	<0.001	<0.001	4.23
14	VTT/EIA/SS7B	2089	<0.001	1.45	0.36	1.26	<0.001	1.40
15	VTT/EIA/SS8T	2503	0.63	8.01	5.26	<0.001	<0.001	0.73
16	VTT/EIA/SS8B	3452	0.15	3.39	4.25	<0.001	<0.001	2.70
17	VTT/EIA/SS9T	1956	<0.001	1.25	2.23	1.29	<0.001	3.90
18	VTT/EIA/SS9B	1624	<0.001	0.65	3.69	0.40	<0.001	1.63
19	VTT/EIA/SS10T	3024	<0.001	6.15	5.32	<0.001	<0.001	2.63
20	VTT/EIA/SS10B	2145	<0.001	4.48	4.12	1.20	<0.001	0.50
21	VTT/EIA/SS11T	1538	0.36	7.25	1.95	3.02	<0.001	0.63
22	VTT/EIA/SS11B	993	0.61	3.45	2.01	4.79	<0.001	0.59
23	VTT/EIA/SS12T	1256	1.26	1.65	4.46	0.63	<0.001	0.90
24	VTT/EIA/SS12B	1591	0.63	1.30	4.25	1.22	<0.001	0.75
25	VTT/EIA/SS13T	2489	<0.001	1.59	5.11	4.23	<0.001	2.23
26	VTT/EIA/SS13B	1346	<0.001	1.96	3.09	1.46	<0.001	1.30
27	VTT/EIA/SS14T	2639	<0.001	3.56	5.03	<0.001	<0.001	1.56

28	VTT/EIA/SS14B	1711	<0.001	2.06	3.63	1.05	<0.001	0.88
29	VTT/EIA/SS15T	886	<0.001	2.63	3.46	2.50	<0.001	0.36
30	VTT/EIA/SS15B	1245	<0.001	5.28	3.91	<0.001	<0.001	0.51
31	VTT/EIA/SS16T	2678	0.62	4.20	1.63	<0.001	<0.001	1.83
32	VTT/EIA/SS16B	1459	0.23	1.32	1.44	<0.001	<0.001	2.10
33	VTT/EIA/SS17T	1569	0.95	3.28	4.41	<0.001	<0.001	2.50
34	VTT/EIA/SS17B	1365	0.64	1.35	5.22	0.40	<0.001	0.66
35	VTT/EIA/SS18T	2096	0.12	6.50	3.24	<0.001	<0.001	1.42
36	VTT/EIA/SS18B	1964	0.08	4.29	1.78	3.20	<0.001	3.90
37	VTT/EIA/SS19T	2763	<0.001	3.15	2.13	0.80	<0.001	4.12
38	VTT/EIA/SS19B	2149	<0.001	1.48	3.66	1.63	<0.001	1.82
39	VTT/EIA/SS20T	4569	<0.001	8.12	4.22	<0.001	<0.001	1.71
40	VTT/EIA/SS20B	3024	<0.001	7.56	3.74	1.42	<0.001	1.36
41	VTT/EIA/SSC1T	3658	<0.001	0.96	5.25	2.12	<0.001	0.80
42	VTT/EIA/SSC1B	3005	<0.001	1.25	2.63	1.28	<0.001	0.50
43	VTT/EIA/SSC2T	2268	<0.001	0.92	1.49	<0.001	<0.001	0.10
44	VTT/EIA/SSC2B	2736	<0.001	1.12	2.50	<0.001	<0.001	0.32

MICROBIOLOGY

S/N	FIELD CODE	THB (cfu/g)	THF (cfu/g)	HUB (cfu/g)	HUF (cfu/g)	SRB (cfu/g)
1	VTT/EIA/SS1T	6.5 x 10^4	5.8 x 10^3	2.2 x 10^2	1.1 x 10^2	Nil
2	VTT/EIA/SS1B	4.3 x 10^4	3.3 x 10^3	1.3 x 10^2	0.7 x 10^2	Nil
3	VTT/EIA/SS2T	5.2 x 10^4	4.2 x 10^3	1.1 x 10^2	0.5 x 10^2	Nil
4	VTT/EIA/SS2B	4.3 x 10^4	3.0 x 10^3	Nil	Nil	Nil
5	VTT/EIA/SS3T	6.3 x 10^4	4.7 x 10^3	1.0 x 10^2	0.2 x 10^2	Nil
6	VTT/EIA/SS3B	4.2 x10^4	3.8 x 10^3	2.0 x 10^2	1.8 x 10^2	Nil
7	VTT/EIA/SS4T	3.6 x 10^4	2.9 x 10^3	1.0 x 10^2	0.5 x 10^2	Nil
8	VTT/EIA/SS4B	2.3 x 10^4	2.4 x 10^3	Nil	Nil	Nil

FIELD CODE
VTT/EIA/SS1T
VTT/EIA/SS1B
VTT/EIA/SS2T
VTT/EIA/SS2B
VTT/EIA/SS3T
VTT/EIA/SS3B
VTT/EIA/SS4T
VTT/EIA/SS4B

9	VTT/EIA/SS5T	3.6×10^4	6.0×10^3	1.2×10^2	0.8×10^2	Nil	VTT/EIA/SS5T
10	VTT/EIA/SS5B	2.7×10^4	4.3×10^3	1.1×10^2	0.6×10^2	Nil	VTT/EIA/SS5B
11	VTT/EIA/SS6T	5.3×10^4	5.5×10^3	1.7×10^2	1.2×10^2	Nil	VTT/EIA/SS6T
12	VTT/EIA/SS6B	4.1×10^4	4.0×10^3	2.2×10^2	1.2×10^2	Nil	VTT/EIA/SS6B
13	VTT/EIA/SS7T	7.2×10^4	3.3 x 103	3.0×10^2	2.2×10^2	Nil	VTT/EIA/SS7T
14	VTT/EIA/SS7B	6.1×10^4	2.2×10^3	2.3×10^2	1.2×10^2	Nil	VTT/EIA/SS7B
15	VTT/EIA/SS8T	5.8×10^4	4.3×10^3	Nill	Nill	Nil	VTT/EIA/SS8T
16	VTT/EIA/SS8B	4.7×10^4	2.2×10^3	Nill	Nill	Nil	VTT/EIA/SS8B
17	VTT/EIA/SS9T	8.2×10^4	6.0×10^3	2.2×10^2	1.2×10^2	Nil	VTT/EIA/SS9T
18	VTT/EIA/SS9B	4.3×10^4	4.0×10^3	1.0×10^2	0.8×10^2	Nil	VTT/EIA/SS9B
19	VTT/EIA/SS10T	3.2×10^4	3.2×10^3	2.2×10^2	1.4×10^2	Nil	VTT/EIA/SS10T
20	VTT/EIA/SS10B	2.2×10^4	2.0×10^3	1.8×10^2	1.1×10^2	Nil	VTT/EIA/SS10B
21	VTT/EIA/SS11T	4.3×10^4	4.3×10^3	1.0×10^2	Nil	Nil	VTT/EIA/SS11T
22	VTT/EIA/SS11B	3.4×10^4	5.2×10^3	0.3×10^2	Nill	Nil	VTT/EIA/SS11B
23	VTT/EIA/SS12T	5.4×10^4	3.7×10^3	2.0×10^2	1.2×10^2	Nil	VTT/EIA/SS12T
24	VTT/EIA/SS12B	3.0×10^4	3.0×10^3	1.8×10^2	1.0×10^2	Nil	VTT/EIA/SS12B
25	VTT/EIA/SS13T	4.0×10^4	4.8×10^3	1.0×10^2	Nil	Nil	VTT/EIA/SS13T
26	VTT/EIA/SS13B	3.8×10^4	2.9×10^3	0.8×10^2	0.4×10^2	Nil	VTT/EIA/SS13B
27	VTT/EIA/SS14T	6.0×10^4	3.1×10^3	2.8×10^2	1.2×10^2	Nil	VTT/EIA/SS14T
28	VTT/EIA/SS14B	4.3×10^4	4.0×10^3	2.0×10^2	0.8×10^2	Nil	VTT/EIA/SS14B
29	VTT/EIA/SS15T	5.2×10^4	5.5×10^3	Nil	Nil	Nil	VTT/EIA/SS15T
30	VTT/EIA/SS15B	3.0×10^4	2.8×10^3	Nil	Nil	Nil	VTT/EIA/SS15B
31	VTT/EIA/SS16T	4.0×10^4	7.3×10^3	2.2×10^2	1.2×10^2	Nil	VTT/EIA/SS16T
32	VTT/EIA/SS16B	2.7×10^4	4.8×10^3	1.8×10^2	0.7×10^2	Nil	VTT/EIA/SS16B
33	VTT/EIA/SS17T	8.3×10^4	3.6×10^3	2.0×10^2	1.2×10^2	Nil	VTT/EIA/SS17T
34	VTT/EIA/SS17B	5.4×10^4	2.2×10^3	1.5×10^2	0.3×10^2	Nil	VTT/EIA/SS17B
35	VTT/EIA/SS18T	3.7×10^4	5.7×10^3	2.9×10^2	Nill	Nil	VTT/EIA/SS18T

36	VTT/EIA/SS18B	3.0 x 10^4	3.8 x 10^3	1.8 x 10^2	Nill	Nil
37	VTT/EIA/SS19T	4.3 x 10^4	6.2 x 10^3	2.3 x 10^2	0.7 x 10^2	Nil
38	VTT/EIA/SS19B	3.3 x 10^4	4.3 x 10^3	2.0 x 10^2	1.2 x 10^2	Nil
39	VTT/EIA/SS20T	4.9 x 10^4	3.7 x 10^3	Nil	Nil	Nil
40	VTT/EIA/SS20B	3.5 x 10^4	3.0 x 10^3	Nil	Nil	Nil
41	VTT/EIA/SS21T	4.0 x 10^4	4.0 x 10^3	1.5 x 10^2	0.9 x 10^2	Nil
42	VTT/EIA/SS21B	3.1 x 10^4	3.2 x 10^3	1.0 x 10^2	0.6 x 10^2	Nil
43	VTT/EIA/SS22T	6.3 x 10^4	3.6 x 10^3	1.8 x 10^2	0.4 x 10^2	Nil
44	VTT/EIA/22B	4.0 x 10^4	2.2 x 10^3	1.2 x 10^2	0.7 x 10^2	Nil
45	VTT/EIA/SSC1T	3.2 x 10^4	1.6 x 10^3	1.0 x 10^2	0.5 x 10^2	Nil
46	VTT/EIA/SSC1B	2.8 x 10^4	1.2 x 10^3	0.7 x 10^2	Nill	Nil
47	VTT/EIA/SSC2T	5.3 x 10^4	3.8 x 10^3	1.4 x 10^2	1.0 x 10^2	Nil
48	VTT/EIA/SSC2B	3.7 x 10^4	2.2 x 10^3	Nill	Nill	Nil
49	VTT/EIA/SSC3T	2.4 x 10^4	4.2 x 10^3	1.8 x 10^2	0.6 x 10^2	Nil
50	VTT/EIA/SSC3B	1.8 x 10^4	2.7 x 10^3	0.6 x 10^2	0.2 x 10^2	Nil

VTT/EIA/SS18B
VTT/EIA/SS19T
VTT/EIA/SS19B
VTT/EIA/SS20T
VTT/EIA/SS20B
VTT/EIA/SSC1T
VTT/EIA/SSC1B
VTT/EIA/SSC2T
VTT/EIA/SSC2B

BDL =

The predominant genera of bacteria isolated from the soil of the study area were Bacillus, Pseudomonas, Enterobacter, Micrococcus and Staphylococcus.

Predominant fungal genera in the study area are Mucor, Penicillium and Aspergillus.

ELD OML 96

Nitrate mg/kg	Total Nitrogen %	THC mg/kg	Bulk Density g/cm^3	Porosity %	CEC (meq/100g)	Phenols mg/kg			*1mm* VCS
0.486	0.110	2.57	1.47	44.5	11.12	<0.001			6.72
0.442	0.100	2.150	1.49	43.80	13.41	<0.001			5.39
0.354	0.080	1.720	1.83	30.90	12.63	<0.001			6.79
0.265	0.060	1.510	1.72	35.10	12.11	<0.001			4.26
0.575	0.130	1.30	1.88	29.10	13.74	<0.001			3.99
0.530	0.120	1.09	1.75	34.00	12.84	<0.001			4.53
0.486	0.110	2.15	1.73	34.70	13.56	<0.001			5.32
0.442	0.100	1.09	1.99	24.90	12.11	<0.001			5.98
0.398	0.090	0.87	1.91	27.90	14.53	<0.001			5.29
0.265	0.060	0.87	2.01	24.20	15.12	<0.001			8.20
0.486	0.110	2.57	1.56	41.10	15.32	<0.001			2.08
0.442	0.100	1.94	1.63	38.5	10.01	<0.001			3.58
0.530	0.120	2.15	1.89	28.70	11.29	<0.001			4.45
0.486	0.110	1.94	1.77	33.20	10.02	<0.001			4.01
0.530	0.120	1.51	1.91	27.90	18.23	<0.001			4.89
0.486	0.110	1.09	1.91	27.90	12.63	<0.001			3.60
0.442	0.100	2.57	2.22	16.20	14.83	<0.001			6.95
0.398	0.090	2.15	2.41	9.10	11.34	<0.001			4.20
0.575	0.130	2.57	1.87	29.40	9.63	<0.001			3.47

0.442	0.100	2.15	1.98	25.30	13.27	<0.001			5.86
0.707	0.160	1.72	1.81	31.70	13.63	<0.001			4.08
0.619	0.140	0.87	1.84	30.60	10.40	<0.001			5.44
0.486	0.110	1.09	1.61	39.20	12.51	<0.001			5.99
0.442	0.100	0.87	1.85	30.20	11.83	<0.001			3.64
0.575	0.130	0.66	2.17	18.10	12.62	<0.001			12.45
0.530	0.120	0.45	2.22	16.20	12.53	<0.001			8.44
0.354	0.080	0.66	2.42	8.70	14.40	<0.001			14.44
0.309	0.070	0.24	2.33	12.10	14.94	<0.001			8.06
0.442	0.100	1.30	2.03	23.40	16.63	<0.001			5.50
0.354	0.080	1.09	1.93	27.20	11.42	<0.001			6.99
0.619	0.140	1.72	2.00	24.50	11.30	<0.001			4.40
0.486	0.110	0.87	1.88	29.10	10.54	<0.001			6.17
0.398	0.090	0.24	2.06	22.30	11.89	<0.001			7.10
0.309	0.070	0.02	2.25	15.10	12.77	<0.001			4.55
0.442	0.100	0.45	2.36	10.90	18.24	<0.001			7.92
0.398	0.090	0.02	2.30	13.20	16.30	<0.001			5.65
0.575	0.130	1.09	1.78	32.80	11.01	<0.001			11.58
0.442	0.100	0.87	1.90	28.30	12.23	<0.001			11.24
0.486	0.110	1.09	1.98	25.30	12.34	<0.001			13.23
0.398	0.090	0.87	2.09	21.10	11.43	<0.001			2.77
0.354	0.080	1.09	1.78	32.80	12.17	<0.001			9.58
0.309	0.070	0.87	2.38	10.20	12.24	<0.001			7.04
0.442	0.100	0.87	1.70	35.80	12.08	<0.001			6.46
0.398	0.090	0.66	1.60	39.60	12.23	<0.001			6.17
0.265	0.060	0.24	2.03	23.40	14.23	<0.001			10.23
0.221	0.050	0.45	2.19	17.40	14.13	<0.001			7.67
0.354	0.080	0.02	2.14	19.20	14.38	<0.001			6.83
0.309	0.070	0.02	2.05	22.60	14.92	<0.001			7.12
0.442	0.100	1.30	1.80	32.10	15.02	<0.001			6.48
0.398	0.090	1.09	1.99	24.90	14.34	<0.001			7.22

Mn mg/kg	V mg/kg	Zn mg/kg	Ba mg/kg	As mg/kg	K meq/100g	Mg meq/100g	Ca meq/100g	Na meq/100g
44.12	0.06	25.01	0.48	<0.001	0.66	4.02	4.42	0.73
33.18	0.07	20.18	0.36	<0.001	0.78	4.12	4.31	0.96
35.04	0.02	15.28	0.11	<0.001	0.52	2.25	4.50	0.93
14.09	0.06	8.26	0.19	<0.001	0.88	2.96	3.96	1.12
29.06	0.08	22.28	0.50	<0.001	0.25	3.00	5.23	1.36
52.24	0.01	19.67	<0.001	<0.001	0.12	1.63	4.53	0.95
4.18	<0.001	3.67	<0.001	<0.001	0.63	1.92	4.22	3.26
5.06	<0.001	2.46	<0.001	<0.001	1.10	0.86	5.13	1.02
16.05	<0.001	5.63	0.66	<0.001	0.62	5.13	4.04	1.63
10.22	<0.001	4.15	0.91	<0.001	0.54	2.93	5.91	1.28
32.25	<0.001	9.12	0.32	<0.001	0.63	2.03	6.52	1.34
52.63	<0.001	11.85	0.18	<0.001	0.47	2.25	3.90	0.83
38.14	<0.001	6.79	<0.001	<0.001	0.74	3.26	2.22	0.91
49.25	<0.001	11.34	<0.001	<0.001	0.91	2.90	2.01	1.24
68.03	<0.001	18.47	<0.001	<0.001	0.86	4.93	5.03	1.55
52.01	<0.001	20.16	<0.001	<0.001	0.63	2.79	4.23	1.30
50.23	<0.001	24.96	0.70	<0.001	0.81	4.60	4.13	1.33
62.14	<0.001	14.60	0.79	<0.001	0.64	3.04	3.36	0.92
50.02	<0.001	19.63	0.36	<0.001	0.58	1.56	2.74	2.10
38.25	0.02	17.42	0.38	<0.001	0.41	1.63	5.49	1.85
49.06	0.01	8.96	0.47	<0.001	0.70	1.59	7.73	0.74
37.11	0.03	15.58	0.16	<0.001	0.60	1.36	5.08	1.41
40.16	0.05	14.36	<0.001	<0.001	0.41	2.38	5.56	0.93
46.35	0.03	10.02	<0.001	<0.001	0.74	3.03	4.12	1.11
39.06	<0.001	19.66	0.15	<0.001	0.78	2.67	3.92	2.05
40.48	<0.001	25.96	0.28	<0.001	0.61	3.12	3.23	1.40
68.67	<0.001	28.36	<0.001	<0.001	0.33	3.44	3.93	0.43

63.48	<0.001	19.37	<0.001	<0.001	0.65	2.74	3.14	1.97
86.26	<0.001	15.59	<0.001	<0.001	0.41	3.34	5.23	1.40
50.96	<0.001	19.45	<0.001	<0.001	0.78	3.58	2.35	1.48
49.68	<0.001	28.69	0.49	<0.001	0.23	3.11	3.06	2.74
40.25	<0.001	21.33	0.26	<0.001	0.21	2.02	3.41	2.43
49.59	<0.001	26.14	0.50	<0.001	0.62	3.73	2.09	1.24
52.16	<0.001	22.93	0.30	<0.001	0.74	3.21	3.43	1.96
115.36	<0.001	30.01	0.56	<0.001	1.41	3.16	7.02	2.20
119.05	<0.001	25.47	0.38	<0.001	1.26	3.43	5.93	1.27
45.89	<0.001	20.34	0.11	<0.001	1.49	2.84	1.53	1.60
52.90	<0.001	18.88	0.08	<0.001	0.96	2.00	3.43	2.04
23.10	<0.001	50.78	<0.001	<0.001	0.82	1.64	4.02	1.39
21.23	<0.001	44.80	<0.001	<0.001	0.66	3.02	2.90	0.82
38.74	<0.001	19.00	<0.001	<0.001	0.81	5.46	3.11	1.13
26.09	<0.001	25.41	<0.001	<0.001	0.99	3.62	3.92	1.32
25.48	<0.001	32.23	<0.001	<0.001	0.32	3.14	4.53	1.54
16.96	<0.001	30.08	<0.001	<0.001	0.21	3.43	3.61	0.33

HYDROCARBONS

TPH (mg/kg)	PAH (mg/kg)	BTEX (mg/kg)
0.936	0.08	BDL
0.714	0.02	BDL
0.443	0.03	BDL
0.256	0.04	BDL
0.553	BDL	BDL
0.512	BDL	BDL
0.748	BDL	BDL
0.602	BDL	BDL

0.616	BDL	BDL
0.403	BDL	BDL
0.234	0.06	BDL
0.413	0.18	BDL
0.993	0.05	BDL
0.714	0.06	BDL
0.532	0.07	BDL
0.436	BDL	BDL
0.921	0.12	BDL
0.918	BDL	BDL
0.838	0.09	BDL
0.808	0.04	BDL
0.330	0.02	BDL
0.621	0.05	BDL
0.513	0.06	BDL
0.096	BDL	BDL
0.312	BDL	BDL
0.234	BDL	BDL
0.431	BDL	BDL
0.062	BDL	BDL
0.452	0.02	BDL
0.214	0.03	BDL
0.212	0.04	BDL
0.145	0.02	BDL
0.103	BDL	BDL
0.008	BDL	BDL
0.203	0.01	BDL

0.008	BDL	BDL
0.400	BDL	BDL
0.314	BDL	BDL
0.347	BDL	BDL
0.246	BDL	BDL
0.379	BDL	BDL
0.553	BDL	BDL
0.008	BDL	BDL
0.007	BDL	BDL

Below Detection Limit of 0.01

PARTICLE SIZE							
				%	%	%	
0.5mm **CS**	***0.25mm*** **MS**	***0.106mm*** **FS**	***<0.106mm*** **VFS**	**TOTAL SAND**	**TOTAL SILT**	**TOTAL CLAY**	**TEXTURE**
15.38	13.09	13.26	1.41	50	16	34	SANDY CLAY LOAM
18.09	16.39	11.63	1.27	53	17	30	SANDY CLAY LOAM
20.83	19.23	21.68	0.94	69	13	18	SANDY CLAY
20.23	24.13	15.88	0.80	65	18	17	SANDY CLAY
14.33	21.00	16.12	0.49	56	21	23	SANDY CLAY LOAM
15.07	22.91	16.29	0.44	59	18	23	SANDY CLAY LOAM
18.77	20.40	20.31	0.45	65	14	21	SANDY CLAY LOAM
19.01	21.06	17.58	0.89	65	14	21	SANDY CLAY LOAM
18.90	20.98	25.71	0.38	71	20	9	SANDY LOAM
20.08	22.19	23.76	0.53	75	15	10	SANDY LOAM
12.38	19.94	26.18	0.95	62	28	10	SANDY LOAM
13.18	16.04	18.49	0.72	52	35	13	SANDY LOAM
13.34	18.72	19.23	1.03	57	30	13	SANDY LOAM
17.51	23.28	18.48	0.49	64	21	15	SANDY LOAM
17.55	22.53	22.82	0.77	69	19	12	SANDY LOAM
19.28	22.20	22.98	0.88	69	21	10	SANDY LOAM
18.57	25.71	15.33	0.86	67	19	14	SANDY LOAM
16.60	24.02	21.09	0.68	67	21	12	SANDY LOAM
18.47	24.49	20.61	0.82	68	21	11	SANDY LOAM

21.47	24.55	18.49	0.82	71	19	10	SANDY LOAM
17.25	21.80	16.87	0.57	61	24	15	SANDY LOAM
21.77	28.23	17.14	0.81	73	18	9	SANDY LOAM
17.32	23.88	11.80	0.56	60	30	10	SANDY LOAM
15.42	25.86	11.49	0.67	57	25	18	SANDY LOAM
19.50	14.96	13.71	0.29	61	17	22	SANDY CLAY LOAM
18.60	20.13	14.77	0.67	63	4	33	SANDY CLAY LOAM
23.74	18.20	12.17	0.59	69	11	20	SANDY CLAY LOAM
20.54	19.10	12.96	0.48	61	14	25	SANDY CLAY LOAM
20.52	23.66	18.75	1.37	70	12	18	SANDY LOAM
20.18	24.28	17.78	1.9	71	14	15	SANDY LOAM
20.05	28.57	15.18	0.75	69	13	18	SANDY LOAM
18.91	24.47	19.82	0.91	70	14	16	SANDY LOAM
21.41	25.16	25.67	1.62	81	11	8	LOAM SAND
18.91	31.55	23.05	0.91	79	13	8	LOAM SAND
20.68	25.51	21.93	0.97	77	14	9	SANDY LOAM
18.85	27.32	26.21	1.01	79	12	9	SANDY LOAM
21.25	21.16	13.79	1.34	69	14	17	SANDY LOAM
19.12	20.85	14.89	1.63	68	12	18	SANDY LOAM
24.54	19.07	10.86	1.64	69	17	14	SANDY LOAM
7.35	72.12	6.24	0.59	89	7	4	SAND
33.92	25.02	12.32	1.56	82	10	8	LOAM SAND
26.07	28.97	20.38	1.24	84	9	7	LOAM SAND
24.62	30.67	20.31	1.44	83	6	11	LOAM SAND
24.98	22.53	24.19	0.98	79	14	7	LOAM SAND
28.76	25.52	16.1	1.62	82	4	14	SANDY LOAM
26.62	27.37	22.04	1.81	86	3	11	SANDY LOAM
21.59	27.61	20.18	1.2	77	6	17	SANDY LOAM
21.83	30.87	15	1.35	76	10	14	SANDY LOAM
16.78	23.55	19.04	0.29	66	17	17	SANDY LOAM
20.85	29.72	26.42	0.31	85	6	9	LOAM SAND

NAME OF CLIENT: *VTT LNG*
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF PROPOSED VTT LNG FACILITY IN GELEGELE FIELD OMI
DATE OF SAMPLE RECEIVED: 16/11/2019
PERIOD OF ANALYSIS: *17th November - 16th December, 2019*
SAMPLE MATRIX: *GROUND WATER*
NUMBER OF SAMPLE: *5*

FIELD CODE	pH	E/COND (µS/cm)	Temp. (^oC)	Redox Potential (mV)	TDS (mg/l)	Colour (Pt-Co)	Alkalinity (mg/L as	Chloride (mg/l)	TSS (mg/l)
Ground Water 1	6.8	192	31.2	-3	96.00	4	90.00	28.99	6.56
Ground Water 2	6.50	51	27.2	-37	25.00	4	120.00	12.49	7.98
Ground Water 3	7.20	44	33.2	26	22.00	3	180.00	11.00	8.77
Ground Water C1	5.70	46	32.5	50	23.00	1	130.00	8.00	1.24
Ground Water C2	5.70	48	31.2	82	22.00	1	30.00	7.00	1.03

HEAVY METALS

FIELD CODE	Fe (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Cu (mg/l)	Hg (mg/l)	Ni (mg/l)	V (mg/l)	Zn (mg/l)
Ground Water 1	2.023	0.015	<0.001	<0.001	0.031	<0.001	<0.001	<0.001	0.425
Ground Water 2	2.113	0.073	<0.001	<0.001	0.063	<0.001	<0.001	<0.001	0.191
Ground Water 3	0.235	<0.001	<0.001	<0.001	0.134	<0.001	<0.001	<0.001	0.183
Ground Water C1	<0.001	<0.001	<0.001	<0.001	0.011	<0.001	<0.001	<0.001	0.113
Ground Water C2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.140

MICROBIOLOGY

	THB	THF	HUB	HUF	Faecal Coliform

FIELD CODE	(cfu/ml)	(cfu/ml)	(cfu/ml)	(cfu/ml)	MPN/100ml
Ground Water 1	1.8×10^3	1.2×10^2	Nil	Nil	Nil
Ground Water 2	2.4×10^3	1.0×10^2	Nil	Nil	Nil
Ground Water 3	1.0×10^3	0.6×10^2	Nil	Nil	Nil
Ground Water C1	1.2×10^3	0.8×10^2	Nil	Nil	Nil
Ground Water C2	0.7×10^3	0.5×10^2	Nil	Nil	Nil

The predominant genera of bact
Bacillus and Pseudomonas

GROUNDWATER HYDROCARBON RESULTS

COMPONENT	Ground water 1	Ground water 2	Ground water 3	Ground water Control 1	Ground water Control 2
TPH (mg/l)	BDL	BDL	BDL	BDL	BDL
PAH (mg/l)	BDL	BDL	BDL	BDL	BDL
Benzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Tolune (mg/l)	BDL	BDL	BDL	BDL	BDL
Ethylbenzene (mg/l)	BDL	BDL	BDL	BDL	BDL
Xylene (mg/l)	BDL	BDL	BDL	BDL	BDL

BDL = Below Detection Limit of 0.01

Total Hardness (mg/L as $CaCO_3$)	DO (mg/l)	Turbidity (NTU)	BOD_5 (mg/l)	COD (mg/l)	O & G (mg/l)	THC (mg/l)	Carbonate (mg/l)	Phosphate (mg/l)	Ammonium (mg/l)	Nitrate (mg/l)	Salinity (mg/l)
13	6.5	7.6	8.40	48	<0.01	<0.01	<0.001	0.025	0.07	0.142	52.37
13	5.70	5.2	9.30	51.2	<0.00	<0.00	<0.001	0.016	0.05	0.18	22.56
19	6.2	5.9	8.70	45.87	<0.01	<0.01	<0.001	0.028	0.12	0.154	19.87
6	6.30	<0.1	4.80	29.87	<0.01	<0.01	<0.001	<0.001	0.03	0.046	14.45
3	6.80	<0.1	4.50	32	<0.01	<0.01	<0.001	0.004	0.01	0.03	12.65

Ba (mg/l)	Mn (mg/l)
<0.001	0.234
<0.001	0.314
<0.001	0.296
<0.001	0.204
<0.001	0.246

teria isolated from the ground water of the study area were

Sulphate (mg/l)	Na (mg/l)	K (mg/l)	Mg (mg/l)	Ca (mg/l)
9.304	18.24	1.36	3.24	8.45
5.097	10.02	1.04	3.21	5.12
2.33	9.24	0.33	0.52	1.56
5.097	10.54	0.29	0.63	1.68
1.973	10.76	0.11	0.84	1.74

Appendix 4.5-Wet and Dry Seasons Results Summary

SUMMARY OF GROUNDWATER RESULTS

Parameters	Unit	DRY SEASON			WET SEASON		
		Min	Max	Average	Min	Max	Average
pH		6.34	6.84	6.57	5.7	7.2	6.38
E/COND	(µS/cm)	45	346	149.4	44	192	76.2
Temp.	(^oC)	25.4	26	25.76	27.2	33.2	31.06
Redox	Potential (mV)	98	134	116.4	-37	82	23.6
TDS	(mg/l)	24.75	190.3	82.17	22	96	37.6
Colour	(Pt-Co)	1	7	4.2	1	4	2.6
Alkalinity	(mg/L as $CaCO_3$)	2	30	18	30	180	110
Chloride	(mg/l)	17.49	102.97	46.786	7	28.99	13.496
TSS	(mg/l)	0.86	7.48	4.778	1.03	8.77	5.116
Total Hardness	(mg/L as $CaCO_3$)	6	43	23.8	3	19	10.8
DO	(mg/l)	8.3	10.6	9.52	5.7	6.8	6.3
Turbidity	(NTU)	11.4	13.9	12.63333	5.2	7.6	6.233333
BOD_5	(mg/l)	1.3	1.6	1.4	4.5	9.3	7.14
COD	(mg/l)	2.41	6.01	4.192	29.87	51.2	41.388
O & G	(mg/l)	0.364	0.474	0.419	<0.001	<0.001	<0.001
THC	(mg/l)	0.15	0.261	0.2055	<0.001	<0.001	<0.001
Carbonate	(mg/l)	0	0	0	<0.001	<0.001	<0.001
Phosphate	(mg/l)	0.075	0.107	0.086667	0.004	0.028	0.01825
Ammonium	(mg/l)	0.06	0.1	0.0804	0.012	0.12	0.0566
Nitrate	(mg/l)	0.126	0.21	0.16475	0.03	0.18	0.1104
Salinity	(mg/l)	0.02	0.16	0.072	12.65	52.37	24.38
Sulphate	(mg/l)	1.612	22.28	7.1158	1.973	9.304	4.7602
Na	(mg/l)	8.19	58.39	25.522	9.24	18.24	11.76
K	(mg/l)	0.1	1.02	0.52	0.11	1.36	0.626
Mg	(mg/l)	0.67	3.16	1.66	0.52	3.24	1.688
Ca	(mg/l)	1.29	8.04	4.366	1.56	8.45	3.71
Fe	(mg/l)	0.201	2.078	1.409667	0.235	2.113	1.457
Cd	(mg/l)	0.013	0.06	0.0365	0.015	0.073	0.044
Cr	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	(mg/l)	0.03	0.09	0.06	<0.001	<0.001	<0.001
Cu	(mg/l)	0.031	0.12	0.068	0.011	0.134	0.05975
Hg	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	(mg/l)	0.1	0.329	0.1844	0.113	0.425	0.2104
Ba	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	(mg/l)	0.117	0.268	0.164	0.204	0.314	0.2588
THB	(cfu/ml)	0.7	2.1	2.5	0.7	2.4	1.42
THF	(cfu/ml)	0.2	1.4	0.7	0.5	1.2	0.84
HUB	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
HUF	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Coliform	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil
TPH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
PAH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

BENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
TOLUENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
ETHYLBENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
XYLENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

SUMMARY OF SEDIMENT RESULTS

Parameter	Unit	Dry Season			Wet Season		
		Min	Max	Mean	Min	Max	Mean
pH		4.3	5.6	5.098	6.72	7.25	6.976
Electrical Conductivity	µs/cm	141	251	171	32	413	190
Redox Potential	mV	82	169	113.6	57	72	68
Chloride	mg/kg	35.45	70.9	49.632	7.09	88.63	38.288
Sulphate	mg/kg	37.76	76.47	55.03	2.36	92.71	38.498
TOC	%	0	0.1	0.04	0.12	6.32	2.34
Phenols	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Carbonate	mg/kg	0	0	0	0	0	0
Nitrate	mg/kg	0.221	0.354	0.2828	2.21	5.53	3.76
THC	mg/kg	0.02	0.45	0.28	0.43	2.12	1.17
SAND		79	93	84.8	18	99	65.4
SILT		4	9	6	0	46	19.2
CLAY		3	15	9.2	1	36	15.4
Fe	mg/kg	345.00	1624.00	924.00	279.40	1417.80	788.80
Cd	mg/kg	0.14	0.96	0.45	0.25	1.25	0.75
Cu	mg/kg	1.18	1.96	1.47	0.90	1.80	1.28
Pb	mg/kg	0.93	6.02	3.25	0.80	4.40	2.48
Cr	mg/kg	0.00	0.39	0.25	0.14	0.32	0.23
Hg	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	mg/kg	<0.001	<0.001	<0.001	0.850	1.230	1.007
Mn	mg/kg	5.34	63.24	21.99	4.36	55.80	19.34
V	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/kg	9.96	27.92	14.50	7.93	25.14	12.81
Ba	mg/kg	0.23	0.96	0.55	0.17	0.74	0.41
K	meq/100g	0.23	0.93	0.61	0.13	0.83	0.48
Mg	meq/100g	1.65	3.93	2.58	1.00	3.89	2.12
Ca	meq/100g	2.84	4.94	3.70	2.07	4.47	3.14
Na	meq/100g	0.36	1.08	0.74	0.40	1.15	0.70
THB	cfu/g	2.70	10.20	7.42	3.80	12.20	9.14
THF	cfu/g	3.10	6.90	4.64	2.00	7.90	4.66
HUB	cfu/g	1.00	3.20	2.36	1.30	5.30	3.36
HUF	cfu/g	0.60	2.80	1.40	0.50	4.20	1.70

SUMMARY OF SOIL RESULTS

Parameter	Unit	Dry Season						Wet Season					
		0-15			15-30			0-15			15-30		
		MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN
pH		5.23	6.79	5.98	4.75	6.74	5.97	6.1	7.3	6.61	6.24	7.1	6.58
Conductivity	µs/cm	184	488	293.57	107	425	258.74	35	326	164.82	42	268	142.86
Chloride	mg/kg	35.45	124.08	71.10	17.73	106.35	60.50	3.55	88.63	31.26	3.55	70.9	23.85
Sulphate	mg/kg	37.76	138.99	91.48	19.89	130.06	78.80	2.36	87.4	39.96	2.36	74.11	40.41
TOC	%	0.23	5.11	2.34	0.08	4.52	1.83	0.2	4.37	1.85	0.04	3.12	1.32
Phosphorous	%	0.002	0.006	0.00	0.001	0.005	0.00	0.006	0.018	0.01	0.005	0.016	0.01
Ammonium	mg/kg	0.077	0.206	0.14	0.065	0.181	0.12	1.802	4.64	3.14	1.54	4.12	2.73
Nitrate	mg/kg	0.265	0.707	0.48	0.221	0.619	0.41	4.635	11.94	8.08	3.975	10.605	7.02
Nitrogen	%	0.06	0.16	0.11	0.05	0.14	0.09	0.06	0.16	0.11	0.07	0.18	0.12
THC	mg/kg	0.02	2.57	1.37	0.02	2.15	1.03	0.26	1.44	0.98	0.09	1.43	0.83
Density	g/cm3	1.47	2.42	1.93	1.49	2.41	1.98	1.34	2.33	1.75	1.42	2.62	1.93
Porosity	%	8.7	44.5	27.04	9.1	43.8	25.39	21.9	49.4	34.40	16.2	47.2	33.71
CEC	(meq/100g)	9.63	18.24	13.61	10.01	16.3	12.64	10.26	19.069	13.48	9.665	16.462	12.62
Phenols	mg/kg	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
SAND		50	82	67.17	52	89	69.43	46	88	71.36	38	83	70.59
SILT		4	30	17.00	3	35	15.26	3	46	16.32	6	51	16.64
CLAY		8	34	15.83	4	33	15.22	4	32	12.32	2	23	12.77
TEXTURE		0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Fe	mg/kg	886	30245	3410.26	993	3624	1954.70	772.4	3528	2100.21	879.2	3558.4	2023.91
Cd	mg/kg	0.12	1.26	0.56	0.08	0.95	0.50	0.52	0.95	0.72	0.3	0.83	0.54
Cu	mg/kg	1.25	8.68	4.07	0.65	10.25	3.49	0.81	7.26	3.34	0.77	9.47	2.88
Pb	mg/kg	1.04	5.32	3.18	0.36	5.22	2.83	0.45	4.95	2.84	0.55	4.8	2.42
Cr	mg/kg	0.4	4.23	1.66	0.4	4.79	1.62	0.9	5.5	2.25	0.5	4.7	1.80
Hg	mg/kg	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
Ni	mg/kg	0.36	4.39	1.99	0.49	3.9	1.59	0.2	4.2	1.74	0.25	4.15	1.28
Mn	mg/kg	4.18	115.36	46.84	5.06	119.05	48.16	8.32	107.52	44.81	7.92	107.14	40.49
V	mg/kg	0.01	0.08	0.04	0.01	0.07	0.04	0.01	0.06	0.04	0.02	0.09	0.05
Zn	mg/kg	3.67	50.78	19.89	2.46	44.8	19.07	6.315	49.8	18.44	6.445	34.15	16.08
Ba	mg/kg	0.11	0.7	0.40	0.08	0.91	0.39	0.07	0.495	0.31	0.105	0.6	0.27

As	mg/kg	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
K	meq/100g	0.21	1.49	0.66	0.12	1.41	0.69	0.385	1.323	0.675	0.497	1.103	0.681
Mg	meq/100g	1.56	5.13	3.02	0.86	4.12	2.72	1.407	5.141	2.919	0.735	3.552	2.508
Ca	meq/100g	1.53	7.73	4.19	2.01	7.02	4.00	1.988	7.161	4.171	1.927	6.063	3.890
Na	meq/100g	0.43	3.26	1.55	0.82	2.74	1.46	0.492	2.216	1.309	0.700	2.317	1.337
THB	cfu/g	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
THF	cfu/g	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
HUB	cfu/g	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
HUF	cfu/g	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
SRB	cfu/g	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00
TPH	mg/kg	0	0	0.00	0	0	0.00	0.1474	0.9572	0.56	0.051	0.8046	0.45
PAH	mg/kg	0	0	0.00	0	0	0.00	0.01	0.12	0.06	0.02	0.13	0.06
BTEX	mg/kg	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00

SUMMARY OF SURFACE WATER RESULTS

Parameters	Unit	DRY SEASON			WET SEASON		
		Min	Max	Average	Min	Max	Average
pH		6.8	8.9	7.6	6.62	7	6.774
E/COND	(μS/cm)	38	48	42.4	133	138	135.6
Temp.	(^{o}C)	27.2	27.9	27.52	26.2	26.8	26.5
Redox	Potential (mV)	15	171	59.2	145	213	186
TDS	(mg/l)	19	22	20	73.15	75.9	74.58
Colour	(Pt-Co)	6	11	7.8	6	14	9.8
Alkalinity	g/L as CaC(	20	50	36	8	20	12.4
Chloride	(mg/l)	9	13.5	11.3	51.48	55.98	53.78
TSS	(mg/l)	1.68	2.31	2.048	1.26	2.21	1.792
Total Hardness	g/L as CaC(	5	13	9.6	13	18	15.6
DO	(mg/l)	6.7	8.9	8.06	8.6	9.5	9
Turbidity	(NTU)	3.1	3.6	3.32	3	4.1	3.5
BOD_5	(mg/l)	5.1	7.5	6.18	3.3	5.7	4.5
COD	(mg/l)	30.93	42.67	36.906	15.6	26.26	21.352
O & G	(mg/l)	0.344	0.984	0.664	1.12	2.02	1.424
THC	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Carbonate	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phosphate	(mg/l)	0.007	0.033	0.0184	0.098	0.151	0.114
Ammonium	(mg/l)	0.011	0.08	0.051	0.05	0.1	0.074
Nitrate	(mg/l)	0.036	0.241	0.1474	0.135	0.225	0.1808
Salinity	(mg/l)	16.26	24.39	20.416	0.06	0.07	0.066
Sulphate	(mg/l)	2.934	6.78	5.1454	3.655	4.737	4.208
Na	(mg/l)	6.24	9.632	8.4804	15.93	19.9	18.17
K	(mg/l)	0.14	0.28	0.208	0.18	0.47	0.32
Mg	(mg/l)	0.45	1.13	0.848	1.48	2.35	1.858
Ca	(mg/l)	2.02	3.24	2.602	5.55	6.3	5.928
Fe	(mg/l)	0.443	0.965	0.6582	0.315	0.776	0.5406
Cd	(mg/l)	0.005	0.019	0.0105	0.006	0.013	0.0095
Cr	(mg/l)	0.004	0.006	0.005	0.002	0.004	0.003
Pb	(mg/l)	0.316	0.626	0.4558	0.34	0.56	0.47
Cu	(mg/l)	0.003	0.015	0.0094	0.004	0.015	0.0096
Hg	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ni	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
V	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	(mg/l)	0.108	0.139	0.1226	0.102	0.129	0.1164
Ba	(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	(mg/l)	0.025	0.163	0.107	0.065	0.15	0.118
THB	(cfu/ml)	0.7	2.1	2.5	3	6.6	5.32
THF	(cfu/ml)	0.2	1.4	0.7	1.2	5	2.28
HUB	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
HUF	(cfu/ml)	Nil	Nil	Nil	Nil	Nil	Nil
ecal Colifo	MPN/100m	Nil	Nil	Nil	Nil	Nil	Nil
TPH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

PAH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
BENZENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
TOLUENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
HYLBENZE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL
XYLENE	mg/l	BDL	BDL	BDL	BDL	BDL	BDL

APPENDIX 4.6A

INTERVIEW GUIDE ON SOCIO-ECONOMIC INDICATORS

1. Age: ……………………………………………………………………………………….
2. Marital Status):………………………………………… ………………………….
3. Ethnic Group: …………………………………………………………………………
4. Religion: ……………………………………………………………………………….
5. Highest Qualification: ………………………………………………………………
6. Number of Children had: ………………………………………………………….
7. How many persons are there in your household? (probe for sex and age composition)
8. For how long have you lived in this settlement? (Probe to know whether or not respondent hails from the settlement)
9. What do you do for a living? (probe to know respondent's nature of occupation and average monthly income). **Probe for the major economic activities in the settlement.**
10. Please describe the ownership of your apartment (probe further to know the nature of respondent's apartment; whether respondent has a personal room; number of persons living in a room; the nature of the building; the monthly rent (in naira); toilet facilities and the roofing. **Take picture where necessary.**
11. How and where do you source for water? (Probe to know the quality of water consumed by respondent). **Take picture where necessary.**
12. Tell us about source(s) of energy for cooking. (Interviewer should probe to know why community members prefer that source and whether they are willing to embrace modern sources). **You may need to take pictures of the cooking environment.**
13. Please tell us how you manage your domestic wastes. (Probe to know if respondent benefits from governmental agencies responsible for waste management).
14. Please describe the nature and conditions of health facilities in your community. (Probe for the number of health centres/clinics/hospitals and their proximity; accessibility to health facilities; affordability, and friendliness of health workers. Also probe for the use of traditional medicine).

15. Please tell us about the culture, festivals, deities and sacred places in this community. (Probe deeply to understand the cultural dynamics of the people, and to know if there are cultural practices that may be affected by the project).
16. What do you consider to be the development challenges in this community? (probe for availability of good roads, markets, schools and so on).
17. What is your perception of this project? What kinds of businesses and properties do you think would be affected by this project and how will it affect them?

APPENDIX 4.6B

QUESTIONNAIRE FOR THE ASSESSMENT OF SOCIO-ECONOMIC CHARACTERISTICS

Dear respondent,

We are conducting a study on the socio-economic characteristics of residents in this community. You have been selected to participate by completing a questionnaire. Please note that your participation is strictly voluntary. You may choose to terminate your participation at any point or refuse to participate at all. I assure you that any information you supply shall be treated anonymously.

SOCIO-ECONOMIC AND HEALTH ASSESSMENT QUESTIONNAIRE

Name of Settlement/Community: ……………………………

L.G.A/State: ……………………………………………………

Interviewer: …………………………………………………..

Date: …………………………………………………………..

Please tick as appropriate response where applicable

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

QUESTIONS	RESPONSE		Write the number here
1. Sex	1) Male	2) Female	
2. Actual Age	…………………………………………….		
3. Education	1) No formal education 2) Primary 3) Secondary 4) OND/NCE	5) HND/B.Sc 6) Postgraduate degree(s)	
4. Religion	1) None 2) Christianity 3) Islam	4) Traditional 5) Others (pls specify)	
5a. Marital Status	1) Never married 2) Married	3) Separated/Divorced 4) Widowed	
5b. If married, what is the marriage type?	1) Monogamy (only one spouse) 2) Polygyny (one man with two or more wives)	3) Polyandry (One woman with two or more husbands)	
6. Ethnic Group	1) Hausa 2) Igbo 3) Igala	4) Igbira 5) Yoruba 4) Others (pls specify)	
7. What is the nature of the apartment wherein you stay?	1) A single room 2) Room and parlour	3) Flat 4) Duplex 5) Others (pls specify)	
8. How many people including you stay in your household?	…………………………………………………		

9. Why are you in this community?

Purpose in the community	**Please Tick**
Living in the community	
Working in the community	
Living and working in the community	
Other (specify)	

10. For how long have you been living in the community?

……………………………………………………………………

11. Residency Status

Status of Resident	Please tick the option that applies to you
Landlord	
Tenant	
Living in family house without rent payment	
Other (specify)	

12. Income Source

INCOME SOURCE		₦
Agriculture	Crop farming	
	Livestock sales	
	Crop, vegetable, fruit sales	
	Animal products' sales	
	Other (specify)	
Employment (non-farm)	Civil service	
	Private sector	
	Self-employment: petty trading (hairdresser, seamstress, carpenter etc), sale of handicrafts	
Other income sources	Pensions	
	Housing and land rent	
	Other income sources (specify) ………..	
ESTIMATED TOTAL MONTHLY INCOME		

13A. Buildings/structures (more than one option/material is possible)

Building Type	Frequency	Number
Which of the followings describe the type of building wherein you live?	1) Mud wall un-plastered with thatch roof 2) Mud wall un-plastered & zinc roof 3) Mud wall plastered with cement & zinc roof 4) Cement block wall un-plastered & zinc roof 5) Cement block wall plastered & zinc roof	

13B. Toilet facilities:

Kindly indicate the toilet type in your house	Please tick
No toilet	
Pit latrine	
Water Closet toilet	

14. Expenditure

Indicate the effect of the following expenditure items on your family income over the past year (Multiple options are allowed)

Item	Very strong effect	Strong effect	Minor effect	No effect
Food				
Education				
Health				
Transport				
Hire of labour				
Other (specify)				

15. Which ailments have persons in your household suffered from in the past 1 year? (Multiple options are allowed)

Illness	Please Tick
Malaria	
Cough / lung problems	
Diarrhea	
Skin infection	
Sexually transmitted disease	
Eye disease	
Tooth ache	
Cholera	
Fever	
Birth complications (women)	
Other (specify) …………………………………………	

16. Where do you normally seek help when a member of your household is sick?

Facility	Please Tick
Government hospital	
Private health facility	
Traditional healer	
Chemist / pharmacy	
Self-medication(orthodox or herbs)	

17. Where does your household get water from? ***(more than one answer may be given)***

Source	Drinking/Cooking,	Washing, / Others
Borehole		
Well		
Rain collected at homestead		
River /spring		
Water sold by other people		
Other (specify) ………………………………		

18. Source of fuel or energy for cooking

Source	Please
Electricity	
Gas	
Charcoal	
Wood	
Other (specify) …………………………………………………..	