



The Shell Petroleum Development Company of Nigeria Limited
Operator of the NNPC/Shell/Agip/TEPNG Joint Venture

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FINAL REPORT

FOR

THE PROPOSED UZU FIELD DEVELOPMENT PROJECT IN YENAGOA
LOCAL GOVERNMENT AREA, BAYELSA STATE

BY

SHELL PETROLEUM DEVELOPMENT COMPANY OF NIGERIA
LIMITED

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Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
BOD ₅	Biological Oxygen Demand
Bscf	Billion Standard Cubic Feet
CAS	Catch Assessment Survey
CBO	Community Based Organisation
CBR	Crude Birth Rate
CDR	Crude Death Rate
CEC	Cation Exchange Capacity
COD	Chemical Oxygen Demand
CPF	Central Processing Facility
CTRL	Control station
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FME _{env}	Federal Ministry of Environment
GEM	Gender Empowerment Measure
HAZID	Hazard Identification
HAZOP	Hazard Operability
HDI	Human Development Index
HIA	Health Impact Assessment
HPI	Human Poverty Index
HSE	Health, Safety, Environment
IFC	International Finance Corporation
ISO	International Standards Organisation
JV	Joint Venture
LGA	Local Government Area
MEDEVAC	Medical Emergency Evacuation
MMscfd	Million Standard Cubic Feet per day
MMstb	Million Stock Tank Barrel
NAG	Non-Associated Gas
NGO	Non-Governmental Organisation
NIWA	National Inland Waterways Authority
NLNG	Nigeria Liquefied Natural Gas
OML	Oil Mining Lease
PRA	Participatory Rural Appraisal
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
RoW	Right of Way

SCD	Sustainable Community Development
SD	Sustainable Development
SIA	Social Impact Assessment
SMART	Specific, Measurable, Achievable, Realistic and Time-based
SPDC	Shell Petroleum Development Company of Nigeria Limited
SWL	Static Water Level
TDS	Total Dissolved Solid
TEG	Tri-Ethylene Glycol
THC	Total Hydrocarbon
ToR	Terms of Reference
TSS	Total Suspended Solid
VOC	Volatile Organic compounds

Executive Summary

ES 1.0: Background Information

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), undertook the Environmental Impact Assessment (EIA) study for the Uzu Field Development and Uzu Deep Exploration. This study is in compliance with the Federal Ministry of Environment EIA Act and the Department of Petroleum Resources regulations. Uzu field is part of the multi-field Gbaran node that is being developed in phases to support SPDC's gas supply obligation to NLNG T1-T6; and, grow oil production. The Gbaran node has a central processing facility (CPF) located in Gbaran field with a 1.25Bscf/d NAG plant and a 120Mbpd oil processing facility. Uzu field development is more of a gas project, with the development objective of 815 Bscf (UR) of gas and 11.3 MMstb (UR) of condensate. The Uzu field development project activities, which this EIA study covers includes drilling, construction of flow lines, bulk lines and pipelines and expansion/upgrade of Gbaran CPF.

ES 2.0: Project Location

Uzu Field is a partially appraised field located in OML-28, in Yenagoa Local Government Area (LGA) Bayelsa State, which is about 85km Northwest of Port Harcourt. The field extends approximately 6 km in the North-South and 13 km in the East-West directions.

ES 3.0: Objectives of the EIA

The objectives of the study are:

- To establish the baseline conditions of the proposed project area with respect to the biophysical, social and health environment.
- To identify and evaluate the potential impacts of the project activities on the biophysical environment of the area.
- To identify and assess the potential socio-economic effects of the project on the communities' livelihood patterns, including impacts on cultural properties, social infrastructures, natural resources and values.
- To identify and evaluate health impacts that may be associated with different activities of the project.
- To develop cost-effective mitigation measures and appropriate Environmental Management Plan (EMP) for sustainable development.

ES 4.0: Legal and Administrative framework

There are legislations, guidelines and standards that govern the assessment of environmental impacts of development projects in the oil and gas industry in Nigeria. These regulations can be classified as follows:

National Legislations and Standards

The Mineral Oil (Safety) Regulations, 1963

Oil Pipelines Ordinances (CAP) 145, 1956 and Oil Pipelines Act, 1965

Petroleum (Drilling and Production) Regulations (1969)

Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988

FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995)

National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv)

Environmental Impact Assessment Act CAP E12 LFN 2004

FEPA (Now FMEnv) National Guidelines for Spilled Oil Fingerprinting (Act 14 of 1999)

FEPA (Now FMEnv) National Guidelines on Waste Disposal through Underground Injection (1999)

FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999)

FEPA (Now FMEnv) National Policy on the Environment (1989)

Forestry Law CAP 51, 1994

Land Use Act of 1978

National Oil Spill Detection and Response Agency (NOSDRA), 2006

Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26)

Endangered Species (Control of International Trade and Traffic) Act 11 of 1985

International Laws and Regulations guiding Environmental management

World Bank Guidelines on Environmental Assessment {EA} (1991)

International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines

Convention on the Migratory Species of Wild Animals (Bonn Convention)

Convention of Biological Diversity

Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and.

United Nations Framework Convention on Climate Change (1992)

Environmental laws and guidelines guiding Environmental management in Bayelsa State

Bayelsa State Environmental and Development Planning Authority Law 1998;

Bayelsa State Pollution Compensation Tax Law 1998;

Bayelsa State Forestry Law 1998.

Bayelsa State Land Use (Environmental Degradation/Protection) Charge Law 2005.

SPDC HSE policy, Biodiversity policy, Emergency response policy, Community relations policy, Waste management policy, Business principles and governing polices

ES 5.0: Project Justification

Need for the Project

The Uzu development is in the Export gas market tranche that will deliver both upstream value (SPDC gas sale) and midstream value (NLNG sale) to Shell, Partners and the Nigerian Government.

Value of The Project

The revenue that will accrue from the sales of gas to be produced from these wells will substantially increase the foreign exchange earnings of the Federal Government and help to improve the social and health standards of the inhabitants of the area covered by the project. The total value of project is put at about F\$400 million.

Envisaged Sustainability

The project project will environmentally sustainable with the implementation of the Environmental Management Plan, an output of this study. Although this project is primarily aimed at gas development, oil is also being matured to ensure that the full resource base is developed. The project would also lead to employment and prosperity of local people and businesses.

Project Objectives

The objectives of the study are:

To meet SPDC gas supply obligation to NLNG T1-T6.

To upgrade Gbaran CPF via installation of an additional 200MMscfd TEG dehydration system with its ancillaries and brownfield tie-ins.

ES 6.0: Project Options and Alternatives

Project Options and Alternatives

The Project options explored for Gas exploration includes:

1: Enwhe Replica (Similar to Gbaran Ph 3A Enwhe project)

Direct tie-in to Gbaran CPF

CS bulkline (B/L) to Gbaran CPF

CI injection for corrosion management

Slug catcher at CPF inlet

2: Abasare Replica (Similar to Gbaran Ph 3A Abasare project)

Tie-in via Zarama manifold/bulkline

DSS bulkline to Zarama manifold

Low Capex (Optimistic concept)

2: Similar configuration to Abasare replica concept

CS flowlines (F/Ls) and bulkline (B/L)

The Project options explored for Oil exploration includes:

Low Capex – Flowline connects to Zarama XHP oil manifold

Optimized Development- Flowline connects to CPF HP oil manifold

Enwhe Replica” for gas and “Low capex” for oil were selected as concepts for the project.

Drilling location alternatives

The use of existing surface locations was considered for the well construction purposes in a bid to minimize footprint. Other surface location selection considerations include reduced CAPEX, reduced collision risk due to high density cluster, reduced environmental and community impact & interaction. The subsurface targets are clustered on the western and eastern flanks of the field and are about 4km apart making the use of one drill site result in extended vertical sections for some wells. The existing surface well locations in the region that overlay the subsurface targets, and are in the vicinity, include the UZU-001, ZARA-008/009, ZARA-010/11, ZARA-015, ZARA-002 and ZARA-003 locations.

Drilling location A: this is the ZARA-008/009 location which will be used to access the subsurface targets on the western flank of the field. There is an existing ROW and no settlements.

Drilling location B: the ZARA-015 location will be used to access the subsurface targets on the eastern flank of the field.

Pipeline Options

Uzu development scope incorporates pipelines. The oil development involves installation of 1Nos 6" x 1km CS Oil flowline (within ANSI 1500# piping class) to be tied to existing 16" x 17.5km Zarama Oil bulkline en-route Gbaran CPF via a barred tee.

The gas development involves:

Installation of 3Nos 8" x 0.5km 1500# DSS NAG flowlines to be tied to new Uzu NAG remote manifold.

Installation of 1Nos 8" x 0.5km 2500# DSS NAG flowline to existing Zarama NAG manifold.

Installation of a new 16" x 18km Carbon steel NAG bulkline from the Uzu NAG manifold to existing Koroama 1 NAG slug catcher at Gbaran CPF and provision for switching to the proposed GNC LP manifold.

ES 7.0: Project Scope

The proposed scope and activities of the project is as follows:

NAG Development Scope:

Drilling and completion of 4 NAG wells

Drilling and completing one Exploration/ Appraisal Well targeting the Zarama Deep reservoir.

Design and Installation of NAG well hook-up skid; which contains the hook-up arm, choke valves and shut down valves.

Hook-up of 3 development NAG wells to Uzu NAG manifold via new 3Nos 8" x 0.5km 1500# DSS flowline.

Hook up of 1 development NAG well to existing Zarama NAG manifold via new 1No. 8" x 0.5km 2500# DSS flow lines

Installation of the Uzu NAG remote Manifold

Installation of a new 16" x 18km Carbon steel NAG bulkline from the Uzu NAG manifold to existing Koroama NAG slug catcher at Gbaran CPF and provision for switching to the proposed GNC LP manifold.

Installation of piping, cabling and utilities to enable production from the Uzu NAG wells to the Gbaran CPF.

Installation of 8km composite Power and FOC cable from Zarama NAG manifold to the new Uzu manifold; for power, data transmission and communications to Gbaran CPF. No FAR with HVAC and associated utilities will be installed at new Uzu remote manifold. Instead, Remote Terminal Unit (RTU) with field cabinets will be installed and 2 Nos RMUs for power; at Zarama NAG and Uzu NAG manifold location.

Installation of telecoms facilities to support construction and operate phase of facility.

Installation of pigging facilities including the pig traps and associated pipe-work and valves for the 16" bulkline.

Installation of corrosion inhibition skid at Uzu remote manifold

Installation of corrosion inhibition line from the corrosion inhibition skid to the NAG bulkline

Provision of chemical storage system at Uzu remote manifold area.

Installation of NAG equalization/Hydrate injection system at Uzu manifold (Zarama 15 location)

Tie-in of existing well equalization/hydrate inhibition injection system at Zarama 08-11 location to new NAG well/flowline at Zarama 08-11 location

Installation of dual stream venturi meter on each flowline and one on the 16" bulkline for well testing and real-time monitoring. In assessing the flow assurance for the bulk line, particular attention should be paid to the design of bulkline & its dual stream venturi meter such that the impact of the meter on flow and pig -ability of the bulkline is not impacted.

Tie-in of Uzu bulkline to Koroama 1 Slug Catcher inlet piping (with considerations for straight run length requirements)

Provide flexibility via 16" x 0.2km line from the Zarama NAG bulkline (downstream the Zarama NAG manifold) tied to the Uzu bulkline and another 16" x 0.2km line from the Uzu bulkline tied to the Zarama bulkline via a 16" header (also accommodates flow from Abasere and single NAG well from Zarama 08-11) with barred-tees outside the fence of the Zarama NAG manifold location where the Uzu bulkline joins the Zarama bulkline RoW; for the switching of the Zarama and Uzu bulk lines such that; the existing 20" Zarama bulkline can be used to flow Abasere and Uzu fluids combined under natural depletion flow (HP mode) to the Gbaran CPF while the Zarama fluids can be produced through the new Uzu bulk line when on compression (LP mode). This would include tie-in of the Zarama bulk line to the Koroama 1 Slug Catcher inlet piping.

Provision of a closed drain vessel with a maintenance vent at the Uzu manifold area.

Civil and location preparation works for extension of Zarama 15 well location area to include new 4-slot well cellar and a remote manifold location

Resurfacing of the existing Zarama 15 access road.

Oil scope:

Drilling and completion of 1No. Horizontal Oil well

Construction of 1No. 6" x 1km CS Oil flowline (within ANSI 1500# piping class) to be tied to existing 16" x 17.5km Zarama Oil bulkline and 6" x 17.5km test line outside the fence of the Zarama NAG manifold location where the Zarama oil bulkline joins the Zarama NAG bulkline RoW en-route Gbaran CPF via a barred tee.

Installation of dual stream venturi meter on the oil flowline

Scope of work for tie-in of new oil flowline will include flushing, cutting, welding, and piping modifications of existing Zarama Oil bulkline. The welded bulkline section will be pressure-tested with aid of a blind flange

Provision of tie-in connection from existing Zarama Oil inlet 14" piping (with RSP in place) to existing HP Oil inlet header at Gbaran CPF. Alternatively, operation of the XHP separator (receiving Zarama oil bulkline fluids) in HP separator regime should also be considered in order to optimize recovery from Zarama and Uzu oil reservoirs

CPF Upgrade Scope:

Installation of 200MMscfd TEG dehydration system with associated ancillary systems and utilities. (The TEG package includes TEG Contactor, Regenerator still, Lean TEG cooler, charcoal filter, solid particle filter, Flash drum, TEG surge drum, Reboiler vessel, PH adjuster and Antifoam package injection, Lean TEG recirculation pump and TEG storage tank)

Installation of new Inlet separator

Installation of 1No inlet Air cooler

General piping modification, installation and tie-ins:

Tie-in of the new TEG dehydration will be at the Dehydration inlet manifold (inlet) while new Dehydration unit outlet piping (outlet) will be tied to existing Dehydration outlet piping en-route export metering system. Blind flanges are available for proposed tie-ins.

Civil works, foundations, piping and support structures for new TEG system, ancillary units and associated in-plot piping.

Installation of instrumentation systems and tie-ins of new facilities to existing CPF automation (PAS) and safety (SIS & F&G) system.

Upgrade of existing metering system from capacity of 1.4Bscfd to 1.5Bscfd

Tie-in to utilities system:

Tie-ins to Flare systems (Inlet separator, glycol contactor and scrubber to HP flare header

Tie-in of TEG overheads to Vent system

Tie-in to electrical power distribution system

Tie-in to instrument /utility air system

Tie-in of Fuel Gas system to glycol regeneration system (for stripping and blanketing)

Tie-in to existing open and closed drain systems

General tie-ins of utilities systems to existing Trains 1 and 2 support systems for flexibility purpose

Project A

ES 8.0: Description of Existing Environment

Methodology

This section covers the Biophysical, Social and Health baseline status of the study area. Information for this section were obtained primarily from field data gathering exercise, which held from 27 February – 5 March 2017 (dry season) and 27th April – 3rd of May 2017 (wet season).

Study Approach

The approach adopted includes the following:

Review of existing literature on the area.

Reconnaissance survey.

Field samples collection.

Field analysis and sample preservation.

Laboratory/data analysis.

Result interpretation

Climate

The area is influenced by two seasonal periods, namely the wet and dry seasons. The wet season is the dominant season, and it lasts from April through November. It is characterised by the South-West trade winds laden with moisture from the Atlantic Ocean. Abundant rainfall marks the wet season with annual rainfall in the range from 2500 – 3000mm. The dry season lasts from November to March and is characterised by North-East trade winds, which brings in harmattan between December and January.

Relative humidity is a measure of percentage water vapor content in the atmosphere. Low and high relative humidity indicate moist and drier conditions. Based on 30-year climatic data obtained from NIMET, the data indicate month of June - September and December – March as wettest and driest periods respectively. The relative humidity of the study area obtained during the fieldwork varied from 65.2% to 82.50% (Mean = 72.90%) in the wet season and between 52.0% and 80.60%, with a mean value of 61.39% in the dry season. Relative humidity values recorded at the control areas fall within these ranges in both seasons.

The proposed project area is characterized by minimum air temperature varying from 21.8 – 24.2°C with an average temperature of 22.9°C while maximum temperature ranged from 29.7 -39.6°C with a mean value of 31.8°C. Highest ambient temperature occurred between the months of January – March, while the lowest is between June and August. The hottest periods are in the dry season while the coolest periods are in the wet season. The greater cloud cover occurs during the wet period, which deplete incoming solar radiation, and this could be attributed to lowest air temperature value recorded during the wet season. The measured air temperature values recorded during the fieldwork activities varied from 29.8 -38.2°C (Mean: 33.7°C) and 33.5 -39.0°C (Mean: 36.3°C) in the wet and dry season respectively.

The surface wind speed in the proposed project area is characterized by small diurnal variation affected by both land and sea breezes which reaches its maximum levels during the night, probably as a result of radiation cooling resulting from intensity in the surface layer. The area experiences mainly South–Westerly Trade winds similar to predominant wind pattern observed during the fieldwork. Average monthly wind velocity of the area is classified as light air (0.10-2.0m/s); light

breezes (2.1 -3.0m/s), gentle breeze (6.10-8.0m/s) and fresh breeze (8.0-11.0m/s) while wind speed above 11.00m/s is called strong gale which occasionally occurs during thunderstorm and are mostly Westerlies especially during rainstorm episodes in the rainy season.

Wind speeds obtained during the field data gathering exercise ranged between 0.2m/s and 1.60m/s (mean values: 0.78m/s) in the wet season and from 0.10m/s to 2.30m/s (mean values: 0.55m/s) in the dry season. The wind directions during the sampling period were SW, S, and W during the wet season and NE, N and SW during dry season.

Air Quality

Gaseous pollutants levels in lower atmosphere of the study area were low. Nitrogen dioxides (NO₂), Sulphur dioxide (SO₂), Carbon Monoxide (CO), Hydrogen Sulphide (H₂S), Carbon dioxides and Volatile (VOC) levels varied from <0.01 – 0.07ppm (mean: 0.04ppm); <0.01 – 0.06ppm (Mean = 0.03ppm); 0.14-14.31ppm (Mean = 3.00ppm), <0.01 - 0.19ppm (Mean = 0.17ppm), 0.021 – 0.039% (Mean: 0.030%) and 0.56-18.96 µg/m³ in the wet season respectively, but these pollutants concentrations ranged from <0.01 – 0.06ppm (mean : 0.03ppm) for NO₂, <0.01-018ppm (Average = 0.025ppm for SO₂), 0.02 – 19.26ppm (Average value : 5.94ppm) for CO; <0.01 -0.029ppm (Average = 0.18ppm) for hydrogen sulphide and 0.020 – 0.034% (Mean = 0.030%) for Carbon dioxide and 0.77- 42.68µg/m³ for Volatile organic Compounds (VOC) in the dry season. Total suspended particulates concentrations varied from 10.80µg/m³ to 36.20µg/m³ (Mean: 22.27µg/m³) in the wet season and 20.36 µg/m³ to 92.44 µg/m³ (Average: 57.10µg/m³) in the dry season. Sources of particulates recorded in the studied and control areas include vehicular emissions and bush burning since suspended particulates could be by-product of combustion in the lower atmosphere. Spatial and temporal variations pattern of the TSP levels, compared with DPR/FMEnv limit of 250.0µg/m³.

Noise Levels

The sound levels in the wet season ranged from 44.20 dB(A) to 62.40 dB(A) with a mean value of 51.76 dB(A) while control points had a mean value of 58.95dB(A) but in the dry season, measured sound levels varied between 41.00dB(A) and 59.40dB(A) with a mean value of 61.80dB(A).

Surface Water Characteristics

pH levels of the waterbodies in the study area varied from 6.3 to 6.7 (Mean: 6.5) in wet season but ranged between 6.9 – 7.6 (mean value: 7.4) in the dry season. The results showed significant seasonal difference (p<0.05) in the mean pH values of the water bodies (creek and creeklets) in the study area. High pH values recorded in the dry season compared with the low pH values recorded in wet season. The values of electrical conductivities of the surface waterbodies ranged between 61.80µS/cm and 196.10 µS/cm for spatial distribution with a mean value of 94.33 µS/cm obtained during the wet season while a range of 60.50-125.40 µS/cm with a mean value of 80.30 µS/cm was recorded in the dry season. Similarly, total dissolved solids varied from 31.00 - 103.20mg/l and 32.07 -66.16mg/l in the wet and dry seasons respectively. The electrical conductivities and total dissolved solids' values obtained for both control points (CTRL SW1 and

CTRL SW2) were within the range values obtained in the study area. There was no significant seasonal variation at $p < 0.05$ in both the electrical conductivities and total dissolved solids.

The waterbody within the proposed project influence zone recorded temperature levels that varied from 27.2°C to 31.9°C (mean = 29.7°C) and between 30.3°C to 33.0°C (Mean = 31.6°C) in wet and dry season respectively. These values are within the ambient temperature of the area. Difference of mean seasonal temperature values was statistically significant at $p < 0.05$. Measured colour values of water bodies in the studied area within the project influence zone and controls (Nun and Orazi Rivers) were characteristically high with varied colour units: from 25.00 – 100.00 Pt.Co for wet season and 25.0 – 50.0 Pt.Co for the dry season. Relatively high colour unit observed in the wet season is attributable to storm water run-off, usually with colored substance of organic origin, as well as suspended particles in the water bodies of the area, particularly Taylor creek. Inland streams, creek and rivers of Nigeria are usually coloured due to input of tannic, hummic and decaying organic material.

Total suspended solids levels in surface water bodies within the proposed project influence zone ranged from 20.60 - 72.00mg/l (mean: 44.25mg/l) and 10.60 - 60.40mg/l (mean: 33.36mg/l) in wet and dry season respectively. Also, measured turbidity values varied between 18.70NTU and 99.20NTU in wet the season and between 6.40NTU to 95.80NTU in the dry season. Slightly high TSS and turbidity values recorded in the wet season could be due to frequent influx of storm water run-off into the waterbodies, particularly Taylor creeks and other studied creeklets in the area, though there were no significant seasonal difference (at $p < 0.05$) in the mean values of these parameters. Measured dissolved oxygen levels varied from 5.30mg/l (SW1) to 6.80mg/l (SW3) (Mean = 5.84mg/l) and 4.20mg/l to 5.60mg/l (mean = 5.28mg/l) in the wet and dry season respectively. BOD₅ of the water bodies in the project influence zone, ranged from 4.17 mg/l - 5.60mg/l (wet season) and 5.00 - 6.40mg/l (dry season). COD values ranged from 5.63 – 8.65mg/l and 6.91 -8.06mg/l in the wet and dry season respectively in the assessed surface water in the study area. A relatively high chemical oxygen demand (COD) values were recorded, compared to the BOD values, in both wet and dry seasons. However, obtained BOD and COD levels were within the FME_{env}/DPR acceptable limit of 10.00mg/l which indicates that the waterbodies in the area are fairly unpolluted.

Low concentrations of the mineral nutrients including ammonium, chloride, nitrate, ammonium, sulphite, sulphate, phosphate, potassium, magnesium, calcium, sodium and manganese ions were recorded in both wet and dry seasons. Generally low levels of these ions, especially chloride, points to the fact that the water bodies within the proposed project influence zone, and even the control points, are characteristically fresh water. The oil and grease contents varied from 0.15-0.33mg/l in the wet season and 0.15 - 0.55mg/l in the dry season. Seasonal difference in the concentrations of oil and grease was not significant at $p < 0.05$. Also, total petroleum hydrocarbon concentrations, in the surface water samples taken from both waterbodies within the proposed project area and the control points, were low with mean values of 0.23mg/l and 0.21mg/l in wet and dry season respectively. Hydrocarbon concentrations exceeded the FME_{env} limit of 0.1mg/l for surface water. However, polynuclear aromatic hydrocarbon and BTEX were below the detection limit of

<0.001mg/l of the analytical instrument (GC/MS) and therefore could be said to be absent. The results recorded low levels for most of the metal ions determined, while $\text{Fe}^{2+}/\text{Fe}^{3+}$, Cd^{2+} and $\text{Cr}^{3+}/\text{Cr}^{6+}$ concentrations exceeded their respective FME_{env} limit. The recorded high levels of these metals in the project area and control could be attributed to metal re-mobilization in aquatic medium, due to observed incessant riverbed sand mining in the area. Hg^{2+} and V^{2+} were below the detection limit of the analytical instrument.

Sediments

The sediment samples pH values were in the acidic ranges of 5.6 - 6.3 (Mean = 5.8) and 4.9 - 5.9 (Mean = 5.3) in wet and dry seasons respectively. There was no significant ($p > 0.05$) seasonal difference in the pH values. Obtained values from the control stations were within the range of values recorded for the project's influence zone. The oxidation-reduction potential (ORP) were of mean value $144.96 \pm \text{mV}$ and $-32.55 \pm \text{mV}$ in wet and dry seasons respectively. The nutrient content, specifically phosphorus varied from 15.00 – 17.48 mg/kg and 15.16-17.24mg/kg in the wet and dry season while concentration range of 0.01- 0.02% (mean = 0.01%) was obtained in the wet season and 0.01 – 0.06% (0.02%) in the dry season for total nitrogen. Phosphorus and nitrogen naturally serve as nutrients to benthic organisms as well as some microorganisms in sediment. Also, ammonium ions concentrations in the sediment samples ranged from 6.05 - 19.27mg/kg in the wet season and 4.47 - 45.78mg/kg in the dry season. The sediments exchangeable cations mean concentration values of 1.55meq/100g, 1.23meq/100g, 0.41 meq/100g and 1.82 meq/100g were obtained for Potassium, Sodium, Calcium and Magnesium respectively in the wet season while 0.83meq/100g was recorded for Potassium, 3.80meq/100g for Sodium; 2.13meq/100g for Calcium and 1.98meq/100g for Magnesium in the dry season.

The orders of magnitude of exchangeable cations' concentrations in the wet and dry seasons were as follows: $\text{Mg} > \text{K} > \text{Na} > \text{Ca}$ and $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$ respectively. High nutrients and minerals (nitrate, phosphate, calcium, magnesium, potassium, and total nitrogen) recorded may be due to observed anthropogenic activities in the study area particularly, along Taylor and Zarama–Epie creeks as well as the control stations. Total organic carbon contents varied from 0.17 – 28.00 % in the wet season while a range of 0.79 - 2.02% was obtained in the dry season. Oil & grease contents in the sediment samples were of mean values of 0.42mg/kg and 1.13mg/kg in the wet and dry seasons respectively, while total hydrocarbon content values varied from 0.21 - 1.28mg/kg (Mean = 0.48mg/kg) in the wet season and between 0.44 - 1.28mg/kg (Mean = 0.88mg/kg) in the dry season. Presence of oil & grease was indication of possible petrogenic hydrocarbon contamination of sediment from the study area. However, polycyclic aromatic hydrocarbon was not found in the sediment.

In the wet season, concentrations of Fe, Cr, Pb, Ni, Zn, and Cu₀ ranged from 1211 – 2120mg/kg, 2.146 -3.270mg/kg, 0.19-20.65mg/kg, 0.29-14.73mg/kg, 16.26-33.58mg/kg, 19.48-55.32mg/kg and 0.17 -9.58mg/kg respectively while in the dry season, concentration ranges of 846.83 - 2432mg/kg were obtained for Fe; 0.04 -3.53mg/kg for Cd; 5.65-55.34mg/kg for Cr; 3.93-40.40mg/kg for Pb; 15.55 - 47.50mg/kg for Ni; 6.38 -79.50mg/kg for Zn and 1.53 -17.03mg/kg

for Cu. The magnitude order of mean concentrations of metals in sediment is Fe > Zn > Ni > Cr > Pb > Cu > Cd in the wet season and Fe > Zn > Ni > Pb > Cr > Cu > Cd in the dry season.

Groundwater Quality/Physiochemical Characteristics

The pH values of the ground water samples in the study area ranged from 5.7 – 7.0 with an average pH of 6.35. Electrical conductivity values for this study range from 47µS/cm to 393µS/cm. Furthermore, the values of Na⁺ + K⁺ ranged from 2.44 mg/l to 7.586 mg/l. The values are similar to those obtained from control Boreholes. Chemical Oxygen Demand (COD) ranged from 6.14 mg/l to 10.67 mg/l while Turbidity value ranged from 1.44 mg/l to 116.00 mg/l. The concentrations of Iron ranged from 0.500mg/l to 4.008 mg/l; zinc from 0.111 mg/l to 0.300mg/l and nickel from <0.002 to 0.0.645 mg/l; cadmium from <0.001 mg/l to 0.091 mg/l, while values of chromium, mercury and vanadium recorded <0.001 mg/l. The Nigerian Standard for drinking water quality maximum limits are 0.3 mg/l, 3.0 mg/l, 1.0 mg/l, 0.05 mg/l and 0.001 mg/l, 0.05 mg/l and 0.001 mg/l respectively. The values for iron are elevated in all the boreholes except BH2 which is situated in Zarama. The elevation is attributed to the presence of lateritic overburden in the area through which precipitation infiltrates to recharged groundwater.

Soil

In the wet and dry seasons, porosity of the topsoil of the project area varied between 36.6 and 84.00% and from 42.0 to 82.00% but bottomsoil had range of 32.0 -86.0% and 36.6-84.0% in the wet and dry seasons respectively. The permeability test on the topsoil of the project area revealed a range 0.08 - 0.40 cm³/s in the wet season and 0.13-0.45 cm³/s in the dry season while for the bottomsoil, a range of 0.06 - 0.37cm³/s was recorded in the wet season and 0.08 – 0.40 cm³/s recorded in the dry season. In the wet and dry seasons, electrical conductivity values of the topsoil in the project area ranged from 38.90 -742.00 µS/cm and from 41.50 to 604.00 µS/cm respectively while bottomsoil recorded a range of 30.00-21.96 µS/cm in the wet season and 38.90 -333.00 µS/cm in the dry season.

The topsoil mean concentrations of total nitrogen were 0.03% in the wet season and 0.05% in the dry season. Similarly, in the bottomsoil recorded mean values were 0.01% and 0.03% in the wet and dry seasons respectively. Measured total nitrogen levels of the soil in the project area and control stations were generally low (< 0.05%). In both wet and dry season, nitrate concentrations in the topsoil were moderate with mean values of 17.93mg/kg and 16.30mg/kg respectively. Also, nitrate concentrations in the bottom soil ranged from of 0.17 -13.92mg/kg (mean 2.20mg/kg) in the wet season and 7.35 -60.06mg/kg (mean, 17.93mg/kg) in the dry season. The nitrite content in the topsoil ranged from <0.02 to 0.14 mg/kg and <0.02meq/100g (i.e. below detection limit of the analytical instrument) in the wet and dry season respectively. A concentration range of <0.02 - 0.14meq/100g (mean, 0.09meq/100g) was recorded in the bottom soil during the dry season while nitrite was practically absent with concentration below the detection limit (<0.02meq/100g) of the analytical equipment in the wet season.

Available phosphate –phosphorus concentrations in the topsoil had a mean value of 14.90mg/kg and 16.12mg/kg in the wet and dry seasons respectively whereas bottomsoil had a mean concentration of 3.95mg/kg in the wet season and 14.90mg/kg in the dry season. Total Organic Carbon levels in the topsoil varied from 0.08 – 1.84% (mean = 0.48%) and 0.04 - 2.98% (mean, 1.46%) in the wet and dry seasons respectively (Table 4.16a and 4.16b). Similarly, bottomsoil contained organic carbons in the concentrations range of 0.14 -1.04% and 0.06 - 2.69% in the wet and dry seasons respectively.

Total hydrocarbon content (THC) in the topsoils ranged from <0.02 – 1.82 mg/kg (wet season) while in the dry season it varied from 0.08-3.20mg/kg but a concentration range of <0.10 – 0.19mg/kg was obtained in the wet season and 0.07-0.98mg/kg in the dry season for the bottomsoil. Obtained mean oil and grease contents in the topsoil were 0.52mg/kg and 0.51mg/kg in wet and dry seasons respectively while mean values of 0.21mg/kg and 0.32mg/kg were recorded in the wet and dry seasons respectively in the bottomsoil. However, polynuclear aromatic hydrocarbon (PAHs) and BTEX levels were practically below the detection limits of the respective analytical equipment.

Iron levels in the topsoil were markedly high with a mean value of 2069mg/kg and 1966mg/kg in the wet and dry seasons respectively. In the bottom soil, Fe average levels were of mean value of 1931mg/kg in the wet season and 23.81mg/kg in dry season. These values were below the iron critical level of 15000mg/kg for plants' normal growth. The soils of the Niger Delta region have been reported to contain high concentrations of Iron. Manganese concentrations in the topsoil varied from 3.69 – 978.58mg/kg and 3.74 – 380.21mg/kg in the wet and dry season respectively while in the bottom soil, a concentration range of 17.10 - 982.10mg/kg was obtained in the wet season and 20.51 -323.55mg/kg was recorded for the dry season. Also, chromium contents of the topsoil ranged from 0.71-51.35mg/kg and 0.62 - 57.50mg/kg during the wet and dry seasons respectively. In the bottomsoil, Cr levels varied between 4.16-77.68mg/kg and 6.97 -105.45mg/kg for wet season and dry season respectively.

Vegetation Cover Characteristics

The study area falls within the subdivision of the freshwater ecosystem described as the Flood Forest Zone. Two other sub systems of the fresh water swamp present are: the Riparian Swamp Forest, and Raffia Swamp Forest. The Flood forest swamp component is observed to make up about 70% of the vegetation cover which is more or less an agroecological flood forest system; only about 15% of the flood forest is at regrowth stage. The Raffia Swamp and the Riparian Swamp contribute 4% and 26% respectively to the vegetation cover of the study area. The Flood forest vegetation cover of the study area is largely fragmented by agricultural activities. The life form spectrum of the flood forest is of the following order: Mesophanerophytes (29%), Nanophanerophytes (21%), Megaphanerophytes (19%), Microphanerophytes (10%), and Liana (7%). Eight plant habit types were identified from the study area and they include Tree (36%), Tree Sapling (22%), Herbs (14%), Shrub (8.6%), and Liana (7%). the significant representation of Nanophanerophytic life form as well as Tree saplings and Herbs across the vegetation cover is indicative of a degraded flood forest vegetation ecosystem.

The vegetation cover is generally stratified into two layers: the prominent lower layer (L1) with a mean height of 6 meters reaching 10 meters around SS 14, VG 5, SS 11, VG 1; and the upper oil palm dominated layer (L2) which ranges from 14 to 20 meters in height. An emergent layer of individual *Irvingia* trees is observed around SS 22, SS 11 and SS 9; which ranges from 25 meters to about 35 meters in height. Mature trees present consist mainly of protected economic non timber species, chiefly *Irvingiagabonensis*, *Elaeisguineensis*, and *Treculiaafricana* occurring sometimes gregariously. Vegetation ground cover varies from under 40% to about 70% while tree canopy cover is mostly under 40%. The floristic composition of the flood forest is represented by 58 species in 35 plant families. The five biggest plant families in the study area, by species representation, in descending order are: MORACEAE (6) > PALMAE (4) > EUPHORBIACEAE (4) > RUBIACEAE, MALVACEAE (3). 22 families had only one species representation while 8 families had 2 species each. The common species in the L1 stratum of tree saplings and shrubs, include: *Elaeisguineensis*, *Musangacecropioides*, *Cleistopholis patens*, *Pycnanthusangolensis*, *Alstoniaboonei*, *Anthocleistanobilis*, *Anthocleistaliebrechtsiana*, *Ficusexasperata*, *Bambusa vulgaris*, *Lophiraalata*, *Fleroyaledermannii*, *Ricinodendronheudelotii*, *Spondianthuspreusii*, *Vitex grandifolia*, and *Ceiba pentandra*. Dominant shrubs and herbaceous species are *Alchornealaxiflora*, *Costusafer*, *Chromolaenaodorata*, *Aspiliaafricana*. Others include *Triumfettacordifolia*, *Melantherascandens*, *Thalia welwitschii*, *Dryopterisfilix mas*. Climbers and Lianas are few and are represented by *Puerariaphaseoloides*, *Mucunaflagellipes*, *Dioscoreaspp*, and *Tetracerapotatoria*. The Riparian Swamp forest Vegetation is mostly closed canopy with Graminoid/Sedge Marsh occurring in open canopy areas. The vegetation is found within the study area around SS 10, 18, and 20. This habitat is predominantly Meso-phanerophytic. The vegetation cover is more or less stratified into two vertical layers. The lower layer being more prominent, is dominated by *Pterocarpussantalinoideis* having a shrubby habit and reaching a height of 10 meters in dense tangles around SS 12, 20 (in Zarama), SS 10 and less so at SS 18. *Alchornealaxiflora* and *Lonchocarpussericeus* is common on the disturbed margins forming its own thicket (Near SS 9). The upper layer is more prominent around VG 24, 20, and stretches from 13 meters up to a height of about 17 meters (VG 4); this layer is sparsely populated, dominated by *Treculiaafricanawhich* occur either gregariously up to 10 trees per acre (VG 4, 18), or as low as 4 trees per acre. The Oil palms are rare in this habitat.

The Raffia Swamp forest vegetation cover has over 80% ground cover with an average height of about 10 meters. *Treculiaafricana* is the only other tree species occurring in this habitat sometimes gregariously with up to 32 trees per acre, or virtually absent in parts of it. The *Treculiacanopy* reaches 15 meters in height. A few shrubs present on the fringes of the habitat include *Alchornealaxiflora* and *Lonchocarpussericeus*. Agricultural activity is observed at most of the sample locations in the Flood forest and is carried out underneath the forest cover in the drier flood forest habitat, and along the river bank of the study area. Crops cultivated are mainly starchy staples including *root crops*: Cassava, Yams; *fruit*: Plantain; *Cereal*: Maize; and Melon (*Egusi*). Plantain, Cassava and yam are the dominant crops; the cultural practice is mostly mixed cropping with Plantain and Cassava; or Cassava and Maize; or Yam, Plantain and Maize simultaneously. A total of 25 species of crops were identified in the agricultural farmlands and home gardens of the

study area. The forests within the considered influence zone of the project provide key resources that sustain the cottage industries in the study area and provides livelihood for the people. A number of Non timber forest resources that were observed, occur in commercial quantities in the area and they include *Treculiaafricana* locally called Bush beans or *Oyeinin* the local dialect; *Irvingiagabonensis* (*Okpukpa*= Ijaw; *Ogbono*= trade name); and *Elaeisguineensis* that provides fruits which are processed into palm oil. The Sap of *Raphia* is readily tapped from the *Raphia* trees by the locals and sold as wine; or brewed into local gin that is not only sold commercially but used in the preparation of many traditional medicines. The vegetation of the study area is observed to be luxuriant and free of disease epidemics. The crops on the farmlands were healthy with the exception of cassava leaf mosaic which was encountered on some farms.

Wildlife

Information from native hunters and observations of key indicators of animal presence show that the project area harbours at least 40 Species of animals belonging in 30 Families; cutting across 3 classes of the Phylum Chordata (including Mammalia, Reptilia and Aves), and a single representative of the Phylum Mollusca (Gastropoda). The most diverse category of wildlife identified in the study area is the Aves with species from 10 different orders. The diversity by species number among the identified Cordates, in decreasing order is: Mammalia (15 species) > Aves (14 species) > Reptilia (13 species). It is observed that the Rodents and Bovidae make up a large part of the species 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.

Hydrobiology

Hydrobiological /ecological paramters studied include phytoplankton, zooplankton, benthic invertebrates and fisheries.

Phytoplankton

Five major families of phytoplankton were recorded; namely *Baccillariophyta*, *Cyanophyta*, *Dinophyta*, *Chlorophyta*, and *Euglenophyta*. *Baccillariophyta* were the dominant family and constituted 55% of the total number of phytoplankton in the dry season and 60% in the control points. In the wet season, 54% of total phytoplankton count in the study area and control belonged to the bacillariophyta division. The dominance of Bacillariophyta is characteristic of the phytoplankton community structure in the Niger Delta of Nigeria and this has been severally reported. The second dominant group of phytoplankton was the Cyanophyta, which contributed 23 % of the total number of phytoplankton in the dry season and 20% in the wet season. They were represented by 15 species. The dominant Cyanophyta species in the dry season were *Isocystis* sp. (2.34%), *Phormidium tenue* (2.12%), *Oscillatoria bonnemaisoniai* (1.59%), *Anabaena flos-aquae* (1.50%) and *O. pseudomina* (1.37%). In the wet season, dominant phytoplankton species include *Aphanizomenon flos-aquae* (1.35%), *Oscillatoria pseudomina* (1.22%) and *Phormidium forseolarum* (1.20%).

Zooplankton

In the dry season, copepods were the dominant zooplankton with respect density and members of this family constituted 44-47% of the zooplankton in both Uzu Field and control. Prominent copepods species in the dry season include *Centropages* sp, *Acartia clausii*, and *Paracalanus* species with a relative abundance of 8.84, 8.16, and 7.39% respectively. Rotifers were the second dominant group in Uzu Field in the dry season with a relative abundance of 42% within Uzu and 29% in the control area. Key rotifer species in Uzu in the dry season include *Keratella tropica*, *Trichocerca*, and *Brachionus fulcatus*. In the wet season, rotifers were the dominant zooplankton with a relative abundance of 42% within Uzu field and 33% in the control area. *Keratella longispina* (7.57%), *Brachionus fulcatus* (7.26%) *Keratella tropica* (6.70%) and *Cephalodella* (6.65%) were dominant species of rotifers. Copepod crustaceans were the second dominant zooplankton and contributed 36% of the zooplankton in the wet season within Uzu Field and major copepods include *Arctodiaptomus* (10.28%), *Acartia clausii* (7.16%), and *Tropodiaptomus* (6.03%).

Benthos

In the dry season, six hundred and forty-eight (648) organisms were encountered during the study while a total of three hundred and five (305) were recorded in the wet season. Benthic fauna encountered in the study belong to seven (7) major taxonomic groupings namely annelids, decapod crustaceans, and larval forms of ephemeroptera, odonata, hemiptera and diptera. In the dry season, annelids with a relative abundance of 43-44% were the dominant benthos within the study area and control. Major species of annelids include *Chaetogaster*, *Branchiura* and *Lumbriculus*. The second dominant benthic group were the members of odonata and key members of this insect order include *Branchiura*, *Lumbriculus* and *Tubifex*. In the wet season, decapod crustaceans constituted 37% of the total count of benthos. However, it is significant to note that larval forms of insects particularly odonates, hemipterans and coleopteran with a relative abundance of 13, 11 and 10% respectively were the prominent group of benthos. Larval forms constituted about 72% of the benthos in the control area.

Fishery Studies

Artisan fishers or small-scale fishers dominate the fishery of the study area (Uzu Field). They operate in dug-out wooden canoes which may or may not be motorized. Fishing gears are largely made of long setlines, circling nets and seine nets of different mesh sizes varying between ½", 1", 1½", 2", 2½ and 3" (1.0mm to 5.0mm). Gears measure 6-12m in length and 2-4 meters in width. Nets are manually operated. They are set and allowed to stay for up to one hour before they are removed with the catch. When the net is set and before it is removed another net is also set. Catch rates are seasonally dependent and varied between 4-7 kg/day.

Microbiology

Microbiological studies were done for all the samples collected including surface and ground water, sediments and soil.

Surface Water Microbiology

In the dry season, Total Heterotrophic Bacteria (THB) population densities varied from 1.03 to 1.63 x 10² cfu/ml (Mean 1.28 x 10²cfu/ml) while Total Heterotrophic Fungi (THF) loads ranged

from 1.00 to 1.35×10^2 cfu/ml with a mean value of 1.21×10^2 cfu/ml. Also in the wet season THB ranged from 1.03 - 3.25×10^2 with a mean value of 2.14×10^2 cfu/ml while THF ranged 1.00 – 1.15×10^2 cfu/ml with a mean value of 1.07×10^2 cfu/ml. Hydrocarbon degraders were absent from the population during the dry season but present in the wet season which confirms the fact that petroleum hydrocarbon may be present in quantities below 0.1mg/l detection limit of the analytical instrument in dry season. Total coliform loads in the surface water were of the mean values of 26 MPN/100ml and 34.89 MPN/100ml in the dry and wet seasons respectively. However, faecal coliform population ranging from 9 – 19 MPN/100ml was obtained in the dry season; while a range of 9 - 20 MPN/100ml was recorded in the wet season. Obtained values compared favourably with values from Control points in both season. Presence of the faecal coliform reveals direct human defecation into the waterbody.

Sediment Microbiology

Total heterotrophic bacteria loads ranged from 1.30 - 3.00×10^4 cfu/g (mean value of 1.97×10^4 cfu/g) in the dry season and from 1.52 - 3.7×10^4 cfu/g (mean value of 2.27×10^4 cfu/g) in the wet season. Also, Total Fungi (THF) populations varied between 1.10 – 2.25×10^4 cfu/g and $1.10 - 2.35 \times 10^4$ cfu/g during the dry and wet season respectively. Hydrocarbon Utilising Bacteria (HUB) ranged from 1.07 - 1.43×10^2 cfu/g (mean value of 1.14×10^2 cfu/g) in the dry season and $1.90 - 3.65 \times 10^2$ cfu/g (mean value of 2.70×10^2 cfu/g) in the wet season. The population densities of the hydrocarbon utilising fungi (HUF) ranged from 1.00 - 1.03×10^2 cfu/g (mean = 1.01×10^2 cfu/g) in the dry season and $1.00 - 1.05 \times 10^2$ cfu/g during the wet season. The high population density of the microbes recorded in this environment is an indication of a viable community with capacity to mineralise organic matter.

Soil Microbiology

The Total Heterotrophic Fungi (THF) load in the topsoil during the dry season ranged from $1.00 \times 10^4 - 4.20 \times 10^4$ cfu/g with an average of 1.61×10^4 cfu/g while THF population densities in the bottom soil ranged from $1.00 \times 10^4 - 3.50 \times 10^4$ cfu/g with a mean of 1.58×10^4 cfu/g. Also in the dry season, THB population ranged from $1.10 - 3.75 \times 10^4$ cfu/g in the topsoil while bottomsoil recorded a range of $1.05 - 1.85 \times 10^4$ cfu/g. In the wet season, THF population varied from $1.03 - 4.50 \times 10^4$ cfu/g in the topsoil while a range of $1.03 - 3.58 \times 10^4$ cfu/g was obtained in the bottomsoil. Similarly, THB was of population range of $1.15 - 6.00 \times 10^4$ cfu/g (mean = 3.05×10^4 cfu/g) in the bottomsoil and a range of $1.07 - 6.00 \times 10^4$ cfu/g (mean = 3.01×10^4 cfu/g) was obtained in the topsoil. The hydrocarbon degraders (HUF and HUB) population densities were relatively low and their HUF and HUB population percentage were far below 10%, indicating very negligible petrogenic hydrocarbon pollution in the soil of the study area.

Ground Water Microbiology

Total heterotrophic bacteria loads ranged from 1.18 - 1.60×10^4 cfu/g (mean value of 1.37×10^4 cfu/g) in the dry season and from 1.05 - 5.70×10^4 cfu/g (mean value of 3.14×10^4 cfu/g) in the wet season. Also, Total Fungi (THF) populations varied between 1.05 – 1.15×10^4 cfu/g and $1.02 - 1.10 \times 10^4$ cfu/g during the dry and wet season respectively. Hydrocarbon Utilising Bacteria (HUB) ranged from 2.15 - 2.65×10^2 cfu/g (mean value of 2.42×10^2 cfu/g) in the wet season and

HUF ranged from 1.00 - 1.03 x 10²cfu/g (mean value of 1.01 x 10²cfu/g) also in the wet season. The population densities of the hydrocarbon utilising fungi (HUF) and hydrocarbon utilising bacteria (HUB) in the dry season is nil showing no hydrocarbon pollution of the environment.

Social Environment

The identified stakeholder's communities in the Uzu Field Development are Okolobiri, Kumbo-ama, Ogboloma, Negugo, Agbia, Ayama, Okotiana, New Jerusalem, Nyambiri, Epe-Zarama, Igbogene and Obungha communities. These twelve communities were visited during EIA field study. The communities are of Ijaw ethnic nationality. Each of the community is autonomous with distinct historical links. The communities are under the local government jurisdiction area of Yenegoa Local Government Area of Bayelsa State.

The stakeholder's communities are descendant of Gbarawei, the founder of Gbaran clan. Be that as it may, most of the communities still claim to have distinct history but all narrative still point to Gbarawei as their fore-father and founder of the Gbaran Kingdom. Okolobiri community migrated from Kabou-wei from Kumbo clan. They settled in present day Okolobiri primarily for fishing and farmer because of their perceived fertility of the soil. Kumbo-ama community on the other hand said Gbarawei is their founding father, who beget Ogoro and Ogoro beget five children, namely Okolobiri, Agbin, Akinima, Odudun. However, of recent, Agbin, Akinima and Odudun opted out of Okolobiri to form Kumbo-Ama community. It was observed that most of the communities in Gbaran Kingdom, which happened to exist as one community has now become autonomous community. However, the fact remains that they are of the same father (Gbarawei) according to history. Zarama clan is another clan in the field where you have communities as Epe-Zarama, Nyambiri, and New Jerusalem. Socio-culturally, inhabitants of Ijaw tribe have over the years traded and inter-married with other tribes like Kalabari, Ikwere, Isoko, Itsekiri, and Urhobo etc tribes with whom they share common cultural and social affinities with respect to marriage ceremonies, dressing patterns and festivals.

The Uzu Field Development stakeholder's communities are mainly Christians by religion. On the average, over 95% of the respondents across the surveyed communities claim to be Christians as against few who practice the African Traditional Religion (ATR) and Islam. There are also mentioned of sacred site (Abani and Kalama bush) at Kumbo-Ama community. Kumbo-Ama was the only community that disclosed their sacred forest while other could not mention names, however, they said they exist but that the names remain reserved to them. The people celebrate Uzu as their festival. Uzu festival is celebrated annually; during the festival, all sons and daughters of Gbarawei far and near come home for the celebration. Uzu festival according to the people, serves as a unifying factor to the people. There were also churches like The Anglican Church, Catholic Churches, Assemblies of God Church, Redeemed Christian Church and Living Faith aka Winners Chapel, Christ Apostolic Church, and white garment churches etc) in the communities.

Sacred shrines exist either within the community's centre or are located far out in the forests/bushes or close to streams/rivers/water-courses. Field visit showed that traditional places

of worships are cultural heritage centers, although not much attention is given to it these days. More often than not, trespasses without the required permission can cause outrage and involved financial reparation. Seasonal cultural festivals and dances with revered shrines have been reportedly jettisoned by some members of the communities due to Christianity religion.

The Ijaw ethnic nationalities which made up the Uzu Field Development project communities have rich and well established cultural and traditional institutions. The community folklore and songs symbolize its inhabitants, as depicted in the numerous cultural societies of its men and women which practice a healthy competition in folk dances, songs and religious serenades. The people of Ijaw have many things in common, including food, dressing and socio-cultural organizations with other tribe like Isoko, Urhobo, Ikwere, Itsekiri etc. Apart from the ‘‘Ogboni and Igbe’’ cults, several other socio-cultural groups also exist within the communities, showing the Ijaw culture generally. There are the men and women age-grades social clubs and all play cultural music and dances during wake keeping and burial ceremonies as well as at Christmas and Easter celebrations. The internal structures of a small 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 a community are subdivided into the youth (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 by other elders or the chiefs/traditional ruler. The women of a community are organized in the same way. Also, there is the young group, married women of working age and the group of the ‘‘elder’’ women. The ‘‘elders’’ (women and men) have a high status in the community.

The Royal Highness (The Amanayebo) in Ijaw land, Council of Chiefs/Elders, the Town Union with both Federal (sons and daughters in Diaspora) and Home EXCOs, hardly distinguishable from the well-known CDC in some parts of the Niger Delta, the quarter chairmen, the youth group, and the women’s forum respectively constitute the local and traditional administrative structures of the Uzu Field Development stakeholder’s communities. Depending on the clan and the system of administration, the King or clan head is called Amanayebo in Ijaw, and such title may be hereditary in some clans. While the kingship system maintained a highly centralized type of government with the King assisted by a council of chiefs, the clan head (in the rule by the elders system) is assisted in the day-to-day administration of the polity by titled officers selected from the various age grades recognized in the clan. Conflicts and contentious issues are often resolved in the community in conjunction with the traditional head (*Amanayebo*), the Council of Chiefs/Elders, the Village Heads, Community Development Union or Committees (CDU/CDC), the Youths as well as Women groups.

The household structure of Uzu Field Development stakeholder’s communities 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 traditional (one husband and one spouse), polygamous, and single male (male with no spouse,

including widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

The socioeconomic sampled survey of the communities showed households' structural composition to be typically pyramidal; i.e. broad-based with the younger ones predominant and the aged fewest in proportion. On the average, children aged 0-4 years are 11.6%, 5-12 years account for 12.3% of the household members and children aged 13-18 years (secondary school age) makes-up about 15.1% of the population. The age range of 19-25 years is 19.2% and 26-59 years 26.2% (both active working proportion), 60-69 years account for 10.3% while 70years+ account for 5.3% of the household composition.

The stakeholder's communities have primary school and secondary school. Kumbo-ama for instance has primary school but share secondary school with her sister community, Okolobiri. However, 93.85% of the total sampled population showed having some form of education, with people having post primary (secondary) educational attainment (62.4%). Also 23.5% of the sampled respondents have primary school leaving certificates, 30.7% have senior school certificate, 18.5% have acquired vocational training, 15.1% have tertiary certificate; 7.8% do not have any formal educational training (NFE), and 4.4% others. Meanwhile the possession of degree certificate was found to be lower with no respondents possessing master/Ph.D. It can be said that, 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. Literacy and educational attainment of respondents' children in the households showed that about 53.45% of the boys and 46.55% of the girls are presently attending various schools within and outside the community. Analysis further showed that 63.45% of the household have secondary education while 36.55% have post-secondary education.

Responses from survey analysis and focus group discussions (FGDs) revealed that the inhabitants of the surveyed communities are predominantly farmers. The popular white collar job, trading, business/contracting, artisans have to a large extent form part of the economic mainstay of the greater proportion of the adult population (male and female). The average response shows that, farming 12.6%, fishing 28.7%, and trading 9.8% account for the primary occupation of the people respectively. Also, 9.4% of the population engages in technical/artisan jobs. Other economic activities include Business/Contracting 7.4% and unemployment 19.5%. Also 8.3% of the sampled populations are civil servants, students/apprentice 8.3%, industrial works 3.7% and others 2.1%. The 19.5% unemployment shows that employment issues are of serious concerns in the host communities.

Agriculture, including fishing is the major occupation of the inhabitant population in Uzu Field Development stakeholder's communities. The principal crops planted by the people are yam, plantain, sweet potatoes, cassava, oil palm, cocoyam, banana, maize, pepper and vegetables. Agricultural yield in the surveyed communities showed a drastic reduction over the years, a significant percentage of the respondents (65.3%) agreed of a reduction in crops harvest as against

about 34.7% who have witnessed no reduction. The survey analysis of the communities, though subject to some uncertainties, could suffice. The income levels were found to be meager and variable with 6.5% earning less than NGN 5,000 in a month, 9.5% of the population had income in the bracket of NGN5001-10,000, 9.7% earn between NGN10001-15000. Also, 11.4% and 10.2% earn between NGN15001-NGN20000 and NGN20001-NGN25000 respectively. While 9.7% also earn between NGN25001-NGN30000, 8.7% earn NGN31001-NGN35000, 8.2% earn between NGN35001-NGN40000, 7.1% earn NGN40001-45000 and 8.1% earn NGN450001-NGN50000 while 10.9% earn N50000 and above per month. Residents who are into Business/Contracting however, earn better incomes.

The Uzu Field Development study environment and constituent communities are generally lacking of basic amenities. Educational institutions available are inequitably distributed and the few available are lacking basic teaching and learning materials, including teachers. Access to potable water; about 95% of the communities have existing boreholes but not functional; while primary health care services are in limited service. Electricity is constant only at Obungha community even as Okolobiri, Kumbo-ama, Igbogene, Okotiana, Epe-Zarama, Nyambiri, Agbia, Ayama etc has power supply but complained of epileptic supply.

Health Environment

Access to water: Most members of the communities are able to meet the daily per capita water requirement of 20 – 40 liters, but from a variety of sources that include boreholes, sachet/bottle water, rainwater and river. Most of the public water facilities in the communities were non-functional at the time of the field study, mainly because little provision was made for their maintenance.

Water quality: The surface water samples had coliform counts that were higher than the WHO guideline value of less than 10/dl, mainly because of the widespread use of over-hung (jetty-type) toilet in the communities. Ground and surface water samples collected during the field study did not contain toxic metals beyond the acceptable limits.

Access to sanitation facility: This was noted to be poor in the communities, due to the widespread use of overhung (jetty-type) toilet. The use of overhung toilet not only contaminates the river with fresh faeces but has also been linked to several excreta-related diseases, including diarrhea, typhoid and schistosomiasis.

Housing characteristics: Most of the houses in the communities are built on the levees of the river and have roofs that are constructed with corrugated roofing sheets; have very high Damp Proof Course, because of the perennial seasonal flooding in the communities; and have floors that are constructed with cement (87%), mud (8%), and planks (5%).

Waste management: The wastes generated in the communities are mainly garbage and other domestic wastes. The wastes were often dumped close to the residential accommodation, or at the bank of the river, where the wastes sometimes served for land reclamation and/or shoreline

protection. Leaches from the wastes can however become a source of contamination of the water bodies.

Household Food Security and the nutritional status of under-five children: The level of malnutrition in the communities is 8.94%, which is comparable to the Bayelsa State average of 10.0% and the south-south average of 12.8%. It is however significantly better than the national averages of 32.2% for rural communities, and 22.1% for urban communities.

Use of alcohol and tobacco: these were commonly used in the communities, like most communities in south-south Nigeria. Alcoholic beverages are freely available and at all time in the communities, while about an average of 20% of adult males in the host communities smoke cigarette.

Sexual behaviour: The sexual behaviour of members of the communities can encourage the transmission of sexually transmitted infections, including HIV/AIDS. Polygamy is common, most adult males and single girls in the communities have multiple sexual partners, and male infidelity is common.

Knowledge of HIV/AIDS: Most people in the communities have heard of HIV/AIDS, but knowledge of the routes of transmission of the disease is at best moderate in the communities, hence the need for HIV/AIDS enlightenment programme before and during the project.

Morbidity and mortality patterns: The disease pattern, morbidity and mortality rates in the communities are not different from those of similar communities in south-south Nigeria. The commonest causes of ill health in the communities were said to be malaria, typhoid fever, upper respiratory tract infections, skin diseases, measles and diarrhoeal diseases. The prevalence of non-communicable diseases like hypertension and diabetes were said to be increasing in the communities.

The health system: The communities have health centers located within the prescribed 30 minutes travel time; though the services are often not provided on a regular basis. Traditional medicine practitioners, especially Traditional Birth Attendants and Massagers are very prominent in the communities and are patronized by many members of the communities. The tertiary health care services are provided by the Federal Medical Centre, Yenagoa and the Niger Delta University Teaching Hospital.

ES 9.0: Associated and Potential Impact

A combination of approaches was used for the assessment of the existing and potential impacts of Uzu field. The ISO 14001 method was used for evaluating the potential impacts. Impacts were assessed at various stages of the project including pre-construction, mobilization, site preparation, drilling and pipeline construction, fabrication, installation and positioning of wellhead, upgrade of Gbaran CPF, commissioning operations and maintenance, demobilization, decommissioning and abandonment. The potential positive impacts of the project include opportunities for business and

employment, increased oil and gas production and revenue generation. Significant potential negative impacts of the project include:

- Risk of accident
- Risk of piracy & kidnapping
- Interference with fishing activities
- Increase in noise and vibration
- Impacts of wastes
- Impacts on vegetation and wildlife
- Impairment of air quality
- Injuries and death from blowouts
- Surface water and sediment pollution from chemicals, drill cuttings, and mud
- Exposure to radiation
- Potential for conflicts arising from labour issues

ES 10.0: Mitigation Measures

Mitigation measures were proposed for the predicted medium and high-ranking impacts. The risk of accident shall be mitigated via compliance with SPDC journey management policy for land transport. The Risk of Piracy & kidnapping shall be mitigated via making adequate security arrangements at the project site and engagement of the youths from the area on worthwhile ventures e. g. skills acquisition. The impact of air quality and noise shall be mitigated by the use of equipment and machineries that are pre-mobbed and meet regulatory emission standards. Compliance with SPDC waste management guidelines shall mitigate the impact of wastes. Surface water and sediment pollution from chemicals, drill cuttings, and mud shall be mitigated by adequate drill cuttings and mud management.

ES 11.0: Environmental Management Plan

SPDC developed an Environmental Management Plan (EMP), to ensure that all identified significant negative impacts and the mitigation measures are implemented throughout project life cycle. The project team shall also rely on ISO 14001 audit and other national and international legal environmental management procedures to ensure compliance of monitoring plan. The EMP team shall liaise with all contractors, engineers, quality assurance officers, supervisors and all relevant SPDC personnel as well as other stakeholders on all environmental matters. Monitoring requirements, duration and frequency of monitoring of key performance indicators as well as action party to manage the biophysical, health and social environments at various stages of the work have been proposed. The EMP is a dynamic working tool and would be updated from time to time during lifespan of project, to incorporate innovations, and changes in policy and in regulations.

ES 12.0: Project Schedule

The project activities shall be executed between 2015 and 2021, when it is planned to be commissioned. The key schedule enablers are incorporation of learnings from Enwhe & Abasare projects that are similar and ahead; and C&P strategy where SEDO will carry out the detailed design and enterprise frame agreements (EFAs) will be used to procure long lead items (LLIs). The critical path is basically FEED, contracting (i.e. receiving commercial bids) and funding approval.

ES 13.0: Decommissioning, Abandonment and Restoration

The decommissioning of the project facilities shall involve these main activities:

- Determining the regulatory requirements
- Evolving a community involvement strategy
- Establishing future land use objectives
- Determining objectives of the mothballing plan
- Determining remediation requirements
- Determining reclamation objectives
- Developing a HSE plan

ES 14.0: Conclusion

The EIA of Uzu field was carried out in accordance with relevant local, national and international regulations based on DPR and FMEnv approved terms of reference. The methodology applied for the study involved desktop studies, two season field data gathering and community consultations. To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various biophysical, social and health components. The magnitude of the anticipated impacts of the project activities on the environmental components: air, water, soils, sediment, vegetation, fauna, fisheries, land use, waste management, social, economic and health issues were assessed, ranked and rated. The EIA of the project shows that it would have a significant beneficial impact on both local and national economy. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. With the implementation of the EMP/Monitoring Plan, GMoU, respect for socio-cultural values, applicable legal and administrative frameworks and SPDC corporate policies and strict adherence to HSE provisions and other corporate best practices and design codes, this Uzu project could be implemented sustainably.

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CHAPTER ONE INTRODUCTION

1.1 Background Information

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), intends to carry out an Environmental Impact Assessment (EIA) study for the Uzu Field Development and Uzu Deep Exploration. This study complies with the Federal Ministry of Environment EIA Act and the Department of Petroleum Resources regulations. Uzu field is part of the multi-field Gbaran node that is being developed in phases to support SPDC's gas supply obligation to NLNG T1-T6; and, grow oil production. Uzu is part of the third phase of development that also includes Enwhe and Abasare developments that are ahead and have passed through concept selection. The Gbaran node has a central processing facility (CPF) located in Gbaran field with a 1.2Bscf/d NAG plant and a 120Mbpd oil processing facility. Uzu field development project objective is to produce 815 Bscf (UR) of gas and 11.3 MMstb (UR) of condensate. The Uzu field development project activities, which this EIA study covers include drilling, construction of flow lines, bulk lines and pipelines and expansion/upgrade of Gbaran CPF.

1.2: Project Location

Uzu Field is a partially appraised field located in OML-28, in Yenagoa Local Government Area (LGA) Bayelsa State (Fig. 1.1). The field extends approximately 6 km in the North-South and 13 km in the East-West directions.

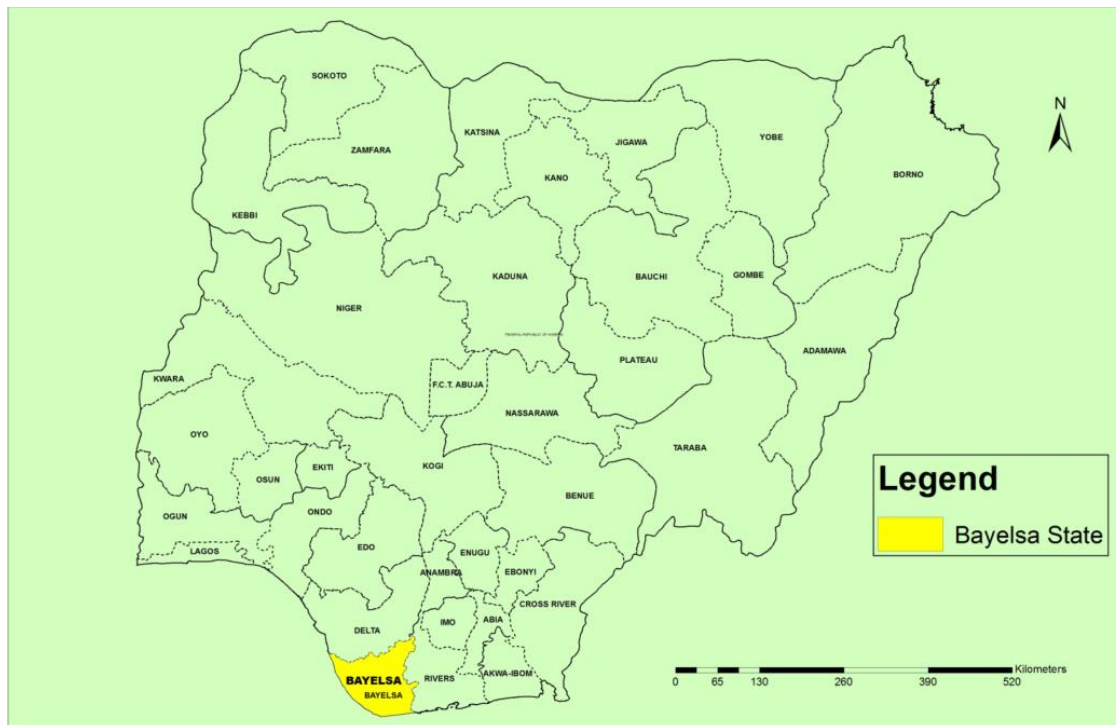


Fig. 1.1: Map of Nigeria showing the location of Bayelsa State where the Uzu Field is located.

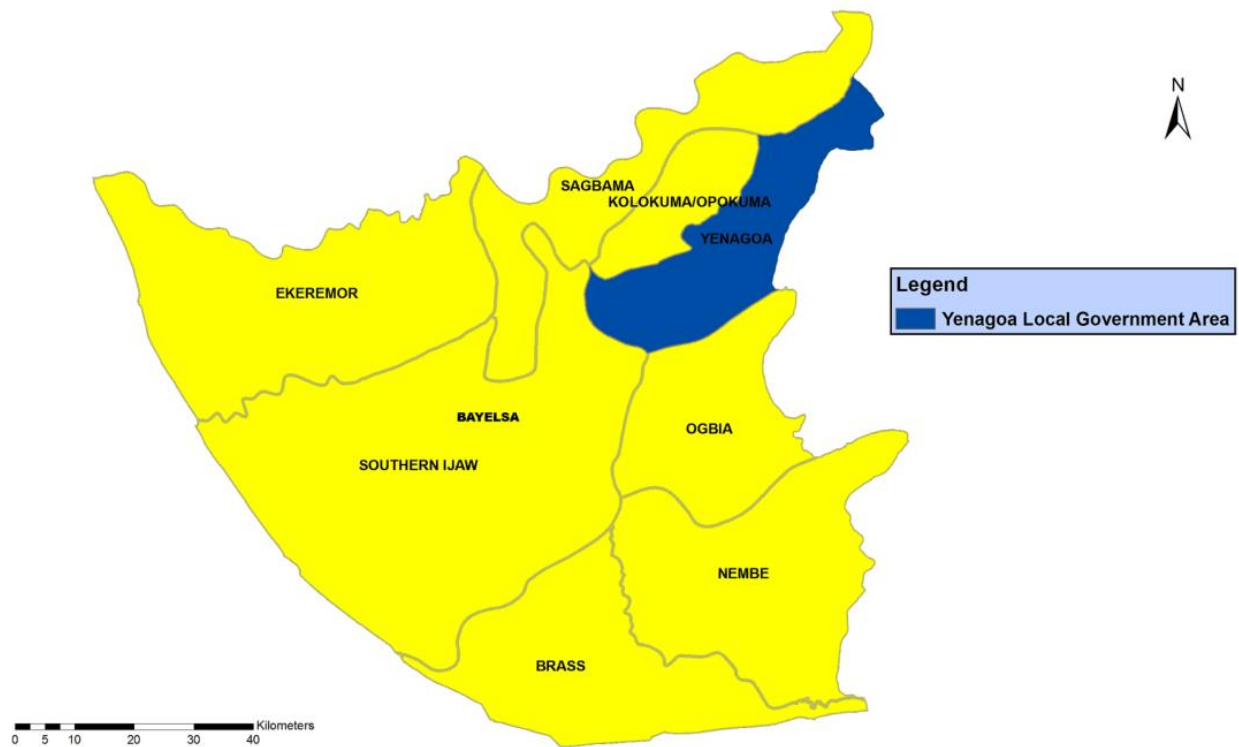


Fig 1.2: Map of Bayelsa State showing Yenagoa LGA where the project is located

1.3 Objectives of The EIA

The objectives of the study are:

- To establish the baseline conditions of the proposed project area with respect to the biophysical, social and health environment.
- To identify and evaluate the potential impacts of the project activities on the biophysical environment of the area.
- To identify and assess the potential socio-economic effects of the project on the communities' livelihood patterns, including impacts on cultural properties, social infrastructures, natural resources and values.
- To identify and evaluate health impacts that may be associated with different activities of the project.
- To develop cost-effective mitigation measures and appropriate Environmental Management Plan (EMP) for sustainable development.

1.4: Legal and Administrative framework

There are legislations, guidelines and standards that govern the assessment of environmental impacts of development projects in the oil and gas industry in Nigeria. These regulations can be classified as follows:

1.4.1: Environmental laws and guidelines guiding environmental management in Nigeria

The Mineral Oil (Safety) Regulations, 1963

Sections 37 and 40 of the mineral oil (safety) regulations, 1963, require provision of personal protective equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

Oil Pipelines Ordinances (CAP) 145, 1956 and Oil Pipelines Act, 1965

The oil pipelines ordinance (CAP 145), 1956, as amended by the Oil Pipelines Act 1965, provides, under Section 4(2), for a permit to survey (PTS) a pipeline route to be issued to the applicant by the Minister of Petroleum Resources, for the purpose of transporting mineral oil, natural gas, or any product of oil or gas to any point of destination to which such a person requires such oil, gas or product, thereof, for any purpose connected with petroleum trade or operations.

Petroleum (Drilling and Production) Regulations (1969)

The Petroleum (Drilling and Production) Regulations (1969), empowers the holder of an OPL to do practically anything in the area covered by the license {Section 15 (1)}, but Section 15(2) holds such a holder responsible for all the actions of his agents and contractors.

Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988

This Act, which was issued in 1988 and amended by Act No. 59 of 1992, provides the setting up of the Federal Environmental Protection Agency, as the apex organization for the overall protection of the Environment and Conservation of Natural Resources. The act also makes environmental impact assessment (EIA) mandatory for all new major projects. In compliance with its mandate, FEPA issued the procedure, guidelines and standards for the execution of EIA with emphasis on the significance associated with current and potential impacts of such projects. The procedure also indicates the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment.

FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995)

In compliance with its mandate, FEPA issued the EIA Procedural Guidelines and Sectoral Guidelines for Oil and Gas Projects in 1995. Contained in the Procedural Guidelines (pg. 8) are Category I projects (mandatory study activities) and listed under item 15, sub-item (a) on page 10 (Petroleum) is Oil and Gas Fields Development, making an EIA mandatory for the proposed project. The Procedural Guidelines also indicate the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment. The guidelines are intended to assist in the proper and detailed execution of EIA studies of projects in consonance with the EIA Act.

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

This provides that the objective of solid and hazardous waste management shall be to:

- Identify solid, toxic and extremely hazardous wastes dangerous to public health and environment,
- Provide for surveillance and monitoring of dangerous and extremely hazardous wastes and substances until they are detoxified and safely disposed,
- Provide guidelines necessary to establish a system of proper record keeping, sampling and labeling of dangerous and extremely hazardous wastes,
- Establish suitable and provide necessary requirements to facilitate the disposal of hazardous wastes;
- Research into possible re-use and recycling of hazardous wastes.

Environmental Impact Assessment Act CAP E12 LFN 2004

This Act provides guidelines for activities of development projects for which EIA is mandatory in Nigeria. The Act also stipulates the minimum content of an EIA as well as a schedule of projects, which require mandatory EIAs.

FEPA (Now FMEnv) National Guidelines for Spilled Oil Fingerprinting (Act 14 of 1999)

This provides guidelines for spilled oil fingerprinting applicable throughout Nigeria, in order to improve the quality of the environment and to free it from pollutants and other environmental and health hazards.

FEPA (Now FMEnv) National Guidelines on Waste Disposal through Underground Injection (1999)

These Guidelines and Standards on waste disposal through underground injection provide the 'modus operandi' for the most viable options for disposal of these wastes in a tropical environment as Nigeria.

FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999)

Nigeria's National Agenda 21 was developed to:

- Integrate environment into development planning at all levels of government and the private sector,
- Intensify the transition to sustainable development,
- Address sectoral priorities, plans, policies and strategies for the major sectors of the economy and,
- Simultaneously foster regional and global partnerships.

FEPA (Now FMEnv) National Policy on the Environment (1989)

This gave the policy goals, conceptual framework and strategies for implementation.

Forestry Law CAP 51, 1994

The Forestry Act 1958 which was amended as the Forestry Law CAP 51, (1994) prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry

property in Nigeria. The law prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria, which is applicable to the mangrove, and other forests of the Niger Delta.

Land Use Act of 1978

The land-use Act of 1978 states that “... it is also in the public interest that the rights of all Nigerians to use and enjoy land in Nigeria in sufficient quality to enable them to provide for the sustenance of themselves and their families should be assured, protected and preserved”.

National Oil Spill Detection and Response Agency (NOSDRA), 2006

The National Oil Spill Detection and Response Agency (NOSDRA) was established in 2006 as the lead Agency in ensuring timely, effective and appropriate response to oil spills, through clean up and remediation of all impacted sites to all best practical extent.

Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26)

An Act to compel every company producing oil and gas in Nigeria to submit preliminary programmes for gas reinjection and detailed plans for implementation of gas re-injection.

Endangered Species (Control of International Trade and Traffic) Act 11 of 1985

This Act prohibits hunting, capture and trade of some *endangered species* like crocodile, alligator, turtles, Parrot, etc. The Endangered (Control of International Trade and Traffic) Decree (No. 11 of 1985) has been enacted by the Federal Republic of Nigeria specifically to implement CITES. It is broader than CITES in that it also covers domestic taking of listed species. Two schedules are included: Schedule I (Endangered Species – Animals in relation to which International Trade is absolutely Prohibited), and Schedule 2 (Animals in Relation to which International Trade may only be conducted under License). The decree prohibits taking of Schedule 1 species and requires that taking of Schedule 2 species be in accordance with a license issued under the decree.

1.4.2: International Laws and Regulations guiding Environmental management

Nigeria is signatory to several laws, treaties and regulations that govern the environment.

Among these are:

- (i) World Bank Guidelines on Environmental Assessment {EA} (1991)
- (ii) International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines
- (iii) Convention on the Migratory Species of Wild Animals (Bonn Convention)
- (iv) Convention of Biological Diversity
- (v) Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)
- (vi) Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and.
- (vii) United Nations Framework Convention on Climate Change (1992)

World Bank Guidelines on Environmental Assessment {EA} (1991)

The World Bank requires the execution of an EIA on a proposed industrial activity by a borrower as a pre-requisite for granting any financial assistance in form of loans. Details of World Bank's EIA procedures and guidelines are published in the Bank's EA Source Book vols. I - III of 1991. Potential issues considered for EA in the upstream oil and gas industry include the following:

- Biological Diversity
- Coastal and Marine Resources Management
- Cultural Properties
- Hazardous and Toxic Materials and
- International waterways.

International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines

The IUCN in conjunction with the Oil Industry International Exploration and production Forum presented a set of guidelines for oil and gas exploration and production in mangrove areas. These guidelines are aimed at conservation of mangroves and enhancing the protection of marine ecosystems during E & P activities. The document also discusses the policy and principles for environmental management in mangrove areas as well as EIA procedures, Environmental Audit and Monitoring.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

The Bonn Convention concerns the promotion of measures for the conservation and management of migratory species.

Convention on Biological Diversity

The objectives of the Convention include the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention)

The convention sets aside areas of cultural and natural heritage for protection. The latter is defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal

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

United Nations Framework Convention on Climate Change (1992)

In order to achieve sustainable social and economic development, energy consumption for developing countries needs to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general. This also includes the application of new technologies on terms which make such an application economically and socially beneficial, determined to protect the climate system for present and future generations.

1.4.3: Environmental laws and guidelines guiding Environmental management in Bayelsa State

The Bayelsa State regulations guiding Environmental management includes but not limited to the following:

- Bayelsa State Environmental and Development Planning Authority Law 1998;
- Bayelsa State Pollution Compensation Tax Law 1998;
- Bayelsa State Forestry Law 1998.
- Bayelsa State Land Use (Environmental Degradation/Protection) Charge Law 2005.

1.4.4: SPDC Policies and Principles

Shell Petroleum Development Company (SPDC) operates under the guidelines of Shell International and complies strictly with them. Where national standards and regulations are more stringent than Shell guidelines, SPDC's policy is to comply with the existing national legislation.

(a) Business Principles

Shell companies have a systematic approach to health, safety, security and environmental management in order to achieve continuous performance improvement. To this end, Shell companies manage these matters as critical business activities, set standards and targets for improvement, and measure, appraise and report performance externally.

(b) Governing Policies

The SPDC 1998 Corporate Policies emerged with five Business Governing policies. Of interest to this document is the section on HSE referred to as 'Health, Safety and Environment Policy'. This policy addresses the health, safety, and environmental risks to the business and the potential impacts on staff, personnel, and the host communities. The policy reflects good practice and is mandatory.

(c) HSE Policy

It is SPDC's Policy that all activities shall be planned and executed in a manner that,

- Preserves the health, safety and security of all Company and contractor personnel and members of the public;
- Preserves the integrity and security of Company assets;
- Minimizes the impact of operations on the environment; and
- Is sensitive to the needs and concerns of the Host Communities.

The implications of implementing this policy are that,

- All activities shall be analyzed to systematically identify related hazards, risks and sensitivities;
- Arrangements shall be put in place to control the hazards, risks and sensitivities and to deal with consequences should they arise;
- Any activity which is unhealthy, unsafe, environmentally unsound or may adversely impact relations with the community, shall be suspended until an acceptable solution is found;
- All personnel, including those of contractors, shall be trained and made fully aware of the hazards, risks, sensitivities and controls in place; and
- Plans and procedures shall be in place to respond to any emergency or loss of control.

Every employee and contractor employee must plan and perform his work in accordance with this policy. Each employee is required to report, and where necessary, suspend any activity considered to be in contravention of this policy.

(e) SCiN Biodiversity Policy

“In Shell, we recognize the importance of biodiversity. Therefore, we are committed to:

- Work with others to maintain Ecosystems
- Respect the basic concept of Protected Areas
- Partner with others to make positive contributions towards the conservation of biodiversity in our areas of operations
- Conduct Environmental Assessments with increased focus on impacts on biodiversity
- Engage and collaborate with other stakeholders to manage biodiversity responsibly especially in sensitive environments

(f) Waste Management Policy

It is the policy of SPDC to:

- Take all practical and reasonable measures to minimize the generation of solid and liquid wastes, as well as emissions from construction equipment and otherwise;
- Manage and dispose off wastes in an environmentally responsible manner;
- Track and maintain records of waste streams and provide an auditable trail as to their management and disposal.

(g) Emergency Response Policy

This states that the response to any emergency within SPDC will be directed towards

- Saving life
- Care for the injured
- Protection of the environment
- Limitation of damage to assets
- Defence of SPDC’s good corporate image
- SPDC shall provide appropriate organization, facilities, procedures and training so that immediate coordinated action can be taken to manage the situation in line with the above

- Maintenance of emergency equipment shall receive high priority. Close liaison will be maintained with appropriate Government and industry organization and communities
- Regular exercises will be carried out to confirm effectiveness, and any necessary improvements made promptly so as to maintain our readiness at all times.

(h) Community Relations Policy

In order to pursue mutually beneficial relations with host communities, SPDC shall:

- Establish and maintain close relationships with all segments of the local population to better understand their concerns, needs and aspirations
- Continuously assess and abate social and economic impact of all business activities and take needed preventive or mitigating measures
- Respond to formal community request in an appropriate and timely manner
- Bring relevant issues affecting host communities to the attention of appropriate authorities and other bodies that can be of assistance
- Manage settlement of compensation for land acquired for company operations and for damages in a demonstrably fair, accountable and transparent manner and in accordance with statutory provisions and approved procedures.

1.5 Terms Of Reference

The DPR approved terms of reference (TOR) for the project is presented in Appendix 1. The work scope covers biophysical, social and health environmental components. The biophysical field data gathering was carried out in two seasons for soil, surface and ground water, sediment, vegetation, air and noise. The collected samples were reanalyzed for physicochemical, hydrobiological and microbiological parameters specified in the TOR.

1.6: Declaration

The Shell Petroleum Development Company of Nigeria (SPDC) in its capacity as the operator of the Uzu field hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the Project phases. Shell Petroleum Development Company is committed to the implementation of the Environmental Management Plan (EMP) covering the Uzu field. The company avows that it has prepared this EIA report using the best available expertise in personnel, equipment and internationally acceptable methods.

1.7: Report Preparation

The report was prepared according to the EIA procedural guidelines.

Chapter 1 –Introduction

Chapter 2 –Project Justification and Alternatives

Chapter 3 - Description of the Project

Chapter 4 - Description of the Project Environment

Chapter 5 –Associated and Potential Impacts

Chapter 6 - Mitigation Measures

Chapter 7 –Environmental Management Plan

Chapter 8: Remediation plans after decommissioning/closure

Chapter 9: Conclusions and Recommendations.

Bibliography

Appendices

CHAPTER TWO PROJECT JUSTIFICATION

2.1: Introduction

The Uzu field is part of the Gbaran Phase-3 developments in continuation of the planned phased development of the Gbaran node to supply gas and grow oil production. This chapter highlights the need for the projects in the Uzu field, value of the project, project sustainability, project options and alternatives.

2.2: Value for The Project

The Uzu development is in the Export gas market tranche that will deliver both upstream value (SPDC gas sale) and midstream value (NLNG sale) to Shell, Partners and the Nigerian Government. Though, primarily aimed at gas development, oil is also being matured to ensure that the full resource base is developed.

The revenue that will accrue from the sales of gas to be produced from these wells will substantially increase the foreign exchange earnings of the Federal Government and help to improve the social and health standards of the inhabitants of the area covered by the project.

Table 2.1: Economic value of the project

	GAS DEVELOPMENT	OIL DEVELOPMENT	CONSOLIDATED DEVELOPMENT
NPV0% (\$mIn)	610.3	25.8	636.2
NPV10% (\$mIn)	176.6	5.7	182.3
IRR	36%	19%	34%
CAPEX (\$mIn)	325.8	47.3	373.1
OPEX (\$mIn)	49.4	19.4	68.8
UTC 0% (\$/boe)	3.0	9.1	3.3
UDC 0% (\$/boe)	2.3	5.7	2.5
PROD (mmboe)	144.0	8.3	152.3

2.4: Envisaged Sustainability

2.4.1: Economic Sustainability

The 100% JV economics evaluation carried out shows that the project is very economic (See Table 2.1 above). From the sensitivity carried out, the impact of including the Gbaran CPF upgrade CAPEX scope in Uzu still results in a very economically attractive project. Since June 2010, gas from the Gbaran node Central Processing Facility (CPF) is being exported via the 1.4Bscf/d capacity Eastern Gas Gathering System Phase 2 pipeline (EGGS2) and supplies gas to Nigeria LNG (NLNG) Trains 1-6, located at Bonny Island. The associated condensate is exported via the Trans Niger Pipeline (TNP) to Bonny combined with oil production from the Gbaran node. A long term gas sales agreement (GSA) is in place that commits SPDC to supply an average Daily Contractual Quantity of 1,941 MMscf/d to the six NLNG Trains 1-6 from Gbaran node, Soku node, Bonny node and the offshore gas gathering system (OGGS). The GSAs expiration

commences in 2021 with Trains 1-2, but there are very strong indications that the GSAs will be extended

2.4.2: Technical Sustainability

This project is technically sustainable because of SPDC's proven oil and gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilised in the execution of the proposed project. New gas wells will be drilled and flowlines constructed to transport the gas to a gathering manifold, from which the gas will be transported via a bulk line to the Central Processing Facility (CPF). The CPF has gas dehydration facilities for high pressure AG and NAG treatment prior to export to NLNG.

The following Existing Proven Technologies that would be adopted for the UZU FDP:

- Seismic (QI) for oil rim identification technology has been used to complement pressures to develop additional volume and hence greatly improve project economics.
- Reducing unit development cost (UDC)- Smart / Intelligent well technology has been applied to combine two reservoirs in one well and produce these reservoirs commingled. The sand-face completions are Cased Hole which minimizes the risks associated with the drilling and completion.
- Well hook up skid- application of this skid will allow for a reduced hook up time and costs.

2.4.3: Environmental Sustainability

National and international regulatory and engineering design standards, innovative technologies that have minimal environmental, social and health impacts shall be utilized in the execution of the proposed project. The incorporation of the findings and recommendations of this report at the various stages of the project development and strict adherence to the Environmental Management Plan (EMP) will ensure environmental sustainability.

2.4.4: Social Sustainability

The integration of appropriate social impact assessment and community interface management mechanisms in the project are critical success factors to the realization of overall business objectives and SPDC corporate reputation in the area. A stakeholder engagement plan has been developed and all stakeholders, especially communities, partners, regulators and other government agencies will be engaged in a proactive and respectful manner to engender participation and secure enabling environment for the Project. The deployment of GMoU and allied processes for interface management and delivery of basic community development intervention projects and programs is critical to the success of this project. Its scope will ensure that we do not create legacy issues, but enhance community participation in the business through active collaboration with SPDC Community Content Team. Skills will also be developed and business supported to enable community participation in the project execution phase and beyond. Approximately, 2.5% of project cost (CAPEX) shall be provided for the implementation of Social Performance intervention programs and projects in the impacted communities. The fund assigned for community

development through the GMoU shall be paid into a joint account maintained with the communities in tranches and spread over the duration of the agreement, which will also align with the duration of that project.

2.5: Project Options

The project alternatives/options considered were;

Gas Development

Do Nothing

Enwhe Replica

Abasare Replica

Low capex

Oil Development

Do Nothing

Low capex

Optimized development

This section presents the various development concepts for the Uzu field opportunity. The concept that holds the most value for the opportunity was selected. The project options are presented in Table 2.2. Development concepts were considered for the Uzu field development differentiated primarily by the tie-in point, either directly to Gbaran CPF or to an intermediate field manifold.

Table 2.2: Project options for the Uzu Field Development

Development Concepts	Differentiation
Gas	
Enwhe Replica (Similar to Gbaran Ph 3A Enwhe project)	Direct tie-in to Gbaran CPF CS bulkline (B/L) to Gbaran CPF CI injection for corrosion management Slug catcher at CPF inlet
Abasare Replica (Similar to Gbaran Ph 3A Abasare project)	Tie-in via Zarama manifold/bulkline DSS bulkline to Zarama manifold
Low Capex (Optimistic concept)	Similar configuration to Abasare replica concept CS flowlines (F/Ls) and bulkline (B/L)
Oil	
Low Capex	Flowline connects to Zarama XHP oil manifold
Optimized Development	Flowline connects to CPF HP oil manifold

Concept selection workshop was carried out with JV Partners and the Regulator (DPR) in attendance. Solution space evaluation was used to determine the relative goodness of the concept options and Decision Quality (DQ) assessment was carried out on the emerging decisions based on the concept select for further optimization. The selected concepts “Enwhe Replica” for gas and “Low capex” for oil were then taken through the Shell competitive scoping (PT2020 process) to ensure that Uzu project is competitive.

2.5.1: Development Alternatives of Uzu

The development alternatives are highlighted above, and the selected development concept work scope is tabulated in Table 2.3.

2.6: Drilling Location Alternatives

The use of existing surface locations was considered for the well construction purposes in a bid to minimize footprint. Other surface location selection considerations include reduced CAPEX, reduced collision risk due to high density cluster, reduced environmental and community impact & interaction. The subsurface targets are clustered on the western and eastern flanks of the field and are about 4km apart making the use of one drill site result in extended vertical sections for some wells. The existing surface well locations in the region that overlay the subsurface targets, and are in the vicinity, include the UZU-001, ZARA-008/009, ZARA-010/11, ZARA-015, ZARA-002 and ZARA-003 locations.

Based on target accessibility, existing right of way (ROW), and other criteria, the following are the chosen surface drilling locations:

- Drilling location A: this is the ZARA-008/009 location which will be used to access the sub surface targets on the western flank of the field. There is an existing ROW and no settlements.
- Drilling location B: the ZARA-015 location will be used to access the subsurface targets on the eastern flank of the field.

Table 2.3.: Uzu Field Development Concepts

Package		Reference Case Concept
Wells		4 NAG wells to develop 7 reservoirs and 1 oil well to develop 1 reservoir
Flowlines		4 NAG DSS flow lines & 1 No CS Oil flow line
Primary Treatment Facility	Manifold	1 No 1500# CS 16” manifold
	Inlet separator	Use existing capacity at Gbaran CPF
	Water Dehydration	Use existing capacity at Gbaran CPF
	HC Dewpointing	N/A
	Condensate Stabilization	Use existing capacity at Gbaran CPF

	Flash Gas Compression	Use existing capacity at Gbaran CPF
	Water Storage	N/A
	Condensate Storage	Use existing capacity at Gbaran CPF
Export Pipeline	Gas	Use existing capacity at Gbaran CPF
	Oil/Condensate	Use existing capacity at Gbaran CPF
	Produced water	Use existing capacity at Gbaran CPF
Production / Logistics Infrastructure	Custody Transfer	Use existing capacity at Gbaran CPF
	Storm Water	ZARA-015 well location area extension to be designed to have storm water drains around the perimeter.

2.6.1: Pipeline Options

Uzu development scope incorporates pipelines.

The oil development involves installation of 1Nos 6" x 1km CS Oil flowline (within ANSI 1500# piping class) to be tied to existing 16" x 17.5km Zarama Oil bulkline en-route Gbaran CPF via a barred tee.

The gas development involves:

- Installation of 3Nos 8" x 0.5km 1500# DSS NAG flowlines to be tied to new Uzu NAG remote manifold.
- Installation of 1Nos 8" x 0.5km 2500# DSS NAG flowline to existing Zarama NAG manifold.
- Installation of a new 16" x 18km Carbon steel NAG bulkline from the Uzu NAG manifold to existing Koroama 1 NAG slug catcher at Gbaran CPF and provision for switching to the proposed GNC LP manifold.

CHAPTER THREE

PROJECT/PROCESS DESCRIPTION

3.1: Introduction

Uzu field is part of the multi-field Gbaran node that is being developed in phases to support SPDC's gas supply obligation of 2Bscf/d to NLNG T1-T6; and also grow oil production. Uzu field development is more of a gas project, with the development objective of 935 Bscf (UR) of gas and 11.8 MMstb (UR) of oil and condensate. The details of the scope of work, proposed project activities and Waste Management in Uzu field are presented in this chapter.

3.2: Project Objectives

Uzu field is one of the gas supply sources to meet SPDC gas supply obligation to NLNG T1-T6. This study is carried out to provide the right technical maturity for the volume contribution from Uzu and the technical basis for funding. As part of Uzu development, there will be an upgrade of the Gbaran CPF via installation of an additional 200MMscfd TEG dehydration system with its ancillaries and brownfield tie-ins. The full project name is hence "Gbaran Phase 3B – Uzu with CPF Upgrade".

3.3: Project Development History

The Uzu field is located in OML-28 and is a partially appraised field that extends approximately 6 km in the North-south and 13 km in the East-west directions. Uzu lies within the greater Zarama structure comprising a simple rollover structure elongated in the East-West direction and a 4-way fault bounded structure. The field was discovered in 1971 by exploration well UZU-001. Five other wells have been drilled into the Uzu structure from the neighboring Zarama field (ZARA-001, ZARA-002, ZARA-008, ZARA-009 and ZARA-015). ZARA-015 is the Uzu appraisal well drilled in 2012, but renamed as ZARA-015 since the surface location is from the neighbouring Zarama field. Hydrocarbons have been encountered between 6,500 and 10,200 ftss in the C, D, E and F sands (14 reservoirs). There has been no production from the field to date. The last previous study carried out on this field is the 2014 Uzu Feasibility Study (Report No: SPDC-2014-09-00000242).

3.4: Proposed Project Scope & Overview

3.4.1 Overview

The Gbaran Phase 3B - Uzu with CPF Upgrade project scope includes infill drilling and/or completion involving 6 wells with flowlines and a bulk line from the Uzu field as well as facility upgrade at the Gbaran Central Processing Facility involving installation of a 200MMscfd TEG dehydration train and the ancillary units, including Brownfield tie-ins. A summary of the Uzu Development drilling scope is shown in Table 3.1.

There is one appraisal well. ZARA-015 is the Uzu appraisal well drilled in 2012, but renamed as ZARA-015 since the surface location is from the neighbouring Zarama field. The completion and hook up of ZARA-015 well will be executed as part of this project.

New wells to be drilled as part of Uzu development will be from two existing well locations; Zarama 15 and Zarama 08-11 locations. Three NAG wells will be clustered at Zarama 15 location in addition to the already drilled but not completed Zarama 15 well, while 1NAG well and 1 Oil

well will be drilled from the Zarama 08-11 location. Zarama 08-11 location has 4 free well slots while Zarama 15 location has 2 free well slots. Extension of Zarama 15 location will be required to accommodate extension of the well cellar (4 slots with provision for relief well) and a manifold location, while free slots at Zarama 08-11 location will be used for the 1 NAG and 1 Oil well drilling. Four NAG wells will be hooked up to the new Uzu manifold (at Zarama 15 well location) via 8" x 0.5km 1500# NAG DSS flow lines and bulk flowed to Gbaran CPF via new 16" x 18km CS bulkline. One NAG well will be hooked up to existing Zarama NAG manifold via new 8" x 0.5km 2500# DSS NAG flowline.

The dimensions of the flowlines are shown in table 3.1 below.

Table 3.1 Summary of Uzu drilling, completion and construction activities

Location	No. of Wells	Flowlines	Manifold	Bulkline
Zarama 15	3 new NAG (drilling & completion)	3no. x 8" x 0.5km x 1500# DSS	New manifold (appropriately sized)	New 16" x 18km CS bulkline
	1 existing NAG – Zara15 (completion)	8" x 0.5km x 1500# DSS		
Zarama 8-11 cluster	1 NAG	8" x 0.5km 2500# DSS	Tie-in to existing Zarama Manifold	Existing 20" x 10.2km Zarama NAG bulkline or New 16" x 18km CS Uzu bulkline
Zarama 8-11 cluster	1 Oil	2no. x 6" x 1km 1500# CS	-	i. Existing 16" x 17.5km Oil bulkline ii. Existing 6" x 17.5km Oil Test line

One oil well will also be drilled, completed and 2 new 6" x 1km 1500# CS Oil pipelines will be tied in to existing 16" x 17.5km Zarama Oil bulkline and 6" Oil Test line respectively en-route Gbaran CPF via barred tees. A schematic showing Gbaran Phase 3B - Uzu with CPF Upgrade project scope is presented in Figure 3.1.

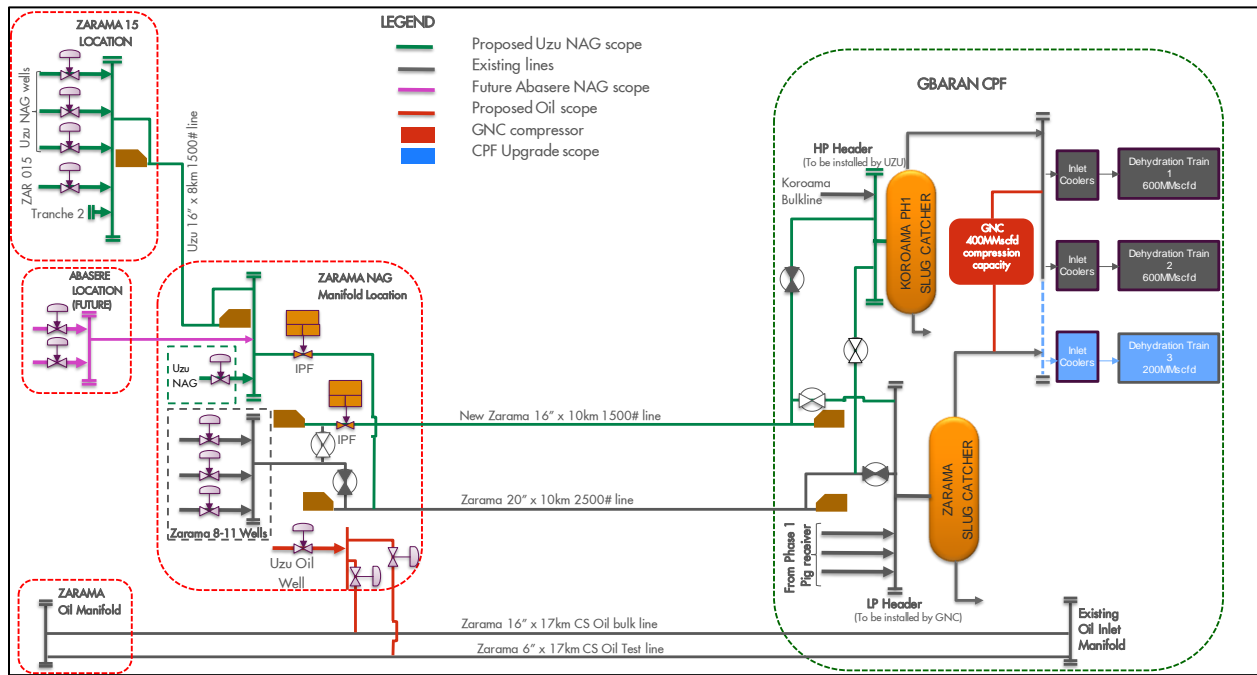


Fig 3.1 Uzu with CPF Upgrade Project Schematic

Current development is focused on Tranche 1 only, while Tranche 2 will be a separate project with its own maturation after input from appraisal during Tranche 1 well drilling. However, Tranche 2 is expected to share facilities such as well location (Zarama 15), bulkline and slug catcher. In line with company-wide standardization and replication drive, a well hook-up skid is planned to be used for hook-up of new Uzu NAG wells. This skid will be designed as part of the project scope. Due to the location of the Uzu wells and its proximity to the Zarama manifold, the plan is to provide flexibility for the switching of the Zarama and Uzu bulk lines such that the existing 20-inch Zarama bulkline can be used to flow Abasere and Uzu fluids combined under natural depletion flow to the Gbaran CPF while the Zarama fluids will be produced through the new Uzu bulk line when on compression.

The Uzu with CPF Upgrade project is an infill project and will utilise the existing plant condensate spiking system, hence would not include installation and/or modification of the spiking system. The CPF upgrade scope involves installation of a 200MMscfd TEG dehydration gas processing train to existing Gbaran CPF in order to increase overall plant capacity to 1.4Bscfd. From initial Gbaran Phase 1 design, the CPF inlet facilities (slug catchers and Dehydration inlet manifold) have been specified for up to 1.8Bscfd in order to accommodate future facility expansion. Hence, the main facility scope will be around tie-ins and integration with existing systems. The EGG-2 evacuation pipeline (with capacity of 1.4Bscfd) will be used for sales gas export. HP liquids from the TEG system (Inlet separator, glycol contactor and scrubber) will be tied to the CPF XHP Oil inlet header en-route XHP separator (and subsequently HP/LP separator and SV) while LP liquids (from glycol regeneration system) will be tied to the HP/LP/SV inlet headers as appropriate. The expended glycol will be recovered and regenerated via the Regeneration unit. The new TEG package will be located adjacent to the existing gas processing trains as recommended in the Phase 1 design (Fig 3.2). Revalidation of this location was done during the Site Selection workshop.

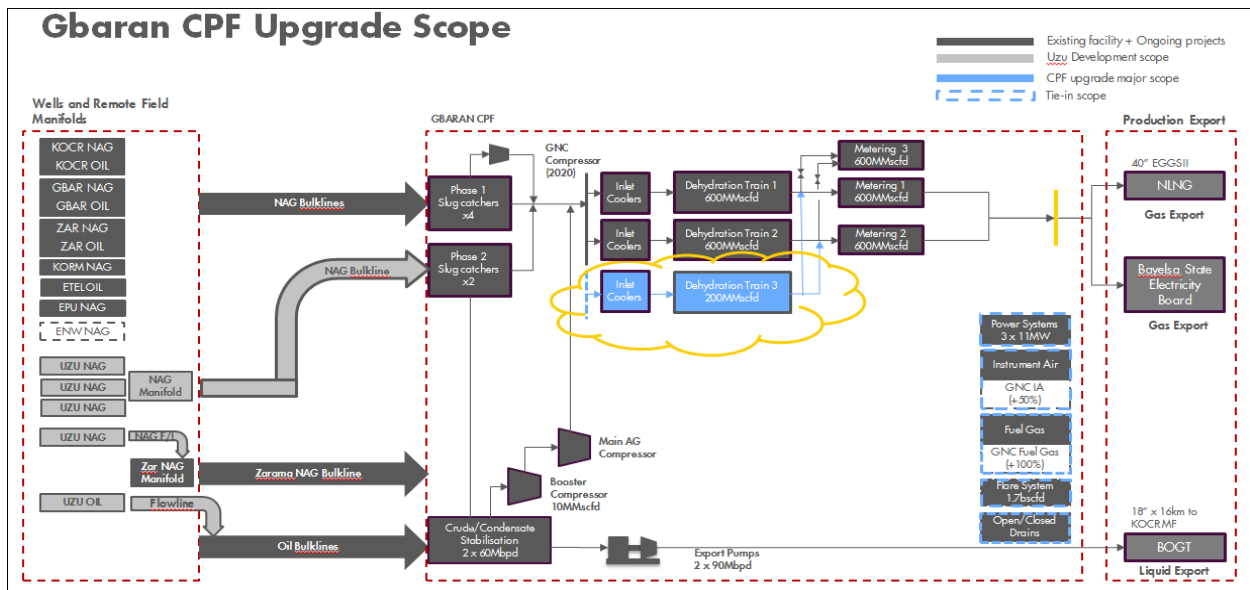


Fig 3.2 Gbaran Overview including proposed CPF Upgrade scope

3.4.2 General Scope Overview:

Overview of the project scope involves the following:

3.4.2.1 NAG Development Scope:

- Drilling and completion of 4 new NAG wells, and completion of existing Zara-015 well.
- Drilling and completing one Exploration/ Appraisal Well targeting the Zarama Deep reservoir.
- Design and Installation of NAG well hook-up skid; which contains the hook-up arm, choke valves and shut down valves.
- Hook-up of 4 development NAG wells to Uzu NAG manifold via new 4 Nos 8" x 0.5km 1500# DSS flowlines.
- Hook up of 1 development NAG well to existing Zarama NAG manifold via new 1 No. 8" x 0.5km 2500# DSS flow line.
- Installation of the Uzu NAG remote Manifold complete with requisite process equipment and utilities.
- Installation of a new 16" x 18km Carbon steel NAG bulkline from the Uzu NAG manifold, passing through the existing Zarama NAG manifold, to existing Koroama NAG slug catcher at Gbaran CPF and provision for switching to the proposed GNC LP manifold.
- Installation of piping, cabling and utilities to enable production from the Uzu NAG wells to the Gbaran CPF.
- Installation of 8km composite Power and FOC cables from Zarama NAG manifold to the new Uzu manifold; for power, data transmission and communications to Gbaran CPF.
- Installation of 2km composite Power and FOC cables from Zarama oil manifold to the new Uzu manifold; for power, data transmission and communications to Gbaran CPF.
- Installation of a FAR with HVAC and associated utilities at new Uzu remote manifold or alternatively, Remote Terminal Unit (RTU) with field cabinets will be installed and 2 Nos

RMUs for power; at Zarama NAG manifold or Zarama Oil manifold, and Uzu NAG manifold locations.

- Installation of telecoms facilities to support construction and operate phase of facility.
- Installation of pigging facilities including the pig traps and associated pipe-work and valves for the 16” bulkline.
- Installation of corrosion inhibition skid at Uzu remote manifold.
- Installation of corrosion inhibition line from the corrosion inhibition skid to the NAG bulkline.
- Provision of chemical storage system at Uzu remote manifold area.
- Installation of NAG equalization/Hydrate injection system at Uzu manifold (Zarama 15 location).
- Tie-in of existing well equalization/hydrate inhibition injection system at Zarama 08-11 location to new NAG well/flowline at Zarama 08-11 location.
- Installation of dual stream venturi meter on each flowline and one on the 16” bulkline for well testing and real-time monitoring. In assessing the flow assurance for the bulk line, particular attention should be paid to the design of bulkline & its dual stream venturi meter such that the impact of the meter on flow and pig -ability of the bulkline is not impacted.
- Tie-in of Uzu bulkline to Koroama 1 Slug Catcher inlet piping (with considerations for straight run length requirements).
- Provide flexibility via 16”x 0.2km line from the Zarama NAG bulkline (downstream the Zarama NAG manifold) tied to the Uzu bulkline and another 16”x 0.2km line from the Uzu bulkline tied to the Zarama bulkline via a 16” header (also accommodates flow from Abasere and single NAG well from Zarama 08-11) with barred-tees for the switching of the Zarama and Uzu bulk lines such that; the existing 20” Zarama bulkline can be used to flow Abasere and Uzu fluids combined under natural depletion flow (HP mode) to the Gbaran CPF while the Zarama fluids can be produced through the new Uzu bulk line when on compression (LP mode). This would include tie-in of the Zarama bulk line to the Koroama 1 Slug Catcher inlet piping.
- Provision of a closed drain vessel with a maintenance vent at the Uzu manifold area.
- Civil and location preparation works for extension of Zarama 15 well location area to include new 4-slot well cellar and a remote manifold location.
- Resurfacing of the existing Zarama 15 and Zarama 08-11 access roads.
- Refurbishment of the Zarama 15 and Zarama 08-11 drilling camp sites.

Well Completion

All four new planned development NAG wells will be deviated. Three wells will be completed in two reservoirs and one well will be completed as a conventional single string single.

NAG Smart wells will be completed as follows:

- X-tree – 5K
- Self equalizing TRSSSV to comply with remote startup ROCI Level 3 requirements
- 5 ½” 13Cr tubing to cater for commingled production from two reservoirs and ensure protection from sweet corrosion.
- Production packer with feed throughs to comply with safety barrier policy and prevent upper casing corrosion.
- Permanent Downhole Gauge (Tripple) to provide continuous bottom hole pressure and temperature measurements for production optimization and allocation purposes.

- R-nipple to set production packer and isolate well if necessary by setting a plug.
- Two ICVs: one conventional and one shrouded to regulate inflow from each zone.
- R-nipple with the plug below shrouded ICV. This plug can be pulled any time when WL access to bottom of the well is required.
- Separation packer to separate reservoirs. The packer will have capability to feed through DPS/DTS fiberoptic cable.
- DPS/DTS fiberoptic line to provide continuous pressure and temperature measurements at each reservoir level and provide, when necessary, redundancy to PDHG.
- Sandface completion – Top Zone Cased Hole Gravel Pack to prevent sand influx and secure well integrity
- Sandface completion – Bottom Zone Cased Hole Gravel Pack to prevent sand influx and secure well integrity

Conventional NAG wells will be completed as follows:

- X-tree – 5K
- Self equalizing TRSSSV to comply with remote startup ROCI Level 3 requirements
- 4 ½” 13Cr Tubing
- PDHG connected with surface fiberoptic cable to monitor bottom hole pressure and temperature in real time will be installed above the packer to minimize leak paths.
- Production packer to comply with safety barrier policy and prevent upper casing corrosion.
- Sandface completion – Open Hole Gravel Pack to prevent sand influx and secure well integrity.

The Oil well will be completed as horizontal producer and will have the following equipment:

- X-tree – 5K
- Self equalizing TRSSSV to comply with remote startup ROCI Level 3 requirements
- 3 ½” 13Cr Tubing
- PDHG connected with surface fiberoptic cable to monitor bottom hole pressure and temperature in real time will be installed above the packer to minimize leak paths.
- Production packer to comply with safety barrier policy and prevent upper casing corrosion.
- Sandface completion – Stand Alone Screen (SAS) to prevent sand influx and secure well integrity.

3.4.2.2 Oil scope:

- Drilling and completion of 1No. Horizontal Oil well
- Construction of 1No. 6" x 1km CS Oil flowline (within ANSI 1500# piping class) with an adjacent 6" test line to be tied to existing 16" x 17.5km Zarama Oil bulkline and 6"x 17.5km Oil test line respectively outside the fence of the Zarama NAG manifold location where the Zarama oil bulkline joins the Zarama NAG bulkline RoW en-route Gbaran CPF via a barred tee.
- Installation of dual stream venturi meter on the oil flowline
- Scope of work for tie-in of new oil flowline will include flushing, cutting, welding, and piping modifications of existing Zarama Oil bulkline and Test line. The welded bulkline and Test line sections will be pressure-tested with aid of a blind flange.
- Provision of tie-in connection from existing Zarama Oil inlet 14" piping (with RSP in place) to existing HP Oil inlet header at Gbaran CPF. Alternatively, operation of the XHP separator (receiving Zarama oil bulkline fluids) in HP separator regime should also be considered in order to optimize recovery from Zarama and Uzu oil reservoirs.

3.4.2.3 CPF Upgrade Scope:

- Installation of 200MMscfd TEG dehydration system with associated ancillary systems and utilities. (The TEG package includes TEG Contactor, Regenerator still, Lean TEG cooler, charcoal filter, solid particle filter, Flash drum, TEG surge drum, Reboiler vessel, PH adjuster and Antifoam package injection, Lean TEG recirculation pump and TEG storage tank)
- Installation of new Inlet separator
- Installation of 1No inlet Air cooler
- General piping modification, installation and tie-ins:
- Tie-in of the new TEG dehydration will be at the Dehydration inlet manifold (inlet) while new Dehydration unit outlet piping (outlet) will be tied to existing Dehydration outlet piping en-route export metering system. Blind flanges are available for proposed tie-ins.
- Civil works, foundations, piping and support structures for new TEG system, ancillary units and associated in-plot piping.
- Installation of instrumentation systems and tie-ins of new facilities to existing CPF automation (PAS) and safety (SIS & F&G) system.
- Upgrade of existing metering system from capacity of 1.4Bscfd to 1.5Bscfd
- Tie-in to utilities system:
 - Tie-ins to Flare systems (Inlet separator, glycol contactor and scrubber to HP flare header)
 - Tie-in of TEG overheads to Vent system
 - Tie-in to electrical power distribution system
 - Tie-in to instrument /utility air system
 - Tie-in of Fuel Gas system to glycol regeneration system (for stripping and blanketing)
 - Tie-in to existing open and closed drain systems
 - General tie-ins of utilities systems to existing Trains 1 and 2 support systems for flexibility purpose

Uzu field development will leverage on use of the following existing facilities in Zarama field area:

- Microwave tower and microwave radio communications equipment at Zarama NAG manifold (about 5km West of Uzu manifold as crow flies) and Zarama Oil manifold (about 2km East of Uzu manifold as crow flies). No new telecoms tower will be required for the Uzu manifold location.
- Field Auxiliary room (FAR) exists at Zarama NAG manifold, Zarama oil manifold and Zarama WLVF-2 well locations. FAR/RTU at Uzu manifold will be connected at Zarama NAG manifold as Uzu location is within the Zarama area.

3.4.2.4 Pipeline Scope

Four NAG wells will be hooked up to the new Uzu manifold (at Zarama 15 well location) via 8" x 0.5km 1500# NAG DSS flow lines and bulk flowed to Gbaran CPF, via Zarama NAG manifold, through new 16" x 18km CS bulk line. One NAG well will be hooked up to existing Zarama NAG manifold via new 8" x 0.5km 2500# DSS NAG flowline. One oil well will also be drilled, completed and new 6" x 1km 1500# CS Oil flowline and new 6" x 1km 1500# CS Oil Test line will be tied in to existing 16" x 17.5km Zarama Oil bulk line and 6" Test line respectively en-route Gbaran CPF via barred tees.

3.5: Conceptual and Detailed Design of Facilities

3.5.1: Existing infrastructure in Uzu field

Uzu is in the same area as the producing Zarama field where we currently have well locations (ZARA-008, 009, 010 & 011 location and ZARA-015 location) in addition to the UZU-001 location. There are also two Zarama manifolds with NAG bulkline 20" x 10.2km and Oil bulkline 16" x 20km (including an oil test line of 6" x 20km). The Gbaran node remote manifolds locations comprises of the following (Gbaran Oil & NAG manifold, Kolo-Creek oil / NAG manifold, Zarama Oil manifold, Zarama NAG manifold & Zarama Well WLVF-2, Etelebou Oil manifold and Koroama NAG manifold.

The nearest processing facility to the Uzu field is Gbaran central processing facility with NAG processing capacity of 1.2Bscf/d and liquid stabilization capacity of 120Mbd (60Mbd dedicated to condensate train). The average daily production is ca. 1.2Bscf/d gas and liquid 40Mbd; fuel consumption 8.97MMscf/d. The forecast at Gbaran CPF shows that it will be full to the gas processing capacity of 1.2Bscf/d from 2020 presenting ullage challenges for the project. However, as part of Uzu with CPF Upgrade project, the Gbaran CPF capacity will be increased to 1.4Bscf/d via installation of the new 200MMScfd TEG system.

3.5.2: Surface Facilities

Well Design Considerations

The Uzu wells are being matured using the Global Well Delivery Process (GWDP). Due consideration was given to the following:

- A. Well Locations:
 - New location;
 - Use existing locations
- B. Well Trajectory:
 - Vertical/deviated, horizontal, conventional or multi-lateral wells
- C. Casing Setting Depths:
 - Surface casing:**
 - Shallowest hydrocarbon zone
 - The depth of fresh water zone (5000 – 5500 ft-TVDss).
 - Full displacement to gas
 - Casing grades and connections meeting design standards
 - Potential structures trapping shallow hydrocarbon
 - Sidetrack targets
 - Intermediate/Production casing**
 - Full displacement to gas
 - Full evacuation

- Production casing load scenarios
 - Casing grades and connections meeting design standards
 - Set at top of reservoir, as EGP is to be installed in drain hole for Well B
 - Set at well TD for wells with IGP sand control
- D. Pore Pressure Data (RFT):
- Casing and mud design shall be driven by pore pressure prognosed for the respective field.
- E. Completion Design Requirements:
- SSS, SSM or Dual completion
 - Sand exclusion (EGP, ESS, premium sand-screen etc.)
 - Smart completions
- F. Lessons from offset wells:
- Stuck pipe
 - Wellbore stability
 - Well control

Well Design Concept Evaluated

Concept #1: Conventional Deviated Wells

The basic design for the conventional deviated well has a 13-3/8" surface casing, a 9-5/8" production casing set above the deepest reservoir and an 8-1/2" x 10-3/4" under-reamed (for gas wells) drain hole below the 9-5/8" casing which will be secured with either a 5-1/2" internal and external gravel pack (EGP) lower completions for gas wells and stand alone screens for oil wells.

Concept #2: Horizontal Wells

Horizontal wells were considered for the Oil wells. The basic casing design for the horizontal well is 13-3/8" surface casing, a 9-5/8" casing across the build up section and an 8-1/2" horizontal drain hole. The 9-5/8" casing will be designed to provide zonal isolation of all the HC's bearing strata over the build up section, as well to isolate the possible gas cap above the target oil zone. The 8-1/2" horizontal drain hole will be secured with either a 5-1/2" Expandable Sand Screen (ESS) or stand alone screens.

Concept #3: Sidetracks

Existing wells were considered for drilling sidetrack wells. This concept is very attractive in view of utilizing existing location and facilities thereby minimizing land take, environmental impact and ultimately well cost. Factors considered for screening of existing wells for re-use either for sidetrack or re-completion:

Installed production casings meeting design criteria.

Age of the well - corrosion issue.

Size of the production casing to accommodate completion accessories for gas wells

This concept was found not feasible as existing wells are either producing or planned to come on stream soon, while the others have been fully abandoned and are over 40years old with casing integrity risks and associated complications with re-entry. The summary of existing well conditions in Uzu field is presented in Table 3.2.

Table 3.2: Conditions of existing oil wells in Uzu field

Well	Issues	Remark(s)
UZU-001	<ul style="list-style-type: none"> Well is 43years old - Integrity of casing in doubt (corrosion issues) Well was abandoned with suspension plug on top of casing and at 4428ft, 7240ft to btm 10-3/4” casing is not gas tight 	Not recommended for reuse
ZARA-001	<ul style="list-style-type: none"> Well is 47years old - Integrity of casing in doubt (corrosion issues) 10-3/4” casing is not gas tight Well was abandoned with several cement plugs 	Wells cannot be reused
ZARA-015	<ul style="list-style-type: none"> Well suspended and will be completed 	Not available for reuse

However as highlighted in the previous sub-section, no existing well in the Uzu development is feasible for reuse or sidetrack.

Concept #4: Multi-lateral wells with Down-hole Splitter

Opportunities exist for multilateral wells and it should be fully exploited where feasible. Using one surface location to access two zones will substantially reduce the number of wells slots; reduce land take, total location preparation cost and subsequently the total project cost.

However, some major challenges with multilaterals as outlined below:

- Experience level in this technology is very low
- No Operator in Nigeria is currently doing multi-laterals and as such the Multi-Lateral service providers are not available in the country.
- To mobilize contractors for ML operations as it is today will be very expensive.

Selected Well Design

Based on the functional requirements and the position (depth and orientation) of the targets, the following well designs have been adopted for the Uzu development:

- Conventional deviated wells with 13-3/8” surface casing, a 9-5/8” production casing set:
 - above the deepest reservoir and an 8-1/2” x 10-3/4” under-reamed drain hole below the 9-5/8” casing which will be secured with a 5-1/2” external gravel pack (EGP) lower completions for one of the gas wells (Well B);
 - at total depth (TD) of well and cased hole gravel pack completions in the 9-5/8” casing for the dual zone smart gas wells (wells D, E & F).
- One horizontal is planned for the oil well with 13-3/8” surface casing, a 9-5/8” casing across the build up section and an 8-1/2” horizontal drain hole. The 9-5/8” casing will provide zonal isolation of all the HC’s bearing strata over the build up section, as well to isolate the possible gas cap above the target oil zone. The 8-1/2” horizontal drain hole will be secured with either a 5-1/2” stand alone screens and 3-1/2” completion tubing. Horizontal leg is planned to be 500ft.

- Wells D, E & F to be completed on two (2) reservoirs each, planned to be completed with smart completions; IGP lower completions for both zones are planned and 5-1/2” upper completions tubings. IGP for both reservoirs ranked higher in the integrated focused completions review and demonstrated no significant impact in productivity based on the simulation carried out.

3.5.3: Blow-out Analysis

A RAM-based risk assessment for the Uzu Wells, based on the SPDC blowout contingency plan and procedure demonstrated the need for the relief wells. Two locations (Fig. 3.3) were identified for each flank (western and eastern flanks) based on minimum lateral distance of surface wellhead within 457m (1500ft) on surface between blowout and relief well in upwind direction to the blowout well. Those locations were translated to the following coordinates;

Western Flank	a. Zarama 07 location: 433982.53 E, 121642.47 N	b. Uzu 01 location: 434092.63 E, 118686.55 N
Eastern Flank	c. Zarama 02 Location: 437532.23 E, 120789.56 N	d. Zarama 03 Location: 439187.42 E, 120960.50 N

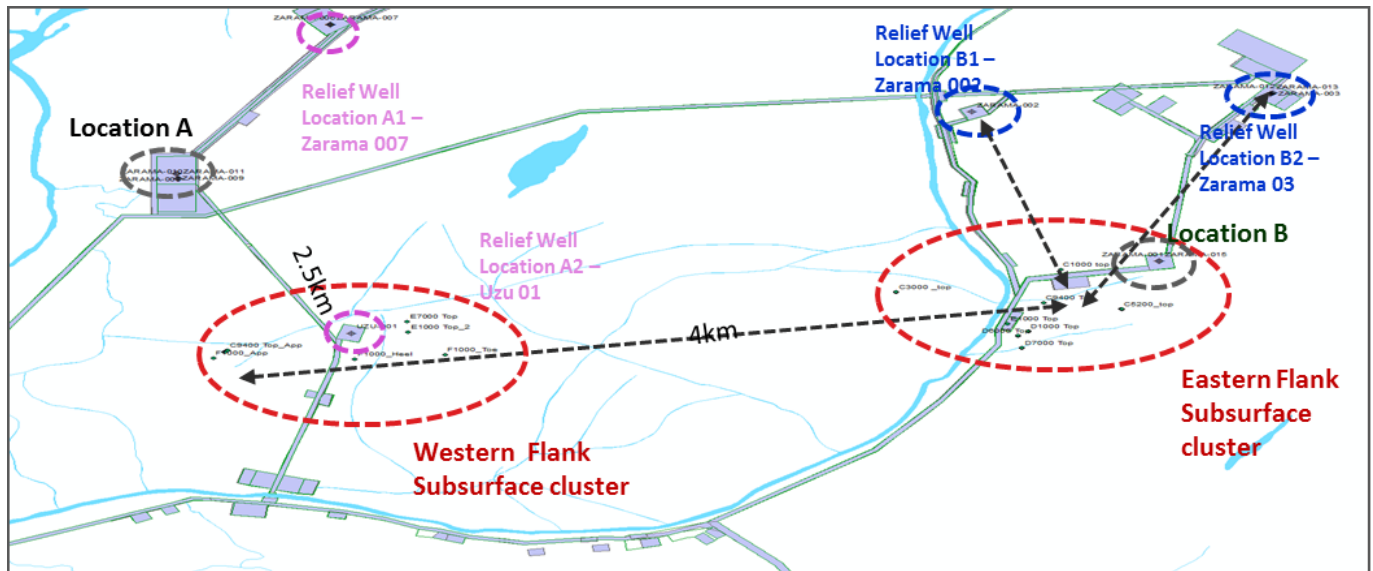


Fig 3.3: Well location clusters used for blow out analysis

The relief well trajectories are proposed to intersect the deepest casing shoe with the following:

- By-passes the target well at least 900 ft (300 m) before intersecting is planned
- Has maximum inclination of 60°
- Has an incidence angle between relief well and target well of about 8°
- The combined position uncertainty of both the target well and the relief well together is less than 45 ft (15 m) at the by-pass depth
- Has a minimum distance of 90 ft (30 m) between the edge of the relief well’s uncertainty ellipsoid and any neighbouring well’s uncertainty ellipsoid at the by-pass depth.
- <3deg/100ft dogleg severity

KRest (Kill Rate Estimation) simulation of the Worst-Case Discharge (WCD) in an uncontrolled blow out situation has been calculated as no greater than 9083 bbl/d oil and 756,900 Mscf/d gas for the western flank wells and 9732 bbl/d oil and 753,664 Mscf/d gas for the eastern flank wells with a required kill rate of 95.8 bbl/min & 91.3 bbl/min respectively. Since the modeled kill rates are <100 bbl/min, these are therefore TIER 1 wells requiring only one relief well.

Well Clean-Up

Upon well completion wells will be cleaned up and tested. Detailed procedures for well clean up and testing have been included into Well Functional Specifications. Care must be taken whilst unloading and testing Smart / Intelligent wells again, see WFS for more details.

Well Delivery History

All wells previously drilled in the Uzu Field are vertical and deviated wells with maximum total along hole depth of 13,700ftah.

The wells used in the study of the drilling risks and hazards are UZU-001, ZARA-001, 008, 009 and 015. Tables 3.3 show a summarized capture of the wells details in this review.

Table 3.3: Summary information of existing wells in Uzu field

	Well Name	Year Drilled	Well Depth (ftah / fttvd)	Max Incl (°)	Surface			Intermediate/ Production			Production			Comments
					Hole Depth (ftah)	MW (psi/ft)	Csg Size (in)/ Depth (ft)	Hole Depth (ftah)	Max MW (psi/ft)	Csg Size (in)/ Depth (ft)	Hole Depth (ftah)	Max MW (psi/ft)	Csg Size (in)/ Depth (ft)	
1	Zarama 1	1967	12809	10	4583	0.46 - 0.47	10-3/4" / 4533	12809	0.47 - 0.58					Logged 8-1/2" section, Set cement plugs@ 12708 ft, 11560 ft, 8550 ft, 8000 ft, 7240 ft, 6450 ft & 4550 ft before the well was abandoned.
2	Uzu-01	1971	12388	8.75	5007	0.46	10-3/4" / 5000	12388	0.46 - 0.53					Set plug at 4428 ftah & 7300 ftahd, also set suspension plug on top casing and abandoned well
3	Zarama 08	2009	13324	26.87	6548		13-3/8" / 6491	12951		9-5/8" / 12946	13324			Log, Ran 4 1/2 in tubing, install Xmas tree & closed all Xmas tree valves and secure well
4	Zarama 9	2009	13703	33.52	6782	0.45 - 0.46	13-3/8" / 6770	13382	0.46 - 0.56	9-5/8" / 12979				Producing
5	Zarama 15	2013	12290	41.88	6530	0.46 - 0.48	13-3/8" / 5800	12290	0.47 - 0.58	9-5/8" / 12236				Well suspended
6	Zarama 10	2010	13757 / 12519	36.17	6682	0.45 - 0.47	13-3/8" / 6670	13322	0.49 - 0.55	9-5/8" / 13310	13770	0.55		Well Completed
7	Zarama 11	2010	12960 / 12272	28	6040	0.44 - 0.47	13-3/8" / 6010	12754	0.57	9-5/8" / 12754	12960	0.57		Well Completed

Key drilling hazards encountered while drilling offset wells include borehole instability, stuck pipe, well control incidents, high torque, loss of cone, down hole mud losses, etc. A summary of drilling hazards experienced is presented in Figure 3.4.

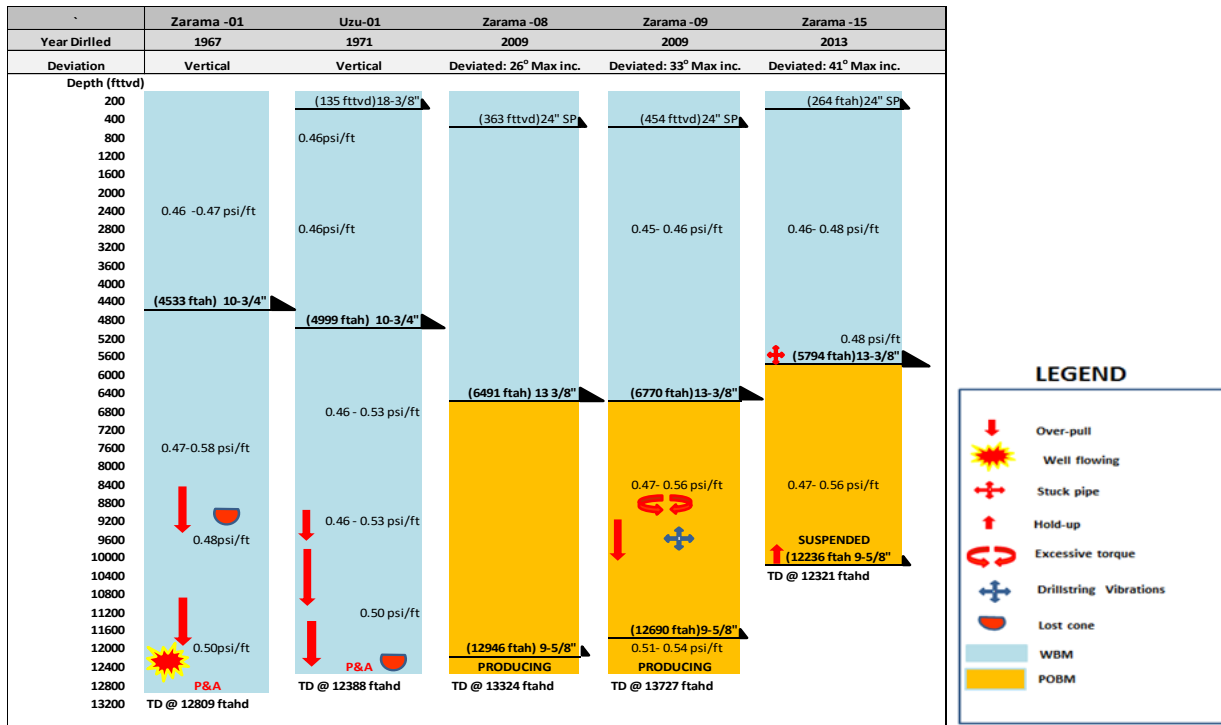


Figure 3.4: Drilling hazards experienced during the study

Hole instability was a re-occurring issue in the Uzu/Zarama field. Seen in all wells, over pulls are a sign of hole instability which can be attributed to poor shale inhibition resulting in shale swelling or brittle shale caving. Shale swelling occurs when the formation draws water from the mud system and hydrates the clay, making it to swell. They cause tight hole and bit balling, resulting in over pulls, frequent reaming and even stuck string. When the bit penetrates brittle shale, the forces generated by the pressure difference between the overburden pressure and the hydrostatic pressure of the mud column cause plastic deformation and fracturing. When this occurs, traces of shale caving are often seen in large quantity on the shale shaker. A build-up of these cavings resulting from washouts often leads to hole pack off. Appropriate shale inhibition, mud engineering and good drilling and hole cleaning practices are planned to mitigate hole instability.

Well Path Design

Well A & B have appraisal objectives combined with the development targets. One horizontal well is planned, and the other wells are conventional deviated wells with maximum inclination ranging from 26° - 60° and maximum doleg severity (DLS) ranging from 1.5 – 3.3 deg/100ft doleg severity. The kick off points have been selected to minimize well inclinations and prevent wellbore collision. A summary of key outcomes of the trajectory plans is presented in the Table 3.4.

Table 3.4: Planned Well Design for Uzu Development Wells

Well Name	Well type (Ver, Dev, Hor)	Target Reservoir	KOP (ft)	Max Inclination	Max. DLS (°/100 ft)	Vertical Section(ft)
A	Horizontal	F1000	3,000ftah	90°	2	6,236ftah

A Appraisal	Deviated	F1000	9,000ftah	36°	1.5	3,792ftah
B ST	Deviated	E7000	6,820ftah	60.27°	3.3	5,721ftah
B Appraisal	Deviated	C9400	2,775.5ftah	25°	2	2,543ftah
D	Deviated	C1000&C3000	Nudge at 1,500 ftah	40.02°	2.5	2,318ftah
E	Deviated	C9400&D1000	Nudge at 1,200 ftah	26.44°	2	2,637ftah
F	Deviated	D7000&E1000	Nudge at 1,500 ftah	27.17°	2.5	3,357ftah

Casing and Completion Design:

Casing Design

The proposed casing setting depths for the Uzu development wells is shown in Table 3.5.

Table 3.5: Proposed Casing Setting Depths for Uzu Wells

Casing (ft MD)	Well A	Well B	Well D	Well E	Well F	Comment
24''	300ft	300ft	300ft	300ft	300ft	-
13 3/8''	6,590ftah	6,500ftah	6,430ftah	6,325ftah	6,390ftah	Casing set in Shale above C1000
9 5/8''	12,390ftah	12,040ftah	7,010ftah	8,220ftah	9,464ftah	Casing set in shale above F1000, E7000 for Wells A & B; into C3000, D1000 & E1000 for Wells D, E & F respectively
Well TD	12,891ftah	12,122ftah	7,022ftah	8,231ftah	9,474ftah	Final TD is 100ft in to E7000, C3000, D1000 & E1000 for Wells B, D, E & F. Well A (oil well) has 500ft horizontal drain hole section in F1000
Well TVD	9,810ft tvd	9,390ft tvd	6,425ft tvd	7,589ft tvd	8,570ft tvd	

Completion Design:

All Uzu development wells are planned to be completed (Table 3.6) with 0.46 – 0.48psi/ft (downhole) KCl brine providing between 155psi and 255 psi overbalance for all wells.

Table 3.6: Summary of Completion Fluid proposed for Uzu Development Wells

Well Content	Gas	Hoist	Land Rig
PVT Analysis	0.14 -1.78% CO ₂ (with max 76 psi Partial Pressure)	DFE	TBA
Completion Fluid	KCl Brine (0.46 – 0.47 psi/ft) - Downhole	Packer Fluid	KCl Brine (0.46 – 0.47 psi/ft) – Downhole

PARAMETERS	Well A	Well B	Well D	Well E	Well F
Formation Top (ft-TVD)	9767	9330	5972	7321	8056
Formation Pressure (psi)	4256	4073	2639	3263	3540
Completion Brine Weight (psi/ft) - Surface	0.46	0.461	0.467	0.47	0.467
Brine Overbalance (psi)	237	218	150	178	198

Mud and Cement Design:

Mud Design

Water based mud (WBM) is planned for the drilling of the surface hole sections (Table 3.7). The wells will be spudded with bentonite spud mud due to its good gel properties and its ability to effectively transport a high volume of cuttings to surface. At ±3000ft, KCL polymer (still a water based mud system) will be introduced for good shale inhibition and will be used to drill the surface hole to section TD. Synthetic Oil based mud (SOBM) is planned for the intermediate and drain hole sections with the exception of the horizontal drain hole which will be drilled with calcium carbonate (CaCO₃) mud system to minimize reservoir impairment. Thixsal mud system is not recommended as it can cause severe impairment in very silty and shaley sands through clay swelling. Mud weights have been selected for each hole section based on offset well review and optiwell modeling. Mud weight has been selected to ensure primary well control is maintained throughout the drilling and completions operations as well as ensure borehole stability.

Table 3.7: Fluid Design for Uzu Development Wells

Hole size (in)	Mud type	Mud weight (psi/ft)	Pore-Pressure (psi/ft)
16” surface hole	WBM: Bentonite/KCL/Polymer	0.46 – 0.49 psi/ft	0.433
12-1/4” hole section	SOBM	0.47 – 0.56si/ft	0.433 – 0.45
8-1/2” drain hole (Wells A & B)	SOBM (CaCO ₃ Weighted)	0.48 – 0.51 psi/ft	0.433 – 0.45

Cement Design

The surface casing is planned to be cemented to surface using a dual cement slurry system while the production casing will be cemented to a minimum of 500ft above the shallowest HC bearing sand (C1000). Below are other considerations for the cementing design:

- All shallow aquifers will be isolated with cement
- The cement slurry free water at BHCT for 9 5/8” should be zero for 45° and 60°.

- The API fluid loss for 9 5/8” casing should be less than 50 and 25 ml/30min respectively.
 - The 9 5/8” casing transition time should be less than 45 min.
 - All slurry mixability should be between 4.0 – 5.0.
 - Surface casing will be cemented to surface and a stinger top up job done if required.
- The cement specifications for the planned wells are listed in Table 3.8

Table 3.8: Proposed Cement Specifications for Uzu Development Wells

Hole size (in)	16”	12 ¼”
Casing size (in)	13 3/8"	9 5/8"
Slurry system	Dual (12 & 15.8ppg)	Single (15.8 ppg)
TOC (ft)	Surface	500 ft above shallowest HC reservoir
6 RPM @ 80oF (lb/100ft)	< 30	< 30
6 RPM @ BHCT (lb/100ft)	> 5	> 5
Free Water @ BHCT (ml)	< 0.5%	0
API FL (ml/30min) @ BHCT	N/A	< 50
Transition time (min) @ BHCT	N/A	< 45
Slurry mixability	4.0-5.0	4.0-5.0
CS @ BHST	500 psi (in 12 Hrs)	> 2000 psi (in 24 Hrs)

Wellhead Requirement

Four (4) sets of 5000 psi compact wellheads and 1 set of 5000 psi spool-type wellhead has been designed for the Uzu development wells.

3.5.4: Rig Requirement

Uzu Development wells are land wells and will be drilled with a land rig similar to the Hilong 19 rig currently in contract with SPDC. Below are some assumptions made in determining the rig requirements:

- With maximum well TD at 9,810ftTVD and maximum pressure of 4,260psi, assuming gas of gradient 0.1psi/ft, the Maximum Anticipated Surface Pressure is 3279psi
- Maximum torque (31,000 lb-ft) occurs while drilling the 12 ¼” hole section with an assumed rotary speed of 120 RPM
- The maximum pump horsepower of 2200HP is required while drilling the intermediate hole section with an SPP of 4200 psi and Q of 900 gpm.
- The maximum hook-load while tripping BHA to drill Well A drain hole at the deepest point is ca. 320,000 lbs at an assumed pipe tripping speed of 120 ft/min
- The maximum hook-load is expected while running the intermediate casing for Well A and is approximately 582,330 lbs.

Below are the rig requirements:

- Land rig with skidding capability
- Minimum BOP pressure rating: 10,000psi
- Minimum hookload capacity (lbs): 600,000
- Minimum drilling depth (ft): 13,000
- Minimum mud pump power requirement: 2,500HP

3.5.5: Pipeline Route description

Bulklines/Flowlines

Table 3.9 shows the Uzu – Zarama NAG manifold pipeline route options and the total length of pipeline, while Figure 3.5 A&B show the options considered and the selected pipeline route map for Uzu – Zarama NAG manifold.

Table 3.9: Uzu pipeline route description

Route Option	Length (m)	Description
1	8.509km	Departs Zarama 15 in a North-Easterly path, turns to the West and finally turns South-Westerly towards Zarama NAG manifold. This option has one pipeline crossing and one river crossing.
2	5.662km	Departs Zarama 15 and moves westerly a North-Westerly path to Zarama NAG manifold. This option has no pipeline or river crossing.
3	9.692km	Departs Zarama 15 and moves West, turns to the South West, then moves north and finally turns North-west towards Zarama NAG manifold. This option has one pipeline crossing and one river crossing.
4	7.477km	Departs Zarama 15 in a North-Easterly path and unlike option 1, turns northwest then turns west again and finally turns South-Westerly towards Zarama NAG manifold. This option has one pipeline crossing and one river crossing.
5	7.432km	Departs Zarama 15 and moves south westerly, then turns north west and takes another turn in the westerly direction and continues like option 1 till it gets to Zarama NAG manifold. This option has one pipeline crossing and one river crossing.

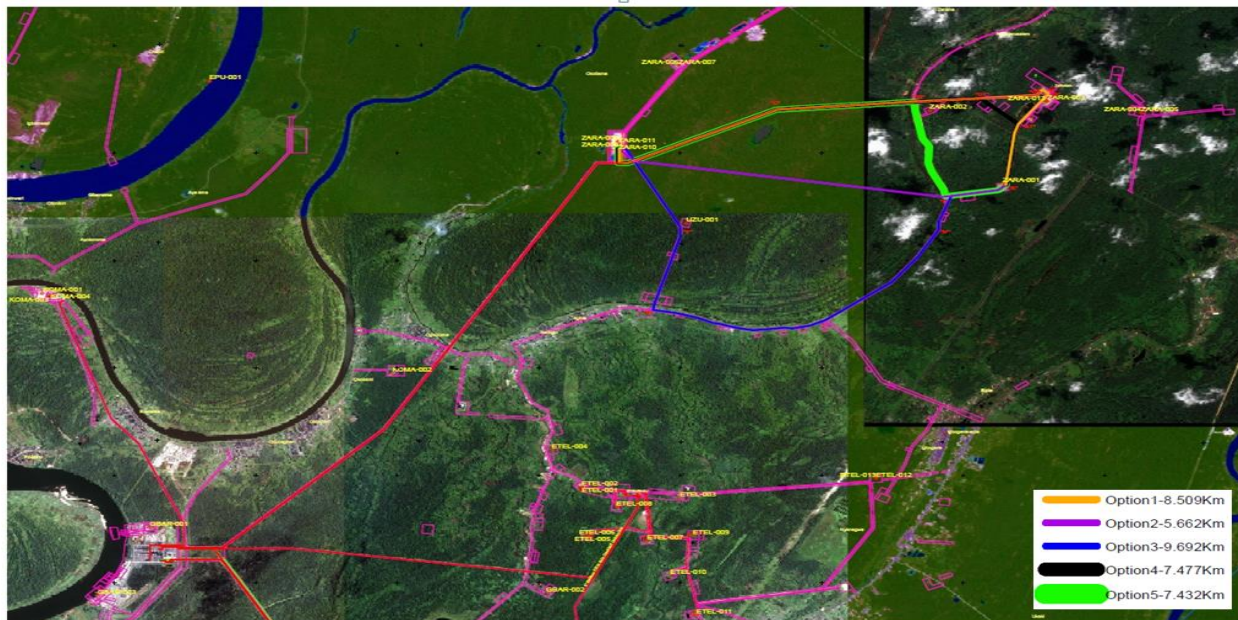


Figure 3.5: (Uzu -Zarama NAG MFD) Proposed Pipeline Route Map

A route selection workshop was carried out and option 5, with a slight deviation, emerged the most favourable pipeline route option.

3.6: Project Activities

3.6.1: Pre-mobilization

Pre-mobilization activities shall include community and other stakeholder engagements and land acquisition. This phase will also include designs and off-site fabrications of modules, pipes etc. During this phase, SPDC shall carry out pre-mobilization inspection of all items/personnel to be mobilized to site. All equipment and personnel mobilized to site shall be certified fit for purpose and approved by SPDC before deployment to site.

3.6.2: Mobilization Phase

This phase will involve:

- Moving construction equipment (dredger, bulldozers, excavators, graders, rollers, pay loaders, asphalt pavers, tippers, trailers, swamp bogey, generators, self loaders, cranes, crew bus, 4WD truck, welding sets, Flushing pumps, Hydro testing unit, Generators, Compressors, Bending Machine, Grit blasting unit, Oxy acetylene torch, Line up clamps, Cold cutter, X-ray units, Thrust boring machine etc) from Contractor's base to site.
- Movement of temporary offices and accommodation to site.
- Set up site office and yard (telecommunication masts, temporary sewage system, messing facilities).
- Movement of personnel from Contractor's base/ SPDC office to site by road.

Movement of rig to site (this is captured as part of mobilization for the purpose of impact assessment although this comes after well location preparation).

3.6.3: Construction Phase

Well Locations Preparations

Well location preparations shall typically involve vegetation clearing, sand filling, pilling, concrete and asphalt works. The well locations will be surfaced with asphalt to prevent groundwater and soil contamination. In addition, pits will be constructed to capture surface run-off. The pads will be graded so that rainfall on the active portions of the pad will be directed into the pit. Areas for storage of fuel, lubricants, chemicals, solid waste, produced oil, and waste oil will be designated within the well site area to protect the environment, and minimize possible fire and explosion hazards.

Well site construction in a seasonally flooded terrain is typically carried out over a period of 12 months. The number of personnel expected to be working at any point in time during the construction of the access and locations will normally be approximately 70 (seventy) persons. The activities that will be involved in the location preparation in the various fields are described below.

Drilling Workslope and Activities

Logging

This is the electrical/nuclear investigation of the drilled well to ascertain the lithology and fluid content. The interpretation of the log data gives an indication of the presence and the quantity of hydrocarbon (in this case gas) in the formation.

Completion

This is the process of hooking up a well for production. The process involves logging, well-bore clean-up, perforation, production testing, sand consolidation and installation of the Christmas tree. The completion of the drilling will be the hooking up to the field manifold.

Pipeline Project Activities

Survey and Staking of Pipeline Routes

Survey shall be carried out to re-establish and clearly mark out boundaries of the permanent ROW and temporary working strip required for construction activities. For a single pipeline route the RoW will be approximately 25 m wide (15 m for the permanent Row and 10 m for the temporary strip). This temporary strip will be re-vegetated and restored to the owners after construction activities. During FEED keen attention was given to reduction in land take and minimization of environmental footprint. In This regard, where technically feasible multiple pipelines have been routed through common corridors and/or installed in same trench. For example, four flow lines (pipelines) laid separately, along different routes, would require a total of about 60 m way leave, whereas, these pipelines may not require more than 35-40 m way leave, if laid in parallel, along a common corridor. In addition to this existing RoW have been used where possible instead of acquiring additional land to lay the new pipelines.

Probing for existing facilities

Along existing RoW and at brownfield locations, existing facilities shall be identified and located using drawings and pipe detectors. Manual excavations at appropriate intervals shall confirm exact positions. Inspection of each exposed location shall be carried out and a permanent mark placed

on all exposed lines and facilities to indicate which are to be removed and which are to be left in place.

Clearing and grading

The working width shall be cleared of trees and hedges. Ditches shall be flumed by installing pipes and ramped over with subsoil to give a continuous running track through the fields. Topsoil shall then be stripped across the working area and stored at one side. An area of the working width adjacent to the stored topsoil shall be designated as a running track for vehicular movements.

Trenching

A trench, nominally 0.3 – 0.6 m wider than the pipe diameter and deep enough to provide minimum cover, will be excavated to for the pipelines burial. Where the pipeline has to cross existing facility the trench depth will be increased to allow a gap to exist between the two facilities.

Stringing and bending

Stringing and bending involves the handling and positioning of pipes or joints along the ROW on one side of the trench in preparation to welding into a continuous pipeline. Line pipes shall be transported to site from the pipe dumps or lay down areas and laid out on wooden skids along a line parallel to the proposed trench. Gaps are left in the strung pipeline to allow access the working width. Strung pipes shall be provided with caps at both joint ends to keep the joint free from dirt and extraneous materials. Where the pipeline negotiates changes in direction factory manufactured bends will be used or, if the change in direction is less severe, bends will be fabricated at site. As much as possible, deviations will be achieved via elastic bending.

Welding

Before welding, each item shall be visually inspected to ensure that the integrity and general condition of the pipes and fittings have not been compromised during transportation and storage, that they are clean internally and that the ends are correctly prepared for welding. Repairs on any damaged item would be done. Once pipes have been certified fit for use the pipes shall be lined up for welding. Pipes shall be checked, fitted and cleaned to ensure their quality prior to welding. Pipes and fitting shall be lined up for welding with all end caps and similar protections removed immediately before lining up each pipe or fitting. Welding of the joints shall be in accordance with sections 21, 25 and 34 of Shells standard construction specifications. A pipe tally shall be kept showing records of pipe length and wall thickness and number of welds made.

Inspection testing and NDT of welds

Quality assurance and control of the weld shall be achieved by visual inspection and radiographic inspection. 100% radiography of all weld joints shall be employed. All radiography films will be processed and interpreted on site to facilitate quick repairs of defective welds. Records of test results shall be prepared and submitted on a regular basis. Defects shall be repaired or cut out.

Field coating

The weld joint sections and any other sections of the pipeline which are bare or which the coating has been damaged shall be coated to form a continuous protective coating. Heat shrinkable sleeves or repair patches shall be used for repairs of defective field joint coatings taking into account the extent of the portion to be repaired.

Lowering

The welded pipe shall be lowered gently into the ditch without subjecting the line to any stress. The pipes will conform to the ditch and substantially supported by the ditch bottom. The bed underneath the pipe shall be prepared by installation of soft material (medium sand bed) to obtain a soft surround for the installed pipe. The material shall be free of stones, rocks, timber, roots, debris and any other material, which may damage the pipe coating. The sand bed shall have a minimum depth of 150mm. During lowering special care shall be taken to ensure the pipe coatings sustain no damage. Coated pipes shall be handled with rubber-covered broadband slings adequate for the pipe diameter. Slings shall be constructed so that they can be removed from under the pipe without dragging any metal parts against the pipe coating.

Tie-in

After the pipeline sections are lowered into the trench, the sections will be welded together and field joint coated after has been ensure that the integrity and general condition of the sections have not been compromised during lowering. Quality assurance and control of the tie-in weld shall be achieved by visual inspection and radiographic inspection.

Backfilling

Backfilling operation shall follow as closely as possible the lowering and tie-in in operation so that the pipeline and its protective coating will not be damaged. Initial backfilling shall be carried out by installation of soft material (medium sand bed) to obtain a dampened surround for the installed pipe. Initial backfill material shall be free of stones, rocks, timber, roots, debris and any other material, which may damage the pipe coating. The sand bed shall have a minimum depth of 150mm. After the trench has been backfilled, the material shall be tamped down as much as possible and the finish surface left proud of the adjacent ground level to allow for subsequent settlement.

Cathodic Protection

Permanent cathodic protection (CP) facilities shall be installed to protect all Enwhe pipelines. Protection source shall be from deep well ground bed installed at the CPF and remote manifold locations to be determined during design. All CP materials and installations shall conform to the relevant Shell standard construction specifications and DEPs. CP test posts shall be installed at regular intervals along the pipeline route and at where the pipeline crosses other underground steel facilities.

Hydrotesting, Pre-Commissioning and Commissioning Cleaning, Testing, De-watering and Drying

After all pipeline and manifold sections have been constructed, inspected and tied in, hydro-testing, pre-commissioning and commissioning will be carried out. Hydro-testing and pre-commissioning involves cleaning, gauging, flooding, hydrostatic pressure testing, de-watering and conditioning of the pipeline systems. It may also involve function checking of valves and other systems. The pipelines will be cleaned using flush water with cleaning pigs. The pipeline shall be deemed clean when no further solid matter or serious discoloration is observed in the receiving pig trap following a pig run and a visual examination of effluent water.

A gauge plate inspection of the pipelines will be run using a plate attached to a suitable pig to transport it through the pipeline. A successful run shall be confirmed when no significant damage caused to the gauging plate is observed. Caliper pig inspection of the pipelines will be run to identify positions of features such as bends, kinks and ovality. Defects observed would be rectified. Baseline intelligent pig inspection (IP) of the pipelines will be carried to identify any base case anomalies and provide a fingerprint for comparison with subsequent IP inspections

Hydrostatic pressure testing shall be carried out on all pipelines to demonstrate the structural integrity of the constructed pipelines. Water shall be the testing medium. Water used shall be lab tested to prove that it will not damage the pipeline integrity during testing or the environment during disposal. The new line shall be de-watered immediately after pressure testing using compressed air and foam pig. All water recovered from the line shall be tested and treated (where necessary), and sent to Bonny Terminal for further treatment to meet regulatory limits before disposal into Bonny River. When required, as in gas lines, to prevent internal corrosion due to presence of water, the pipeline shall be dried. Drying methods include, nitrogen or air drying with pigs or vacuum drying.

3.6.4: Commissioning and Handover

A pre-commissioning audit of the newly constructed pipelines to verify their conformity with the construction drawings and operability shall be carried out. The contractor shall participate in the pre-commissioning audit, and shall effect any remedial works identified. SPDC personnel shall manage the commissioning operations at the well heads, manifolds and CPF. The contractor shall provide crew support as necessary during the start-up and the introduction of hydrocarbon into the line. Baseline Cathodic Protection (CP) Survey and intelligent pigging shall be carried out prior to handover.

Reinstatement

At the end of site works, contractor shall ensure that the RoWs and work sites are properly cleaned up and reinstated. Although it is manifestly impossible to restore the route traversed by the pipelines to the exact condition in which it was before work started, the general aim should be to make it as nearly as possible. All the debris of construction shall be removed to Shell’s approved site. Shell shall issue to the Contractor a Site Restoration Certificate on satisfactory completion of site re-instatement, which is a prerequisite for contract payment.

3.6.5: Decommissioning, Abandonment and Restoration

The decommissioning of the project facilities shall involve these main activities:

- Determining the regulatory requirements
- Evolving a community involvement strategy
- Establishing future land use objectives
- Determining objectives of the mothballing plan
- Determining remediation requirements
- Determining reclamation objectives
- Developing a HSE plan

The decommissioning plan for the facilities proposed as part of the Uzu is presented in Table 3.10. This is subject to change in future as technology develops.

Table 3.10: Decommissioning Plan

Facilities	Decommissioning
Wells	Leave potable water wells as agreed with local authorities; isolate production interval to prevent communication between aquifers of different nature or salinity; isolate from the surface; plug and abandon downhole according to applicable guidelines; place

Facilities	Decommissioning
	surface cement plug below the cellar to allow removal of surface components; backfill to surface.
Flow lines and pipelines.	Purge and flush with water to remove residues; cut above ground lines and sell for scrap; remove or plug and abandon below grade lines.
Redundant buried structures, foundations and cables.	Purge and clean to remove residues; abandon in place or remove completely according to proposed end land use.
Concrete and steel structures including concrete foundations, wellhead cellars, skid foundations and telecom masts, gratings, buildings (including workshops, offices, houses, etc.) and bridges.	Remove steel structures for reuse or recycling; remove wellhead cellar to 1 m below soil surface; remove concrete foundations and slabs down to soil level (unless abandoned in place for future use); break up concrete slabs at ground level into 1 m ² to allow vegetation to regrow through the fissures or remove completely according to proposed end land use; remove buildings or leave in place for reuse; provide access controls for physical structures remaining on-site, that are unsafe or hazardous to humans or animals.
Earthworks such as roads, quarries, asphalt covered areas and walls.	Reach agreement with local authorities & communities for use of usable assets such as roads, remove asphalt for remediation and/or land filling; level mounds and dispose of waste rock; remove and recycle or reuse gravel (if clean); decompact subsoils and re-establish vegetation.

All wastes generated in the course of project execution will be handled in line with existing statutory and SPDC Waste Management guidelines as detailed in **figure 3.11**

3.7: Waste and By-Products Generated

Drilling wastes consist of drilled cuttings, spent mud and brine, and wastewater. During drilling, all activities related to waste management for the Uzu development wells would be governed by the policies, standards and procedures as incorporated in the SPDC Waste Management Manual, as well as in line with Federal Environmental Protection Agency (FEPA) regulations.

Brine used for initial completion would be re-cycled, while excess or unwanted brine will be disposed. The cuttings generated during drilling will be disposed of in an environmentally appropriate manner (Table 3.11). The current preferred disposal method for pseudo-oil based mud is to ‘skip and ship’ the drill cuttings to TDU location. This practice involves filling cuttings skips, transporting them to a thermal desorption unit (TDU) location for processing and disposal.

Water Based Mud (WBM) cuttings are however, treated and used for landfill. Other wastes generated at the well site include domestic and other industrial wastes. Domestic waste will be transported to dedicated SPDC handling facilities. Paper waste shall be segregated, shredded and

recycled. Spent lube oil and diesel spills will be collected in dedicated storage tanks and taken to approved disposal sites. Other industrial wastes such as plastics, metals, rubber and wood will be segregated on site and collected in designated waste baskets. Recyclable waste will be returned to Shell industrial area where it will be assigned for recycling while other wastes are disposed as per the approved waste management plan.

Table 3.11 Envisaged waste streams and proposed management practices

S/N	Envisaged Streams Wastes	Proposed Management Practices	*SPDC Responsible Party
1	Domestic wastes	Food and organic wastes shall be segregated at source and packaged Segregated waste shall be conveyed to Government approved dumpsite at Eneka	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team
2	Oil Contaminated soil/Oil stained Combustible materials, Waste lubricants; Spacers; Spent/contaminated; water-based muds and cuttings; Spent/contaminated oil-based muds; Spent bulk chemical; Spent special products	Collection at site and sent for treatment at Government approved Thermal desorption unit (TDU) at Onne. Treated waste will be re-used and recycled in line with EGASPIN waste treatment guidelines.	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team
3	Empty Chemical Container	Decontaminated containers will be properly perforated and crushed to prevent re-use for other purposes. Crushed containers will be packaged and convey to Kidney Island, Port Harcourt for recycling.	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team

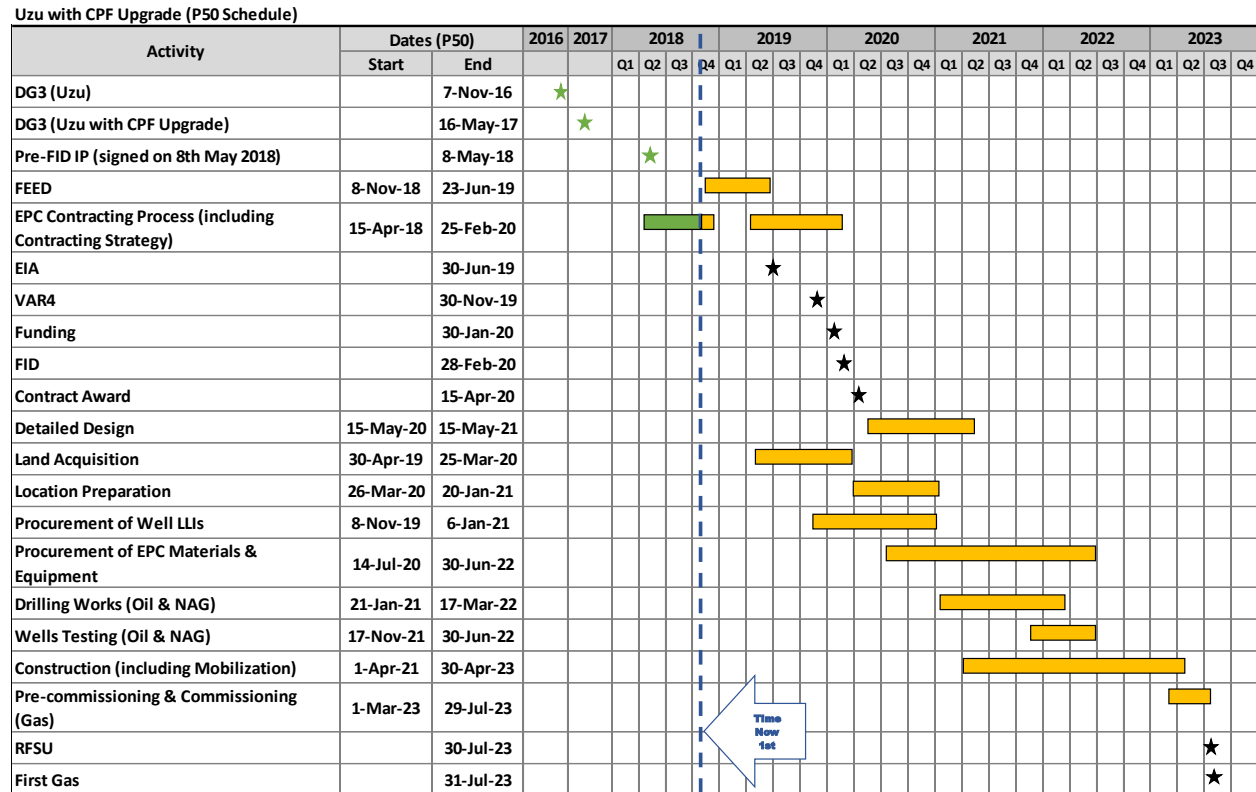
4	Metal Scraps(Tubings, Casings, Well heads & Flowlines	The major scrap items that would be generated for this project are disused pipe supports, tubings and casings. These will be decontaminated and disposed to NAPIMS/SPDC/Community in line with sharing formula in the SPDC/NAPIMS approved Scrap Disposal Policy	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team
5	Medical Wastes	Medical waste shall be collected and taken to medical incinerator at SPDC Industrial Area (IA) Port Harcourt	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team
6	Scrap metals/Drum	De-contaminated scrap metals/drums shall be collected and taken to SPDC Waste Recyclable Depot (WRD) at I.A., Port Harcourt, for onward delivery to any SPDC approved metal recycling vendors.	Uzu Project Team/ Gbaran Operations Team & Gbaran Decommissioning and Restoration Team
7	Cuttings	Treatment by thermal desorption unit at Onne.	Well Engineering Team
9	Wellhead (Xtmas Tree)	These will be decontaminated and disposed to NAPIMS/SPDC/Community in line with sharing formula in the SPDC/NAPIMS approved Scrap Disposal Policy	Gbaran Decommissioning and Restoration Team

***Action party will be dependent on the life cycle stage of the project.**

3.8: Project Schedule

A High-level Project Schedule for Uzu development is presented in Table Table 3.12. The project activities shall be executed between 2016 and 2023, when it is planned to be commissioned.

Table 3.12: High level project schedule for Uzu field development



A key schedule enabler is that this project is a replication of Enwhe & Abasere projects that are ahead. Enwhe & Abasere projects have passed through concept select (DG3) and are in the execution phase now so there will be a lot of learnings to leverage on. The critical path is basically contracting, funding, and wells. The key risks impacting on the project are Delay in Project Schedule (18%) and significant misalignment between company estimate and Contractors bid (6%).

CHAPTER FOUR

DESCRIPTION OF EXISTING ENVIRONMENT

4.1: Introduction

This section covers the Biophysical, Social and Health baseline status of the study area. Information for this section were obtained primarily from field data gathering exercise, which held from 27th February – 5th March 2017 (dry season) and 27th April – 3rd of May 2017 (wet season), and secondarily from literature reviews including EIA and other environmental studies carried out particularly within the project area and generally in the Niger Delta area.

4.2 Methodology

The detailed methodology used in data acquisition is presented in Appendix 2, while a summary is presented in this section of the report.

4.2.1 Study Approach

The approach adopted includes the following:

- Review of existing literature on the area.
- Reconnaissance survey.
- Field samples collection.
- Field analysis and sample preservation.
- Laboratory/data analysis.
- Result interpretation

4.2.2: Field Consultation Prior to Sampling

The consultation process involved the close knitting of ideas of stakeholders and the clients from the onset of the project which is a prerequisite for a successful and sustainable outcome. The regular liaison with stakeholders, clients, agencies and local people to exchange views on the project proposals and agree on realistic goals in relation to quality, time and cost further helped in the successful completion of the data gathering exercise, reduce the feeling of insecurity and restiveness. The stakeholders involved during the consultation exercise include but not limited to:

- All communities in the study area.
- Traditional rulers in the communities.
- Federal Ministry of Environment.
- Department of Petroleum Resources.
- Bayelsa State Government.
- Non-Governmental Organizations.
- Community Based Organizations.
- Shell Petroleum Development Company.
- Other interested parties.

4.2.3 Field Sampling

Field data gathering, and ecological samples collection were carried out from 27th of February to 5th of March 2017 and 27th April – 3rd of May 2017 for dry and wet seasons respectively. The various samples collected during the field data gathering exercise and its associated methodologies is summarised in Table 4.1. The results obtained were used to describe the environment of the project area.

Table 4.1 Environmental components sampled and its associated methodologies

S/N	Environmental components	Methodologies
1.	Air Quality/Meteorology	RKI SC-01, RKI GX-2003 Air sampler, Airmetrics Mini volume air sampler, Precision Gold 4-in-one Env meters.
2.	Surface water/Ground water	Hydro bios water sampler, pH meter, DO meter, Turbid meter, Temperature and Conductivity meter.
3.	Soil	Screw-type soil auger and description of each sample with Munsell colour chart.
4.	Sediment	Eckman grab sampler.
5	Microbiology	Collection of water samples with Hydrobios water sampler into sterile McCartney bottles; Soil samples with soil auger into aluminum foil Sediments samples with Eckman grab sampler into aluminum foil.
6	Vegetation	Direct observation/ Assessment, Discussion, Key Informant interview, Transects and Quadrants
7	Wildlife	Direct observation, Group Discussion, Key Informant interview, hunter interview
8	Fisheries	Direct observation, Group Discussion, Key Informant interview, fisher folks interview,
9	Phytoplankton & Zooplankton	Collection with plankton net and preserved
10	Socio economics	Key informant interviews, Focus Group Discussion, Direct observation and questionnaires.
11	Health	Key informant interviews, Focus Group Discussion, hospital records, Direct observation, field measurements and Administration of questionnaires.
12	Waste Management	Physical examination and Observation survey

4.3 Meteorology

Summaries of the climatic conditions are presented in Tables 4.2, while detailed results of the measured parameters are presented in Appendix 3.

4.3.1 Rainfall

The area is influenced by two seasons, namely the wet and dry seasons. The wet season lasts from April through November (Figure 4.1). It is characterised by the South-West trade winds laden with

moisture from the Atlantic Ocean. Abundant rainfall is in the range from 2500 – 3000mm. The dry season lasts from November to March and is characterised by North-East trade winds, which brings in harmattan between December and January.

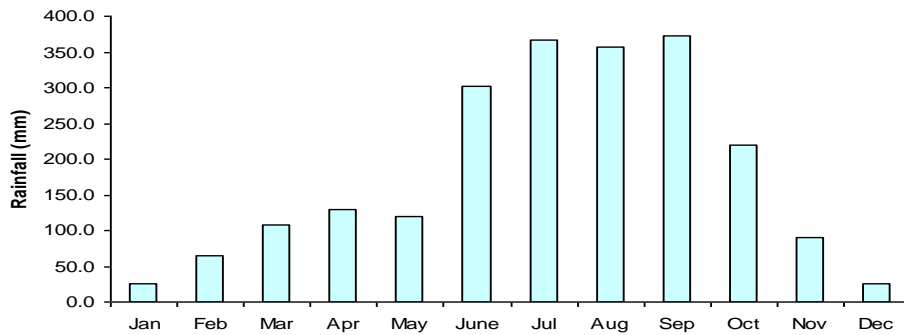


Fig. 4.1: Average Monthly Rainfall distribution for Warri Synoptic Station

4.3.2 Relative Humidity

Relative humidity is a measure of percentage water vapor content in the atmosphere. Based on 30-year climatic data obtained from NIMET (Figure 4.2), the data indicate month June -September and December – March represents wettest and driest periods respectively. Data from present field study varied from 65.2% to 82.50% (Mean = 72.90%) in the wet season and between 52.0% and 80.60%, with a mean value of 61.39% in the dry season. Similar range of results were obtained at the control locations. The obtained mean value agreed with the historical 30–year climatic data of the area which ranged from 52.0% to 99.40% (NIMET, 2016).

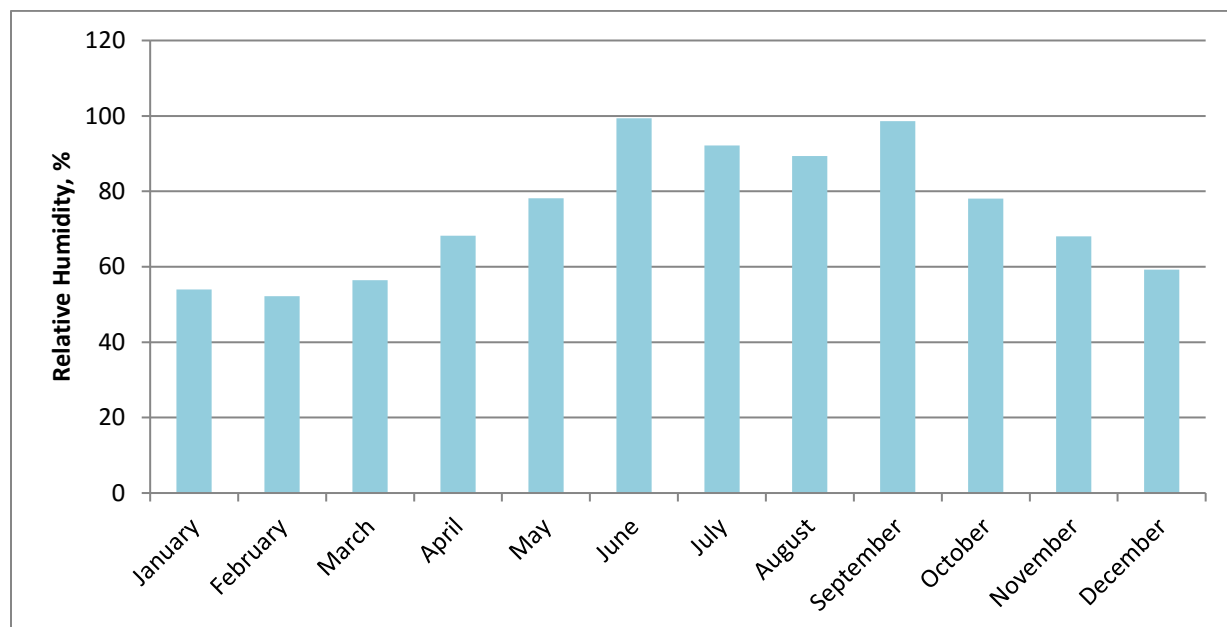


Figure 4.2: Historical mean relative humidity values in the area for the period of 30 years (1986 - 2016)

4.3.3 Ambient air temperature of the study area

The proposed project area is characterized by minimum air temperature varying from 21.8 – 24.2°C with an average temperature of 22.9°C while maximum temperature ranged from 29.7 - 39.6°C with a mean value of 31.8°C (Table 4.2). Highest ambient temperature occurred between the months of January – March, while the lowest is between June and August (NIMET, 2016). The hottest periods are in the dry season while the coolest periods are in the wet season. Air temperature values recorded during the fieldwork activities varied from 29.8 -38.2°C (Mean: 33.7°C) and 33.5 -39.0°C (Mean: 36.3°C) in the wet and dry season respectively.

Table 4.2: Summary of Meteorological Data in the Study Area during the Fieldwork (2017)

Parameter	Wet Season			Dry Season		
	Range	Mean	Control (Mean)	Range	Mean	Control (Mean)
Ambient Temp. °C	29.8 - 38.2	33.69	35.90	33.50 - 39.00	36.32	35.40
Wind Velocity, m/s	0.20- 1.60	0.78	0.30	0.10 -2.30	0.55	0.30
Wind Direction	-	W, S, SW, NE	SW, S, W		N, NE, SW	SW
Atm. Pressure, mmHg	746.30 – 762.30	757.26	756.20	750.20 - 759.0	754.90	756.00
Relative Humidity , %	65.20 - 82.50	72.90	57.55	52.00 - 82.60	61.39	57.55

4.3.4 Atmospheric Pressure

The historical atmospheric pressure of the area (1986 -2016) ranged from 720.0 to 770.0mmHg for NIMET (2016). Present field measurements varied between 746.26 mmHg and 762.70mmHg with an average value of 757.26mmHg in the wet season and 750.2 - 759.0mmHg with 754.90mmHg as a mean value in the dry season. These values are normal for the proposed project area.

4.3.5 Wind Speed and Direction

The area experiences mainly South–Westerly Trade winds. Wind speeds obtained during the field data gathering ranged between 0.2m/s and 1.60m/s (mean values: 0.78m/s) in the wet season and from 0.10m/s to 2.30m/s (mean values: 0.55m/s) in the dry season all of which fall within the medium to light breeze category. The wind directions during the sampling period were SW, S, and W during the wet season and NE, N and SW during dry season.

4.4 Air Quality

The summary of results of air quality measurements in the project area are presented in Table 4.3 Detailed field results of measured air pollutants are presented in Appendix 3. Nitrogen dioxides (NO₂), Sulphur dioxide (SO₂), Carbon Monoxide (CO), Hydrogen Sulphide (H₂S), Carbon dioxides and Volatile (VOC) levels varied from <0.01 – 0.07ppm (mean: 0.04ppm); <0.01 –

0.06ppm (Mean = 0.03ppm); 0.14-14.31ppm (Mean = 3.00ppm), <0.01 - 0.19ppm (Mean = 0.17ppm), 0.021 – 0.039% (Mean: 0.030%) and 0.56-18.96 $\mu\text{g}/\text{m}^3$ in the wet season respectively, concentrations ranged from <0.01 – 0.06ppm (mean : 0.03ppm) for NO_2 , <0.01-018ppm (Average = 0.025ppm for SO_2), 0.02 – 19.26ppm (Average value : 5.94ppm) for CO; <0.01 -0.029ppm (Average = 0.18ppm) for hydrogen sulphide and 0.020 – 0.034% (Mean = 0.030%) for Carbon dioxide and 0.77- 42.68 $\mu\text{g}/\text{m}^3$ for Volatile organic Compounds (VOC) in the dry season respectively. Total suspended particulates concentrations varied from 10.80 $\mu\text{g}/\text{m}^3$ to 36.20 $\mu\text{g}/\text{m}^3$ (Mean: 22.27 $\mu\text{g}/\text{m}^3$) in the wet season and 20.36 $\mu\text{g}/\text{m}^3$ to 92.44 $\mu\text{g}/\text{m}^3$ (Average: 57.10 $\mu\text{g}/\text{m}^3$) in the dry season. Sources of particulates recorded in the studied and control areas include vehicular emissions and bush burning since suspended particulates could be by-product of combustion in the lower atmosphere. Spatial and temporal variations pattern of the TSP levels, compared to DPR/FMEnv limit of 250.0 $\mu\text{g}/\text{m}^3$, are presented in Figure 4.3. The levels gaseous contaminants, in both the study area and control were lower in the wet season compared to the dry season. This is in agreement with other seasonal air pollution studies (Bhatia, 2002; Gobo *et. al* 2012) and is attributable to rain related atmospheric wash-out of pollutants (NADP, 1982). Apart from SPM that was higher, all the other parameters were lower than the values obtained in the study area in 2003 (SPDC 2003).

Table 4.3: Summary results of Air Quality and Noise levels in the Study Area.

Parameter	Wet Season			Dry Season			Regulatory Limit	
	Range	Mean	Control (Mean)	Range	Mean	Control (Mean)	FMEnv	DPR
Nitrogen Oxides (NO_x), ppm	<0.01 – 0.07	0.04	<0.01	<0.01 – 0.06	0.03	0.031	0.04-0.06	0.04-0.06
Sulphur Oxides (SO_x), ppm	<0.01 – 0.06	0.03	<0.01	<0.01 – 0.18	0.025	0.020	0.10	0.10
Carbon Monoxides (CO), ppm	0.14 – 14.31	3.00	0.34	0.02 – 19.26	5.94	5.19	20.00	10.00 – 20.00
H_2S , ppm	<0.01 – 0.19	0.17	<0.01	<0.01-0.29	0.18	<0.01	N/A	N/A
VOC, ppm	0.56 – 18.56	5.46	5.11	0.77 – 42.60	10.16	7.81		160.00
Ammonia, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		

Parameter	Wet Season			Dry Season			Regulatory Limit	
	Range	Mean	Control (Mean)	Range	Mean	Control (Mean)	FMEnv	DPR
Carbon Dioxide (CO ₂) %	0.021 – 0.039	0.030	0.030	0.02 – 0.034	0.029	0.030	N/A	N/A
TSP, µg/m ³	10.80-22.27	22.27	34.75	20.36-92.44	57.10	72.43	250.00	250.00
Heavy Metals								
Cadmium, µg/m ³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Lead, µg/m ³	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chromium, µg/m ³	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, µg/m ³	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel, µg/m ³	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium, µg/m ³	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic, µg/m ³	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Others parameters								
Noise, dB(A)	44.20 - 62.10	51.76	58.95	41.00-59.40	47.93	61.80	90.00	80.-100
NORM, µR/hr	95.20-104.30	100.44	100.50	99.50-101.50	100.45	99.60	50≤BRL	

All heavy metals–in-air levels were practically below the respective minimum detection limit of the analytical instrument (Atomic Absorption Spectrophotometer, AAS). The observed gaseous and particulate pollutant concentrations were at background levels.

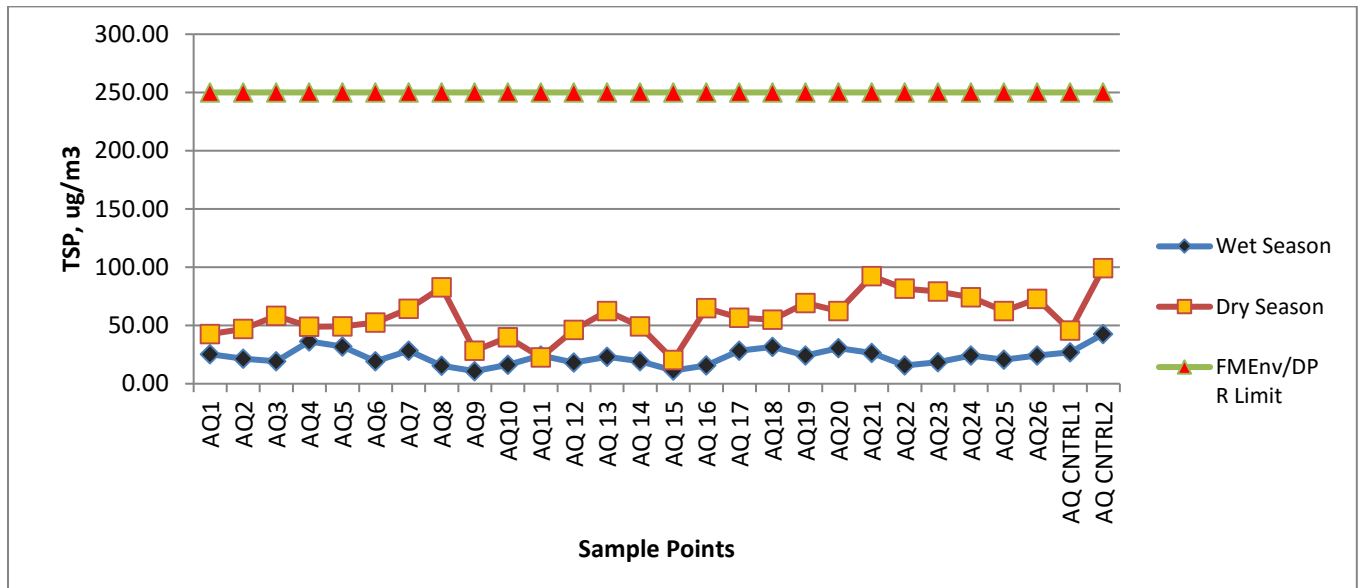


Fig. 4.3: Spatial and seasonal variations in concentrations of total suspended particulates in the study area compared with DPR /FMEnv set limit

Classification of Airshed in the Project Area

According to the World Bank Air shed classification, the air shed in the proposed project area could be classified as undegraded, as all the monitored air pollutants were within their respective FMEnv, and DPR set limits during both seasons.

4.5 Noise Levels

The noise levels in the wet season ranged from 44.20 dB(A) to 62.40 dB(A) with a mean value of 51.76 dB(A) while control points had a mean value of 58.95dB(A) but in the dry season, measured levels varied between 41.00dB(A) and 59.40dB(A) with a mean value of 61.80dB(A) (Table 4.3). The noise levels in the study area were generally below the shop floor limits of 100 dB(A) and 90 dB(A) set by DPR and FMEnv respectively (Figure 4.4), though some points (AQ2, AQ14, AQ18, AQ20 AQ22 AQ23) and the control points (Mbiama (AQ CNTRLL 1) and Tombia (AQ CONTRL 2)) were observed with noise levels which exceeded the World Bank set limit of 55.0 dB(A) for the rural areas. Relatively high sound levels observed at these points could be linked to vehicular movements and the Gbarain gas plant. Measured sound levels at the proposed project area and control points are both similar and none of the sampling locations had sound level that exceeded the World Bank’s set 70dB(A) limit for an industrial area. The levels of noise recorded in this study is similar to what was previously obtained in the area in 2003 (SPDC 2003)

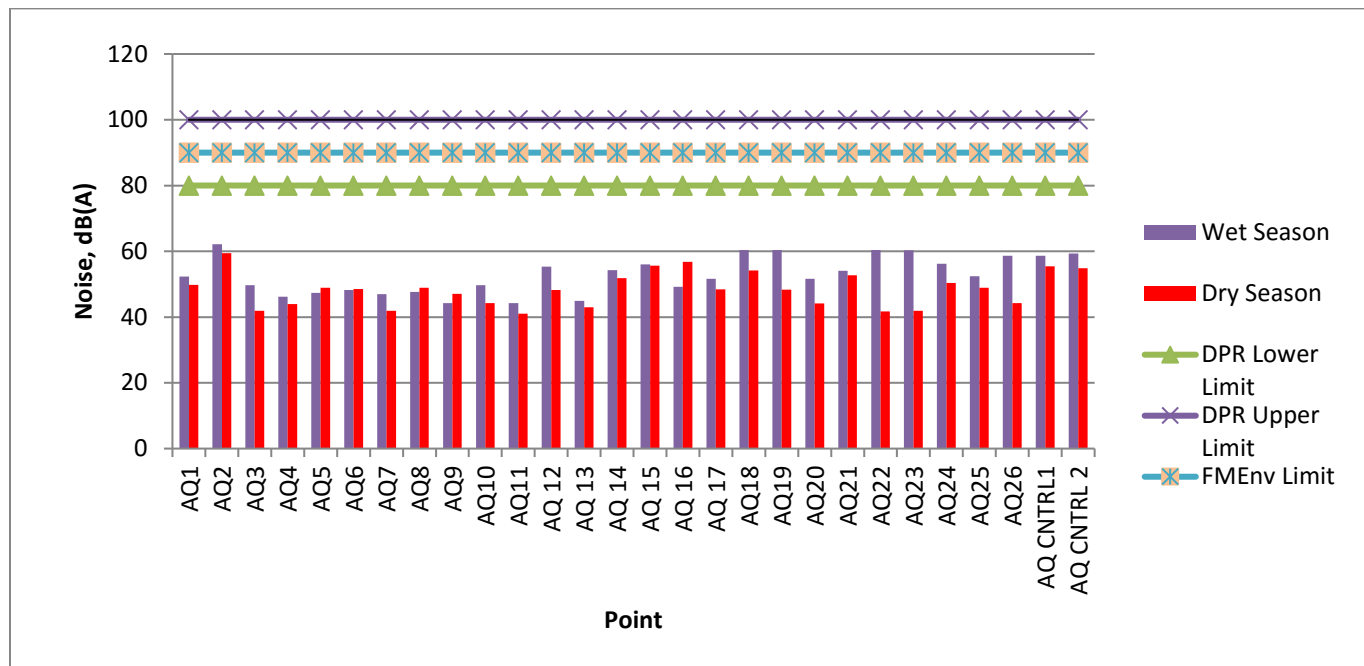


Figure 4.4: Spatial and seasonal variations of sound levels in the study area and the control points compared with DPR and FMEnv limits.

4.6 Naturally Occurring Radioactive Materials Emissions Values

The radioactive emission values obtained during the wet season in the proposed project and control areas were similar for values recorded in the dry season and not significantly different at $P < 0.005$ from the mean background values of $100.00 \mu\text{R/hr}$ (Table 4.3, Appendix 3).

4.7 Surface Water

Presented in Table 4.4 is the summary of the physico-chemical characteristics of the surface water collected from the project zone and control points, while detailed analytical results are shown in Appendix 4. Surface water bodies in the project area include Taylor Creek, Epie – Zarama Creek, River Nun and Orashi River.

4.7.1 General Physicochemical Properties

The summary of the physico-chemical characteristics of the surface water are presented in Table 4.4 while detailed results are shown in Appendix 4.

pH Value

pH levels of the waterbodies in the study area varied from 6.3 to 6.7 (Mean: 6.5) in wet season but ranged between 6.9 – 7.6 (mean value: 7.4) in the dry season. The results showed significant seasonal difference ($p < 0.05$) in the mean pH values of the water bodies (creek and creeklets) in the study area. Higher pH values were recorded in the dry season. Similar findings were reported by Alagoa and Aleye-Wokaoma (2012) on pH values of Taylor Creek. Low values of pH are common in Nigerian inland waters and are attributed to input of humic and decaying organic materials from forested catchment (Akpan, et al., 2002). According to Tepe et.al 2005, most natural

water bodies are characteristically known to have pH values ranging from 5-10 while fresh water pH values usually range between 6.5-7.5.

Table 4.4: Summary results of Physico-chemical variables of Surface Water in the Study Area (Fieldwork, 2017)

Physico-chemical	Wet Season		Dry Season			Seasonal Variations Statistics			
	Project Influence Zone		Control	Project Influence Zone		Control	Student's t-value	p-value	Statistical Implication
	Range	Mean	Mean	Range	Mean	Mean			
pH	6.3 - 6.7	6.5	6.4	6.9 - 7.6	7.4	7.3	10.25	0.001	DSS
Temperature, °C	27.2 - 31.9	29.66	29.35	30.3 - 33.0	31.59	32.65	3.110	0.0068	DSS
E. Conductivity, (µS/cm)	61.8 - 196.1	94.33	48.20	60.50 - 125.40	80.30	57.3	0.7700	0.4545	DNSS
Total Dissolved Solid, (mg/l)	31.0 - 103.2	49.30	25.55	32.07 - 66.46	42.44	30.37	0.7096	0.4881	DNSS
Turbidity, (NTU)	18.7 - 99.2	51.82	36.15	6.40 - 95.80	57.42	30.85	0.4240	0.6770	DNSS
Colour, Pt,Co	25.0 - 100.0	47.78	50.00	25.00 - 50.00	30.56	37.5	1.6787	0.1125	DNSS
Dissolved Oxygen, mg/l	5.3 - 6.8	5.84	5.50	4.20 - 5.60	5.28	4.85	2.4666	0.0253	DSS
OR-P, ±mV		- 66.30	-45.40		- 107.74	-88.6	-	-	-
Depth, m	0.3 - 3.8	1.86	4.85	0.35 - 4.00	1.91	5.05	-	-	-
Flow rate, meter/min	1.8 - 3.2	2.43	4.05	1.50 - 3.40	2.04	3.15	-	-	-
Bicarbonate (Alkalinity), mg/l	4.88 - 19.52	10.35	9.79	30.60 - 46.36	39.32	37.56	11.005	0.0001	DSS
BOD, mg/l	4.7 - 5.6	5.17	5.40	5.00 - 6.40	5.37	5.55	1.5991	0.1306	DNSS
COD, mg/l	5.63 - 8.65	7.37	6.73	6.91 - 8.06	7.41	7.72	0.0837	0.9344	DNSS
TSS, mg/l	20.6 - 72.0	44.42	70.00	10.60 - 60.40	33.36	18.5	0.9122	0.1539	DNSS
Salinity (as chloride), mg/l	3.55 - 7.09	6.44	6.88	3.55 - 24.85	9.85	7.09	1.6506	0.1183	DNSS
Potassium (K ⁺) mg/l	1.28 - 2.62	1.97	1.39	0.97 - 2.69	2.17	1.345	0.3887	0.8851	DNSS

Physico-chemical	Wet Season			Dry Season			Seasonal Variations Statistics		
	Project Influence Zone		Control	Project Influence Zone		Control	Student's t-value	p-value	Statistical Implication
	Range	Mean	Mean	Range	Mean	Mean			
Sodium (Na ⁺) mg/l	3.57-5.43	4.60	4.645	1.75 - 7.58	4.35	2.985	0.6528	0.4585	DNSS
Calcium (Ca ²⁺)mg/l	5.81 - 11.38	8.46	9.845	1.08 - 18.49	6.47	6.03	0.2987	1.0741	NDSS
Manganese (Mn ²⁺) mg/l	0.06 - 0.78	0.35	0.025	0.02 - 0.22	0.10	<0.01	0.0127	2.8211	DSS
Magnesium (Mg ²⁺)mg/l	1.81-2.76	2.39	2.085	0.64 - 3.87	2.17	1.795	0.5346	0.6346	NDSS
Ammonium (NH ₄ ⁺)	0.12 - 0.77	0.34	0.315	0.16 - 0.63	0.38	0.38	0.4156	0.8356	NDSS
Nitrate (NO ₃ ⁻) mg/l	0.28 - 0.57	0.43	0.041	0.11 - 2.34	0.62	0.52	0.0447	2.1779	DSS
Nitrite (NO ₂ ⁻)mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-
Phosphate (PO ₄ ³⁻) mg/l	0.04 - 1.85	0.65	0.045	0.01 - 0.04	0.02	0.18	0.0104	2.9037	DSS
Sulphate (SO ₄ ²⁻) mg/l	0.74 - 3.04	2.11	1.78	0.04 - 1.17	0.57	0.13	0.0001	5.6293	DSS
Silica (SiO ₂) mg/l	<0.02	<0.02	<0.02	<0.01	<0.02	<0.01	-	-	-
Sulphite (SO ₃ ²⁻) mg/l	0.02 - 0.04	0.03	<0.01	0.01 - 0.36	0.10	0.03	0.1220	1.6329	DNSS

Key DNSS: Difference not statistically significant, DSS: Difference is statistically significant

Electrical Conductivity and Total Dissolved Solids

The values of electrical conductivities of the surface waterbodies ranged between 61.80µS/cm-196.10 µS/cm with a mean value of 94.33 µS/cm during the wet season and from 60.50 µS/cm - 125.40 µS/cm with a mean of 80.30 µS/cm in the dry season. RPI/NNPC (1985) reported a range of 10-42500 for Niger Delta surface waters. Similarly, total dissolved solids varied from 31.00 - 103.20mg/l and 32.07 -66.16mg/l in the wet and dry seasons respectively. The electrical conductivities and total dissolved solids values obtained for both control points (CTRL SW1 and CTRL SW2) were lower than values obtained in the study area. There was no significant seasonal variation at p<0.05 in both the electrical conductivities and total dissolved solids. Low levels of electrical conductivities and its corresponding dissolved solids concentrations indicate that the waterbodies are characteristically freshwater, in both wet and dry seasons at the project influence zone and control points. Low levels of these parameters agree with findings of Alagoa and Aleleye-Wokaoma (2012) on a study conducted on Taylor creek – a major water body in the area of influence of the proposed project.

Temperature

Temperature is one of the environmental variables affecting metabolic activities, growth, feeding, reproduction, distribution and migratory behavior of the aquatic organisms (Suski *et.al*,2006).

According to Aiyesanmi *et. al.* 2006, increase in temperature decreases the solubility of gases, the reaction rate of chemical and toxicity of Ammonia to fishes. The waterbody within the proposed project influence zone recorded temperature levels that varied from 27.2⁰C to 31.9⁰C (mean = 29.7⁰C) and between 30.3⁰C to 33.0⁰C (Mean = 31.6⁰C) in wet and dry season respectively. These values are within the ambient temperature of the area. Difference of mean seasonal temperature values was statistically significant at $p < 0.05$. However, as also reported by Aghogbovw and Ohimain 2014, on lower Kolo creek, observed spatial variation in temperature values could be linked to sampling period and measurement time.

Colour:

Measured colour values of water bodies in the studied area within the project influence zone and controls (Nun and Orazi Rivers) were characteristically high with varied colour units: from 25.00 – 100.00 Pt.Co for wet season and 25.0 – 50.0 Pt.Co for the dry season . Relatively high colour unit observed in the wet season is attributable to storm water run-off, usually with colored substance of organic origin, as well as suspended particles in the water bodies of the area, particularly Taylor creek. Inland streams, creek and rivers of Nigeria are usually coloured due to input of tannic, hummic and decaying organic material (Akpan *et. al.* , 2002). The obtained values for colour units indicate higher colour values when compared with 15.00 Pt.Co unit set by USEPA and WHO (2008) for potable water.

Total Suspended Solids and Turbidity

Suspended solids are materials capable of altering transparency or light scattering of the surface waterbodies. Total suspended solids levels in surface water bodies within the proposed project influence zone ranged from 20.60 - 72.00mg/l (mean: 44.25mg/l) and 10.60 - 60.40mg/l (mean: 33.36mg/l) in wet and dry season respectively. RPI/NNPC (1985) reported a range of 1.20 – 397.00mg/l for TSS in surface water in Niger Delta region of area. Also, measured turbidity values varied between 18.70NTU and 99.20NTU in wet the season and between 6.40NTU to 95.80NTU in the dry season. Slightly high TSS and turbidity values recorded in the wet season could be due to influx of storm water run-off into the waterbodies, particularly Taylor creeks and other studied creeklets in the area, though there were no significant seasonal difference in the mean values of these parameters. Similar values were reported on Taylor creek by Alaoga and Aleleye –Wokoma (2012).

Dissolved Oxygen, Biochemical Oxygen Demand and Chemical Oxygen Demand

The dissolved oxygen contents of an aquatic system are determined by several factors including, photosynthesis by green algae, salinity and pollution from anthropogenic activities. Dissolved Oxygen concentrations in unpolluted waters are usually close to, but less than 10 mg/l (Chapman, 1996). Measured dissolved oxygen levels in wet and dry season varied from 5.30mg/l (SW1) to 6.80mg/l (SW3) (Mean = 5.84mg/l) and 4.20mg/l to 5.60mg/l (mean = 5.28mg/l) in the wet and dry season respectively. Also, dissolved oxygen contents recorded at both control points: Nun River (SW CTRL 1) and Orazi River (SW CTRL 2) in both seasons, were within the obtained DO concentration ranges recorded in the assessed surface water bodies within the proposed project

influence zone. Dissolved oxygen contents recorded in both seasons were significantly different at $p < 0.05$. Relatively lower dissolved oxygen levels that were recorded in the dry season may be attributable to increased temperature levels observed during the dry season. Aerobic biodegradation process on the organic matter commonly results to dissolved oxygen depletion in surface water medium (Alaoga and Aleleye –Wokoma (2012). The obtained DO contents were higher than 5.0mg/l minimum benchmark values for optimum survival of the aquatic organisms (Obot *et.al* 2016). Obtained DO concentrations, mainly on Taylor creek were similar to values reported by Daka, *et. al*, 2014 on Nun River and Taylor creek.

Biochemical Oxygen Demand (BOD₅) is an important parameter in surface water pollution monitoring as it represents the amount of oxygen required for biological decomposition of biodegradable organic matter under aerobic condition (Ewa *et al.* 2011; Obot *et al.*, 2016). BOD₅ of the water bodies in the project influence zone, ranged from 4.17 mg/l -5.60mg/l (wet season) and 5.00 - 6.40mg/l (dry season).

Chemical Oxygen Demand (COD) is a measure of the oxygen equivalent of the organic matter in water sample that is susceptible to oxidation by a strong oxidizing agent. It also measures the organic strength of a water body. COD values ranged from 5.63 – 8.65mg/l and 6.91 -8.06mg/l in the wet and dry season respectively in the assessed surface water in the study area. BOD and COD levels were within the FME_{env}/DPR acceptable limit of 10.00mg/l which indicates that the waterbodies in the area are fairly unpolluted.

Considering pH, dissolved oxygen , BOD, COD and TSS values recorded in the surface water bodies in the proposed project zone and control are within acceptable quality Class II, according to Pratt’s classification (Table 4.5) of surface water quality (Aiyesanmi, 2006).

Table 4.5: Pratts’ classification of surface water quality

Parameter	Class I	Class II	Class III	Class IV	Class V
pH	6.5-8.0	6.0 -8.4	5.0 -9.0	3.9 -10.1	<3.9 - >10.1
Dissolved Oxygen, mg/l	7.80	6.20	4.60	1.80	<1.60
BOD, mg/l	1.5	3.0	6.0	12.0	>16.0
COD, mg/l	10	20	40	80	>80
TSS, mg/l	20	40	100	278	>278

Source: Aiyesanmi et.al., 2006. Class I: Excellent quality, Class II: Acceptable Quality; Class III: Slightly polluted; Class IV: Polluted and Class V: Heavily Polluted

4.7.2 Mineral Nutrients

Low concentrations of the mineral nutrients including ammonium, chloride, nitrate, ammonium, sulphite, sulphate, phosphate, potassium, magnesium, calcium, sodium and manganese ions were recorded in both wet and dry seasons. Generally low levels of these ions, especially chloride, points

to the fact that the water bodies within the proposed project influence zone, and even the control points, are characteristically fresh water.

4.7.3 Hydrocarbon Contents

Presented in Table 4.6 is the summary of the hydrocarbon concentrations in the surface water body in the study and control areas. The oil and grease contents varied from 0.15-0.33mg/l in the wet season and 0.15 - 0.55mg/l in the dry season. Seasonal difference in the concentrations of oil and grease was not significant. Also, total petroleum hydrocarbon concentrations, in the surface water samples taken from both waterbodies within the proposed project area and the control points, were low with mean values of 0.23mg/l and 0.21mg/l in wet and dry season respectively. However, polynuclear aromatic hydrocarbon and BTEX were below the detection limit of <0.001mg/l of the analytical instrument (GC/MS) and therefore could be said to be absent. Basically, oil and grease composed of hydrocarbons of both petrogenic and biogenic origins. Whilst biogenic hydrocarbons are known to include fat, oil and waxes of plant and animal, petrogenic hydrocarbons are particularly of petroleum. Values of oil and grease obtained during this study was lower than the values obtained in the study area in 2003 (SPDC, 2003).

Table 4.6: Summary of results of Hydrocarbon Contents of the Surface Water in the Area

Physico-chemical	Wet Season		Dry Season			Seasonal Variation Statistics		
	Project Influence Zone		Control	Project Influence Zone				Control
	Range	Mean	Mean	Range	Mean	Value	p-Value	Statistical Implication
Total Hydrocarbon Content (mg/l)	0.14 - 0.34	0.23	0.355	0.12 - 0.52	0.21	0.15	0.5963	DNSS
Oil & Grease, mg/l	0.15 - 0.33	0.24	0.355	0.15 - 0.55	0.25	0.18	0.8203	DNSS
Polynuclear Aromatic Hydrocarbon, (PAH), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
BTEX, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

Source: Environmental Impact Assessment of Uzu FDP SPDC 2016/2017. Key DNSS: Difference not statistically significant, DSS: Difference is statistically significant

4.7.4 Heavy Metals Concentrations

Heavy metals concentrations of the surface water samples collected from the proposed project influence zone and controls are summarized in Table 4.7

4.7.5 Surface Water Hydrology

Hydrology basically encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the movement within each phase of the hydrologic cycle. In the context of this study, surface water hydrological properties (Discharge and Flow rates) provide understanding of the movement of potential contaminants input and their relationship with the water body (SPDC, 2006). Table 4.8 below presents some basic hydrological features of Taylor creek, Epie –Zarama Creek and Okolobiri creeklet, Nun and Orazi rivers in the study area and the control stations.

Table 4.7: Summary of heavy metals concentrations in the surface water samples from the project and control areas

Physico-Chemical	Wet Season			Dry Season			Seasonal Variations Statistics		FMEnv Limit
	Project Influence Zone		Control	Project Influence Zone		Control	p-value	Statistical Implication	
	Range	Mean	Mean	Range	Mean	Value			
Heavy Metals, mg/l									
Total Iron (Fe ²⁺ & Fe ³⁺)	1.79 - 5.04	2.91	2.20	0.75 - 1.84	1.08	1.115	2.8074	DSS	1.00
Cadmium (Cd ²⁺)	0.04 - 0.12	0.08	0.03	0.07 - 0.10	0.08	0.105	1.0248	DNSS	
Chromium (Cr ³⁺ & Cr ⁶⁺)	0.08 - 0.23	0.17	0.14	0.01 - 0.06	0.04	0.04	0.7280	DNSS	
Nickel (Ni ²⁺)	0.14 - 0.39	0.28	0.40	<0.02	<0.02	<0.01	9.2202	DSS	
Vanadium (V ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		DNSS	
Lead (Pb ²⁺)	<0.02	<0.02	<0.02	0.020 - 0.080	<0.02	0.045	9.311	DSS	
Zinc (Zn ²⁺)	0.06 - 0.15	0.10	0.09	0.090 - 0.170	0.13	0.21	0.1718	DNSS	
Mercury (Hg ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	DSS	

Physico-Chemical	Wet Season			Dry Season			Seasonal Variations Statistics		FMEnv Limit
	Project Influence Zone		Control	Project Influence Zone		Control	p-value	Statistical Implication	
	Range	Mean	Mean	Range	Mean	Value			
Copper (Cu ²⁺)	0.016 - 0.11	0.06	0.15	0.12 - 0.33	0.22	0.165	5.9885	DSS	

. Key DNSS: Difference not statistically significant, DSS : Difference is statistically significant

Taylor Creek, Orazi and Nun rivers are perennial and navigable all year round. Flood levels vary between the dry season and the rainy season with significant discharge rates recorded for Taylor creek at approximately 24.10m³/min in the dry season and 25.80m³/min in the wet season. The creek flows were reasonably fast at 1.95m/min and 2.30m/min in the dry and wet season respectively, which indicate that contaminants input at pipeline crossing point (if any) of Taylor creek will speedily arrive at a downstream point of the creek and finally empty into Nun River.

Table 4.8: Selected Hydrological Features of the Creek, Creeklets Rivers in the Study and Control Areas

Hydrological Parameter	Taylor Creek	Epie-Zarama Creek	Okolobiri Creeklet	Orazi River	Nun River
Flow rate (Dry Season) m/min	1.95	2.20	1.40	3.12	2.80
Discharge rate (Dry Season) m ³ /min	24.10	25.20	15.20	34.50	31.50
Flow rate (Wet Season) m/min	2.30	2.60	1.59	3.85	3.40
Discharge rate (Wet Season) m ³ /min	25.80	27.40	16.00	39.20	36.40
Average depth, m	6.90	1.50	1.80	8.10	10.20
Average Width,(m)	Approx. 285.0	Approx. 8.55	Approx. 10.60	Approx. 260.0	Approx. 350.0
Flow Direction, (m)	South	SE	SW	South	South
Tidal Regime	Non-tidal	Non-tidal	Non-tidal	Non-tidal	Non-tidal
Flooding Regime	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal
River bed Current (m/s)	N/A	N/A	N/A	N/A	2.60*

Hydrological Parameter	Taylor Creek	Epie-Zarama Creek	Okolobiri Creeklet	Orazi River	Nun River
Seasonality	Perennial	Annual	Annual	Perennial	Perennial

Source: Uzu FDP EIA Field Data Gathering (Feb. & May, 2017)

*SDPC (2010): Nun River Current Metering Report

Surface water Use

Taylor Creek and surface water bodies in the study area are being used for different purposes. The inhabitants of the surrounding settlements rely mainly on the creeks and rivers for their domestic water supply, fishing, inter-village transportation, cassava fermentation, palm produce processing, fishing and sand mining. The water bodies are also source of water for irrigation, particularly during dry season farming period. There was no evidence of use for either industrial or aqua cultural purposes, although the water bodies are also being used for transportation of logs harvested from the fringing freshwater swamp forests.

4.8 Sediment

Physicochemical properties of the sediment samples collected across the study area are discussed in this sub- section. The descriptive statistical analysis results, including values obtained for parameters in sample collected at the control stations, are presented in Table 4.9. Detailed analytical results are presented in Appendix 5.

Table 4.9: Statistical summary of the physico-chemical characteristics of sediments of the study area and control stations

Parameter	Wet Season			Dry Season		
	Project Influence Zone		Control (Mean value)	Project Influence Zone		Control (Mean Value)
	Range	Mean		Range	Mean	
pH	5.6 - 6.3	5.8	6.3	4.9-5.9	5.3	5.9

Oxidation –Reduction Potential, (ORP) ± mV	109.00 – 201.80	144.96	189.65	-	- 32.55	-51.85
Available PO ₄ -P, mg/kg	15.00 - 17.48	5.82	1.54	15.16 - 17.24	16.27	16.24
Total Nitrogen , %	0.01 - 0.02	0.01	0.01	0.01 - 0.06	0.02	0.03
Anions, mg/kg						
Ammonium (NH ₄),	6.05 -19.27	12.60	6.59	4.47- 45.78	31.08	15.76
Nitrate (NO ₃)	<0.02 - 9.28	2.60	0.31	6.93 - 15.86	10.34	5.16
Nitrite (NO ₂)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cations, (meq/100g)						
Potassium (K)	0.17 - 2.84	1.55	1.40	0.06 - 2.40	0.83	1.33
Sodium (Na)	1.08 - 1.33	1.23	1.14	0.77 - 24.78	3.80	1.07
Calcium (Ca)	0.11 - 1.21	0.41	0.47	0.65 - 6.01	2.13	2.59
Magnesium (Mg)	1.32 - 2.04	1.82	1.81	0.61- 2.44	1.98	2.36
Organics						
Total Organic Carbon, %	0.17 - 28.00	3.38	0.82	0.79 - 2.02	1.41	1.58
Total Hydrocarbon Content, mg/kg	0.21 - 1.28	0.48	<0.01	0.44 - 1.28	0.88	1.45
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & Grease, mg/kg	<0.10 -0.42	0.42	<0.10	0.81 - 1.63	1.13	1.63

Source: SPDC (2017). Uzu FDP EIA Fieldwork/Laboratory Results

4.8.1 General Physico-chemical properties

Sediments in the study area were predominantly clayey in texture and grey to dark brown in colour. Clay and organic matter content of soil/sediment have direct influence on other physical and chemical characteristics, including reserve of exchange bases and the interaction and dynamics of trace metals and organic pollutants in sediment, hence, maximum soil/sediment capacity for heavy metals and organic pollutants are adjusted according to these soil/sediment macro-characteristics (DPR, 2002). The sediment samples pH values were in the acidic ranges of 5.6 - 6.3 (Mean = 5.8) and 4.9 - 5.9 (Mean = 5.3) in wet and dry seasons respectively. There was no significant ($p>0.05$) seasonal difference in the pH values. Obtained values from the control stations were within the

range of values recorded for the project's influence zone. According to Aiyesanmi, 2006, recorded sediment acidity may be attributed to combination of possible oxidation of pyrite (FeS_2) in the sediment which produces sulphuric acid and causes depletion of calcium level or increasing aluminum concentration in sediment. The oxidation-reduction potential (ORP) were of mean value $144.96 \pm \text{mV}$ and $-32.55 \pm \text{mV}$ in wet and dry seasons respectively. The nutrient content, specifically phosphorus varied from 15.00 – 17.48 mg/kg and 15.16-17.24mg/kg in the wet and dry season while concentration range of 0.01- 0.02% (mean = 0.01%) was obtained in the wet season and 0.01 – 0.06% (0.02%) in the dry season for total nitrogen. Phosphorus and nitrogen naturally serve as nutrients to benthic organisms as well as some microorganisms in sediment. Also, ammonium ions concentrations in the sediment samples ranged from 6.05 - 19.27mg/kg in the wet season and 4.47 - 45.78mg/kg in the dry season. The sediments exchangeable cations mean concentration values of 1.55meq/100g, 1.23meq/100g, 0.41 meq/100g and 1.82 meq/100g were obtained for Potassium, Sodium, Calcium and Magnesium respectively in the wet season while 0.83meq/100g was recorded for Potassium; 3.80meq/100g for Sodium; 2.13meq/100g for Calcium and 1.98meq/100g for Magnesium in the dry season.

The order of magnitude of exchangeable cations' concentrations in the wet and dry seasons were as follows: $\text{Mg} > \text{K} > \text{Na} > \text{Ca}$ and $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$ respectively. High nutrients and minerals (nitrate, phosphate, calcium, magnesium, potassium, and total nitrogen) recorded may be due to observed anthropogenic activities in the study area particularly, along Taylor and Zarama–Epie creeks as well as the control stations. Total organic carbon contents varied from 0.17 – 28.00 % in the wet season while a range of 0.79 - 2.02% was obtained in the dry season. Oil & grease contents in the sediment samples were of mean values of 0.42mg/kg and 1.13mg/kg in the wet and dry seasons respectively, while total hydrocarbon content values varied from 0.21 - 1.28mg/kg (Mean = 0.48mg/kg) in the wet season and between 0.44 - 1.28mg/kg (Mean = 0.88mg/kg) in the dry season. Presence of oil & grease was indication of possible petrogenic hydrocarbon contamination of sediment from the study area. However, polycyclic aromatic hydrocarbon was not found in the sediment. Seasonal comparison of selected parameters is depicted in Figure 4.5. Oil and grease was lower in this current study that what was previously recorded in the study area in 2003 (SPDC 2003).

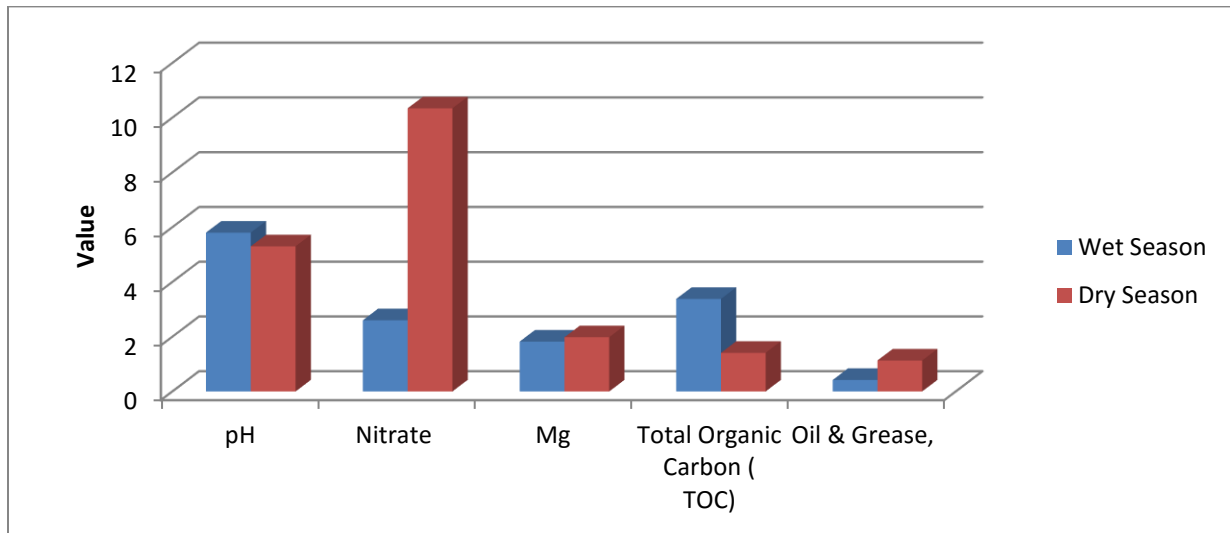


Figure 4.5: Seasonal comparison of wet and dry season for pH, Nitrate, Magnesium, TOC and Oil & Grease.

(Units of selected parameters are outlined in Table 4.8). (Source: SPDC, 2017)

4.8.2. Heavy Metals Levels in the Sediment

Summarized in Table 4.10 are heavy metals' contents in sediment while details of the analytical results are given in Appendix 5. Heavy metals determined are Nickel (Ni), Cadmium (Cd), Copper (Cu), Iron (Fe), Mercury (Hg), Chromium (Cr), Lead (Pb) and Zinc (Zn). All metals, except Vanadium, showed measurable concentrations in the entire study area. In the wet season, concentrations of Fe, Cr, Pb, Ni, Zn, and Cu ranged from 1211 – 2120mg/kg, 2.146 -3.270mg/kg, 0.19-20.65mg/kg, 0.29-14.73mg/kg, 16.26-33.58mg/kg, 19.48-55.32mg/kg and 0.17 -9.58mg/kg respectively while in the dry season, concentration range of 846.83 -2432mg/kg was obtained for Fe; 0.04 -3.53mg/kg for Cd; 5.65-55.34mg/kg for Cr; 3.93- 40.40mg/kg for Pb; 15.55 - 47.50mg/kg for Ni; 6.38 -79.50mg/kg for Zn and 1.53 -17.03mg/kg for Cu. The magnitude order of mean concentrations of metals in sediment is Fe >Zn> Ni> Cr> Pb> Cu > Cd in the wet season and Fe > Zn > Ni > Pb > Cr > Cu > Cd in the dry season. As reported by Odu, 1985, relatively high level of Fe recorded in sediment could be linked to high lithological level of Fe in Niger Delta soil. Metals are mostly mobilized from crustal rocks into the streams, creeks and rivers via natural weathering, erosion and other geochemical process. Most metals present in stable state in sediments, are said to have originated from crustal natural weathering process and also from anthropogenic activities, including direct industrial effluent discharge, refuse dumping and sewage discharge into rivers and creeks in the Niger Delta region. Also, flocculation of metals to suspended particulates by adsorption in the aquatic system is regarded as a source of metals incorporation into bottom sediment. Concentrations of most of these metals at the proposed project zone are significantly different (at $p < 0.05$) from the control points. Each of the metals determined in both wet and dry season, had mean concentration below the respective ISQG value (Table 4.10), except for Cadmium.

Table 4.10: Summary of heavy metals contents of the sediment of the study area and control stations, in the wet and dry seasons

Parameter	Wet Season			Dry Season			ISQG Value
	Project Influence Zone		Control (Mean value)	Project Influence Zone		Control (Mean Value)	
	Range	Mean		Range	Mean		
Iron (Fe)	1211- 2120	1765	1971	846.83 - 2432	1944	2286	-
Cadmium (Cd)	2.15 - 3.27	2.80	3.05	0.04 - 3.53	1.4	0.80	0.60
Chromium (Cr)	0.189 - 20.65	9.80	20.2	5.65 - 55.34	25.3	30.99	37.30
Lead (Pb)	0.29 -14.73	8.00	13.69	3.93 - 40.40	30.8	35.85	35.0
Nickel (Ni)	16.26 - 33.58	25.2	13.61	15.55 - 47.50	27.7	18.7	-
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-
Zinc (Zn)	19.48 - 55.32	32.10	41.395	6.38 - 79.50	32.1	43.05	123.0
Copper (Cu)	0.17 -9.58	4.60	3.89	1.53 - 17.03	11.0	15.48	35.70

Source: SPDC Uzu FDP EIA Fieldwork/Laboratory Results, February & April 2017. ISQG: International Sediment Quality Guideline for Aquatic Life Survival

4.9 Geology

The project area lies in the Niger Delta which is made up of a vast sedimentary basin made up of sands, silt, clay, shale and peat. This sedimentary basin comprises of three stratigraphic formations namely: The Akata Formation, Agbada Formation and Benin Formation (Figures 4.6 and 4.7.

The *Akata formation* which are outcrops of sediments (600 – 700m) range in age from Eocene to Recent is the lowest of all the formations and consist of turbidite sand, clay, silt and shales typically uncompacted and overpressured forming diapiric structures (Doust and Omatsola, 1990)

The *Agbada formation* range in age from Miocene to Recent (300 - 4,500 m thick) and consists of intercalations of sands, silts and shales of various thicknesses and proportions indicative of cyclic sequences of offlap units, glauconite, lignite streaks, limonite and shell fragments.

The *Benin Formation* range in age from Oligocene to Recent (2100 m thick) and constitute the present day surface deposits in the Niger Delta with medium to fine grained ferruginous sands. It is a fresh water bearing continental sand and gravel formation deposits.

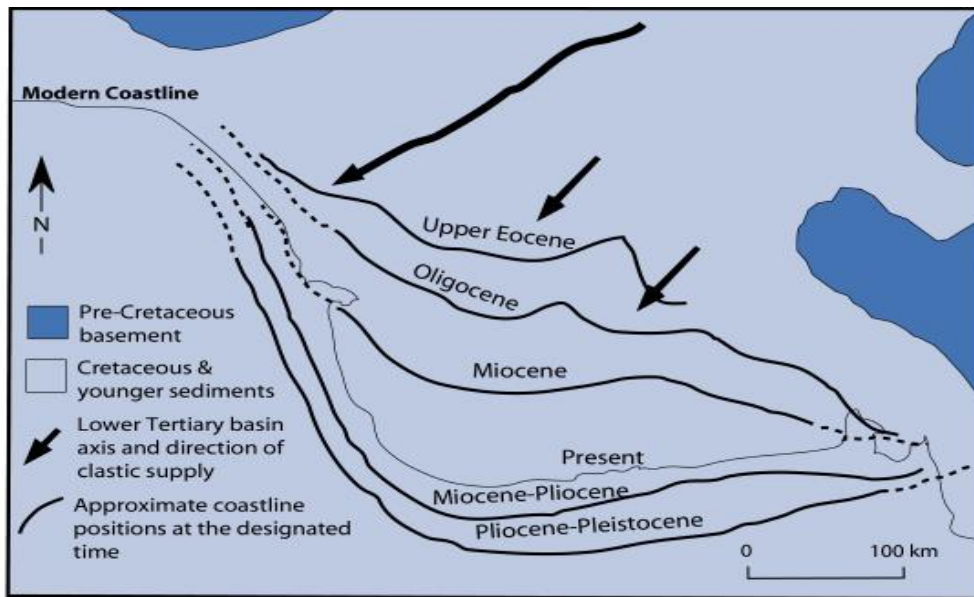


Figure 4.6: Map showing the progradation of the Niger Delta since 35Ma (After Doust and Omatsola, 1990)

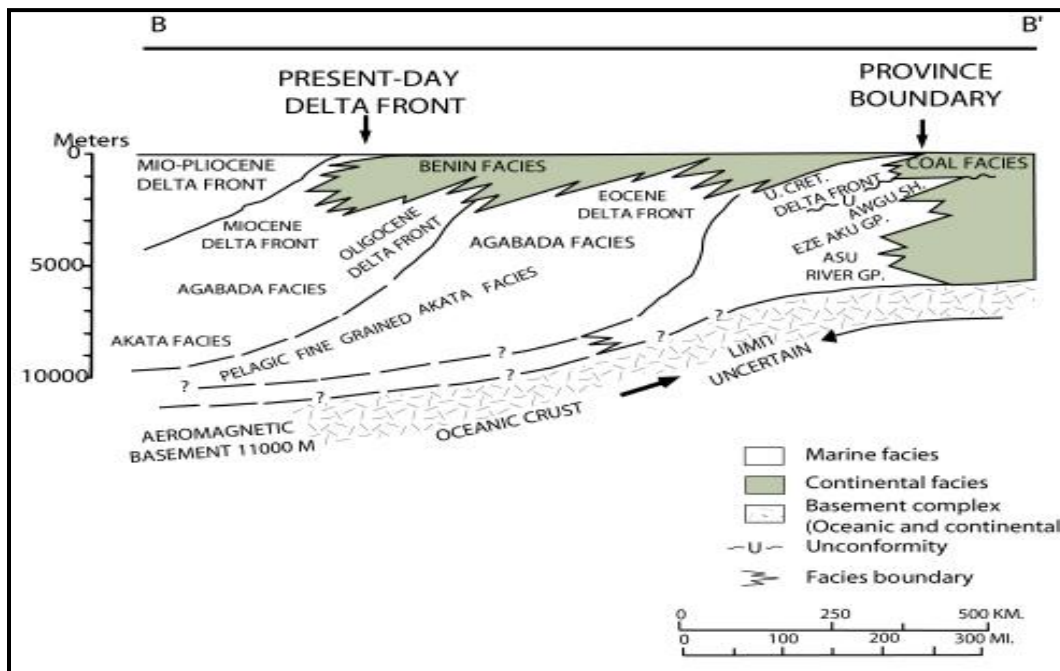


Figure 4.7: Stratigraphic cross-section of the Niger Delta showing Benin, Agbada and Akata Formations

4.10 Hydrogeology

4.10.1 Regional Geomorphology

The Deltas and estuaries with their saline wetlands have a total surface area of 858,000 hectares while fresh waters cover about 3,221,500 hectares (Nwilo and Badejo, 2005) other bodies include small reservoirs, fish ponds and miscellaneous wetlands suitable for rice cultivation cover which is about 4,108,000 hectares (Kuru 2004). The entire Gulf of Guinea is highly stratified with a thin surface layer of warm fresh tropical water. The stratification of the upper water column along the Gulf of Guinea is generally very strong except in areas subjected to upwelling events. The Nigerian coastal geology is sedimentary and dominated by the geology of the Niger Delta (Nwilo and Badejo 2005).

The Niger Delta is composed of an overall classic sequence, which reaches a maximum thickness of 9 – 12 kilometers (Ibe 1988). The Nigerian continental shelf is narrow in the west (less than 30km) but relatively broad off the Niger Delta and the eastern flanks where it measures 45-80km in width. The shelf is interrupted by several submarine canyons, which include Avon 1 mahin, etc. The natural delta of Niger River is a vast sedimentary basin. The deltaic deposits comprise mainly medium to coarse unconsolidated sands, silt, clay, shale and peat. The delta is mostly flat, lowly swampy basin criss-crossed by dense network of meandering rivers and creeks.

4.10.2 Local Stratigraphy

The local lithostratigraphy profile and topography within Gbaran and environ cluster is presented in 4.8a, b and c. The subsurface of Gbaran area is characterized by clay from the surface to depth 20ft. Below the clayey section is the silty sand and sands to the maximum probed depth of 40ft. at borehole 1 and borehole 2 locations. Fine grained sand constituted 1-20% of the mineral skeleton. The lithostratigraphic of Okolobiri is characterized by different thickness of clay layer which is about 5ft at the BH1 location and thickens to about 20ft at BH2 control. The clay layer is underlain by sands which are textually fine – medium grained sizes.

4. 10.3 Groundwater Hydrology

(i) Gbaran an Environ of Study

The results of field measurements directed at the evaluation of the groundwater system around Gbaran and environ are represented in the map of the local ground topography which may exert influence on groundwater pattern especially in terms of aquifer recharge mechanism. Figures 4.8a is a map depicting the depth to the ground water level within the area. Figure 4.8c is a map depicting the ground water plezometric surface and flow direction within Gbaran and environ. It is noted that because of the local stratigraphy of the area, the groundwater system may be confined and semi-confined, consequently, the ground water is pressurized. This explains the shallow depth 0.92ft at BH2 to 5.20ft at BHC to the water levels in the drilled boreholes. Figures 4:8b and 4.8c capture the aerial distribution of the depth to the potentiometric surface viz-avis the surface topography. Figure 4.9c shows the potentiometric surface which defines the hydraulic head that drives the groundwater flow in the North-west

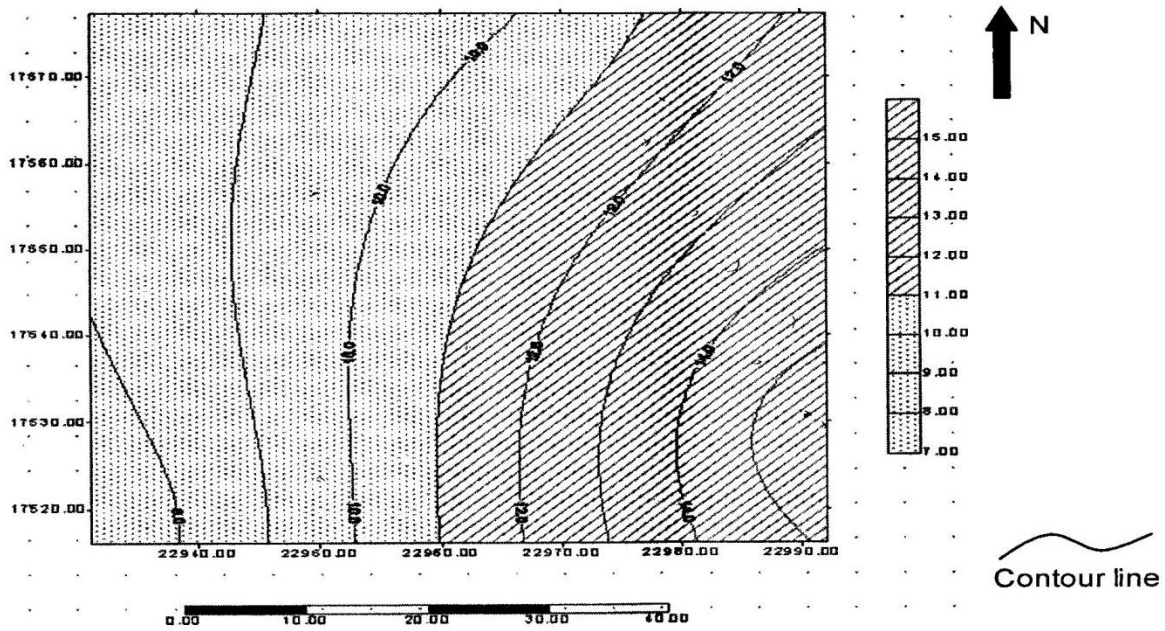


Fig. 4.8a: Local Groundwater surface topography of Gbaran and environ, 150ft depth

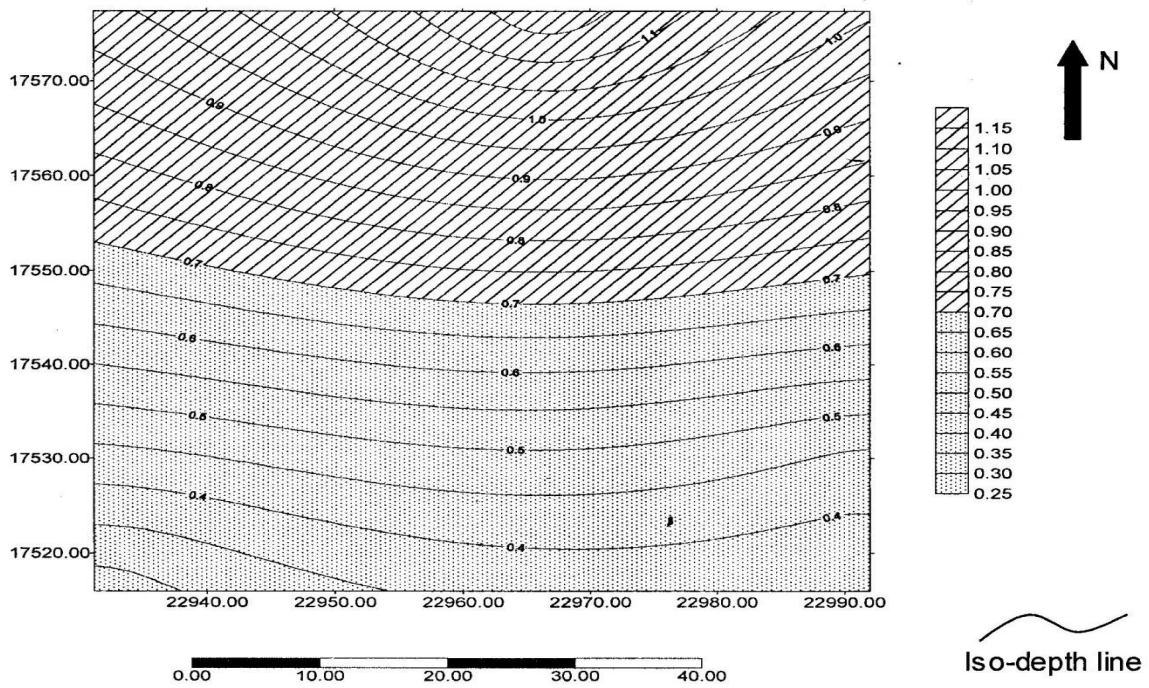


Fig. 4.8b: Local Groundwater surface topography of Gbaran and environ, 150 depth

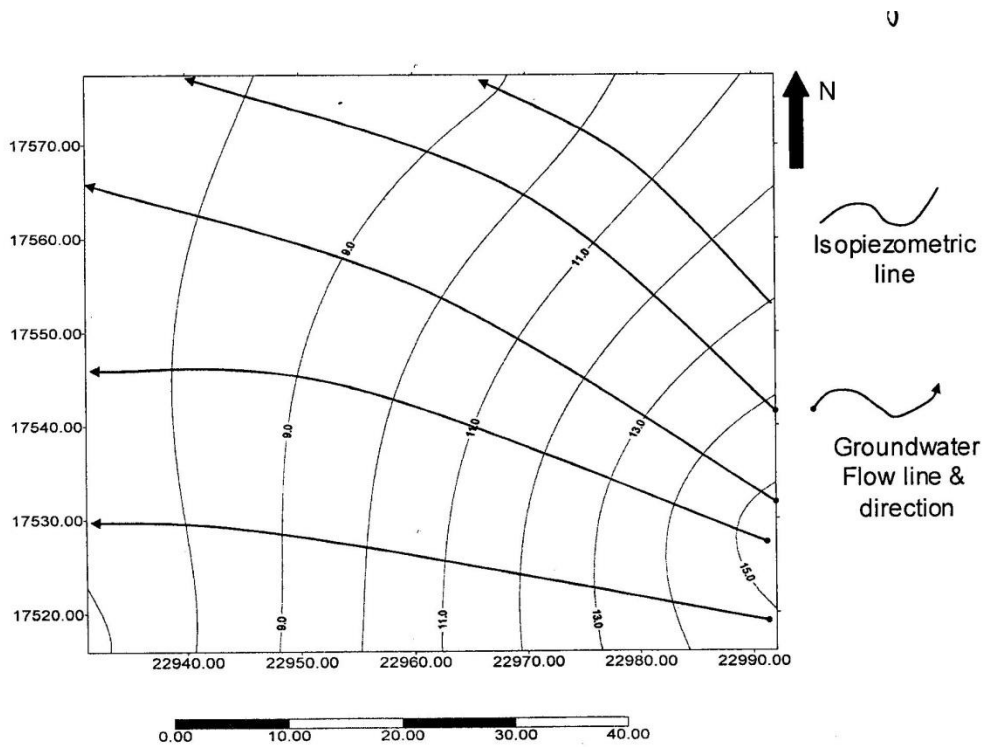


Fig. 4.8c: Groundwater piezometric surface and flow direction of Gbaran and environ.

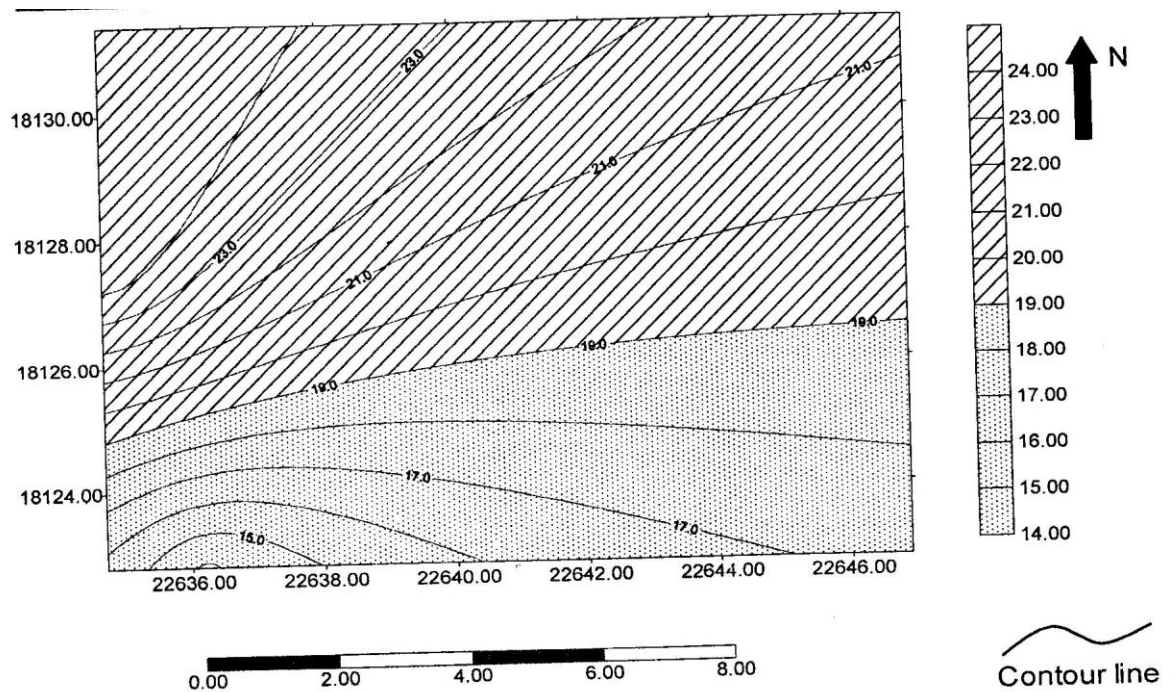


Fig. 4.9a: Local ground surface topography of Mbiama area.

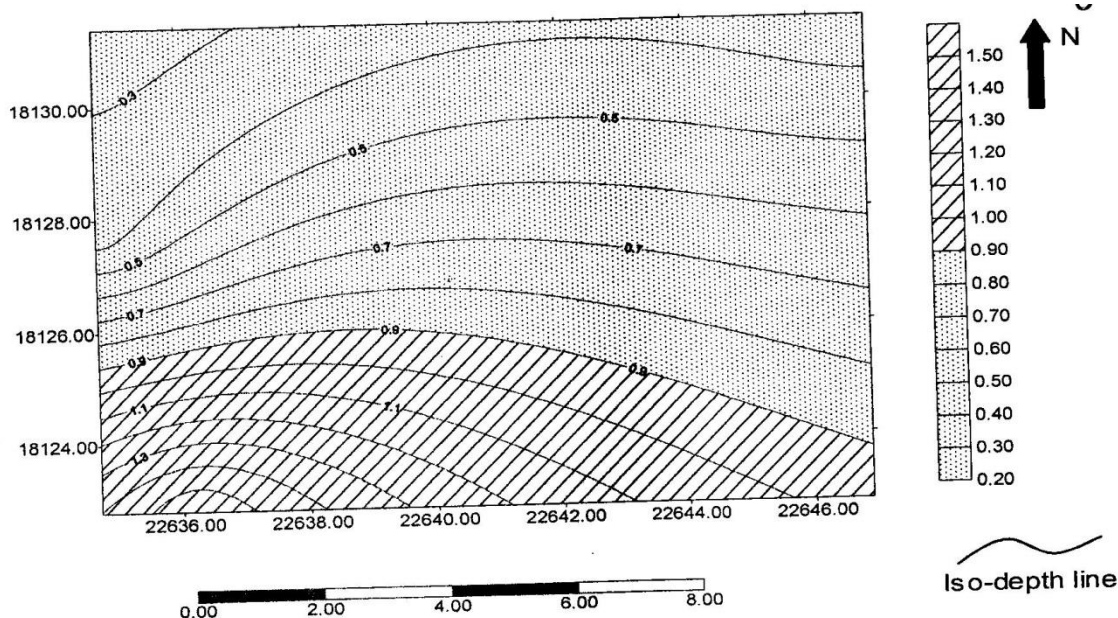


Fig. 4.9b: Depth to groundwater level in drilled holes of Igbogene area.

(ii) Mbiama Area

The results of hydrogeological investigation (Table 4.11) for Mbiama area can be found in Figure 4.10a, b. The map of the local topography of the study area 4.10b depicts the depth to the groundwater surface as observed in the Gbaran Area, the depth to the ground surface is also observed to be shallow here. It ranges from 1.08ft at BH2 location to 10.4ft at BHC1 location. These shallow depths in boreholes are again indicative of pressured ground water regime prior to drilling. Figure 4.10c depicts the groundwater piezo-metric surface and groundwater flow direction. The flow direction is depicted to be essentially southward of Mbiama area.

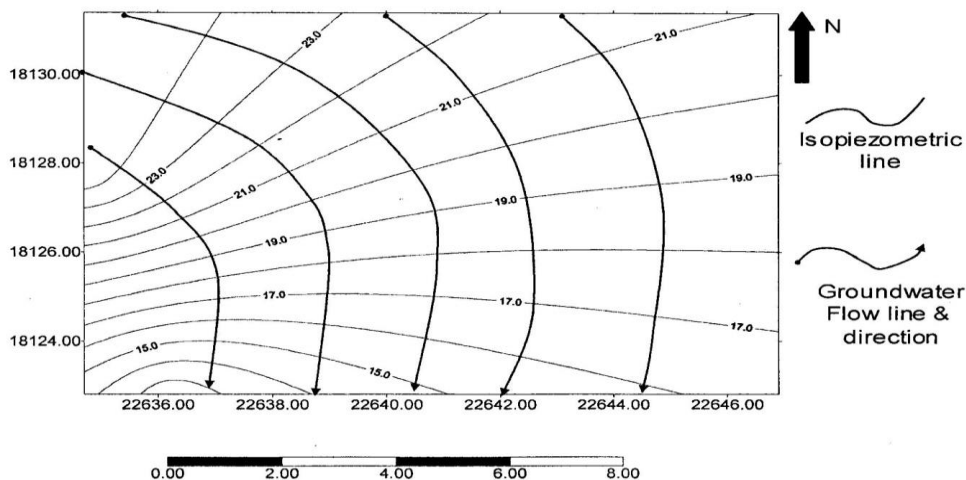


Fig. 4.9c: Groundwater piezometric surface and flow direction.

It should be noted generally that ground water flow directions obtained in Igbogene and Tombia areas are of local significance because of the limited number of sampled data points and limited area of coverage. The hydrodynamic interplay between the groundwater system and surface waters can lead to periodic reversal of groundwater flow direction.

Table 4.11: Field hydrogenical Data of Gbaran (Okolobiri), Zarama, Igbogene, Tombia and Mbiama.

Boreholes ID	Locations	Ground Surface Element (m)	Depth to Ground GL Ref (m)	Static water level elevation (m)	Depth to Ground top Casing Ref (m)
BH ₁	Okolobiri (Gbaran)	8.00	2.14	5.41	1.40
BH ₂	Zarama	7.00	0.32	5.30	1.30
BH ₃	Igbogene	12.00	0.63	10.40	1.56
BHC ₁	Tombia	14.00	1.20	7.00	1.20
BHC ₂	Mbiama	7.20	0.41	6.20	1.30

(iii) Igbogene

Igbogene area with a relatively thick layer of about 50ft near surface clay layer presents a luxuriant environment in terms of groundwater vulnerability. The clay layer with low hydraulic conductivity and a high cationic exchange capacity is capable of keeping groundwater protected from harmful materials originating from the surface. Groundwater portability should be a problem in this area provided:

- The continuity of clay cover is not breached (natural or otherwise).
- The recharge area is not contaminated
- The river / surface water system which may have hydraulic link with the ground water.

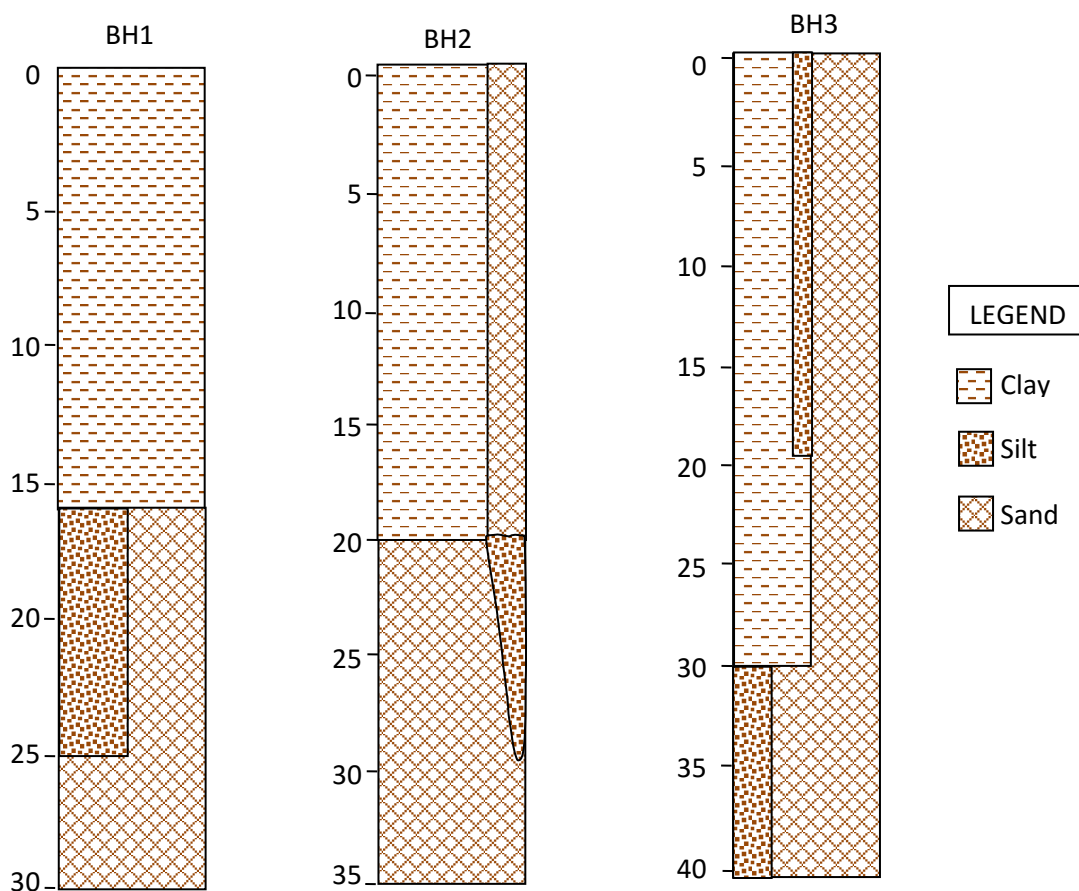


Fig. 4.10a: Lithologic matrix decomposition of BH samples Gbaran and environ.

Gbaran area with near surface clay layer (5-20ft) also presents a safe groundwater environment. The varying clay thickness may affect the quality of groundwater from one area to another. BH2 and BH3 locations with their clay layers have similarity with borehole 2 control which has slightly lower ground water table which is expected to be potable. Finally, the Gbaran, Zarama and Igbogene show concentration levels of metal. At Gbaran the concentration levels are observed to drop from a depth range of 20-25ft. This depth range correlates with the depth of (aquifer) occurrence with less consistency observed at Igbogene and Zarama. The significant level of concentration of the heavy metals in the clay section is due to the following:

- Natural filtering effect (high retaining capacity) characterized by the distribution of grain size.
- Natural background of high metal concentration compared to sand.
- Other physiochemical reaction especially cation exchange capacity for clay minerals.

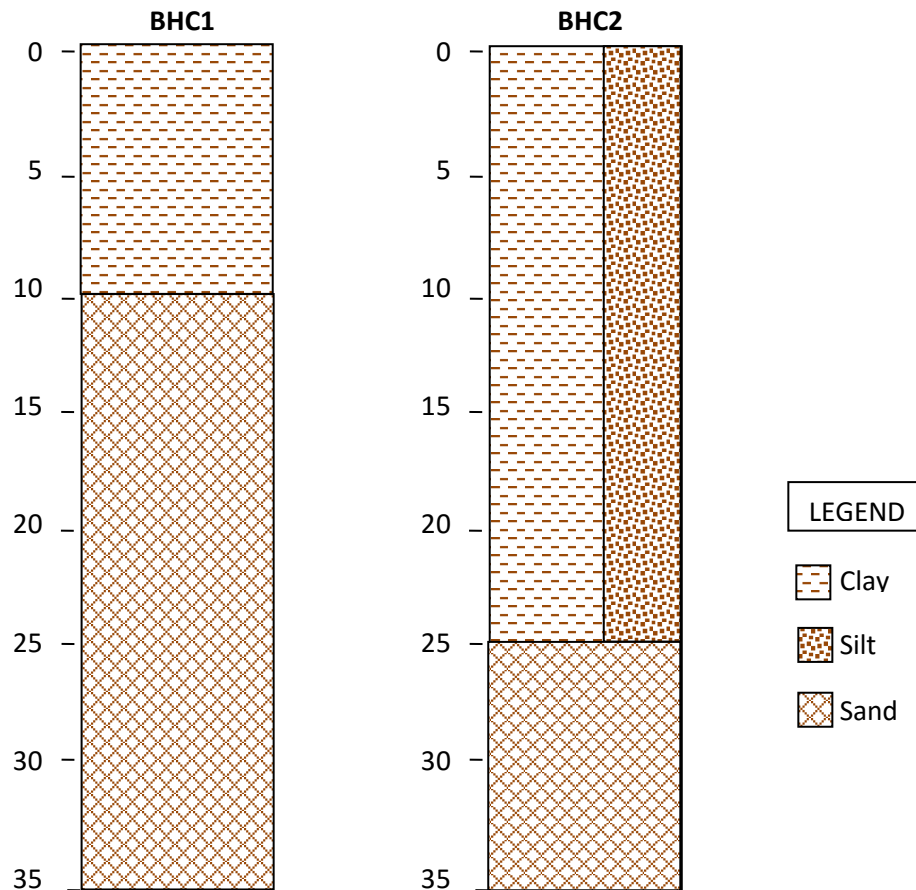


Fig. 4.10b: Lithologic matrix decomposition of BH Control samples Gbaran and environ.

4. 10.4 Groundwater Quality/Physiochemical Characteristics

The pH values of the ground water samples in the study area ranged from 5.7 – 7.0 with an average pH of 6.35 (Table 4.12). This shows that the groundwater of the study area is mostly slightly acidic as in most areas of the Niger Delta and fails to meet Nigerian Standard for drinking water quality minimum permissible limit of 6.5-8.5. The moderately high acidity of the groundwater in the region is attributed to emission and geology. The pH values of the groundwater is paramount because it regulates many chemical and biological processes that occur in the water and can be used as a proxy for water quality condition since it is easily changed by chemical contamination.

Electrical conductivity values for this study range from 47 μ S/cm to 393 μ S/cm. Furthermore, the values of Na⁺+K⁺ range from 2.44 mg/l to 7.586 mg/l. The values are similar to those obtained from control Boreholes. Chemical Oxygen Demand (COD) ranges from 6.14 mg/l to

10.67 mg/l while Turbidity value ranges from 1.44 mg/l to 116.00 mg/l. These elevated values for turbidity may be attributed to high Iron content of the host rock and influence of surface water bodies on the groundwater system of the study area. Turbidity is not an indicator for health risk. It could serve as habitat and a good source of food for the pathogens.

Trace metals can be toxic and even at relatively low concentration because of the tendency to accumulate in the body organism higher up the food chain and progressively accumulate metals. Humans at the uppermost part of the chain can experience severe health problems. Some studies have found positive correlations between the concentration of trace metals in water (for instance, lead, nickel, and iron) and the death rates for some cancers. The most common sources of contamination as documented by Forstner and Wittman (1981) include:

- Effluent from mining (oil mining)
- Industrial waste water
- Run-off from solid waste or waste water from urban and fossil fuel.

For this study, most of the metals analysed have occurred in concentration below threshold or regulatory limit. The concentration of Iron ranges from 0.500mg/l to 4.008 mg/l; zinc from 0.111 mg/l to 0.300mg/l and nickel from <0.002 to 0.0.645 mg/l; cadmium from <0.001 mg/l to 0.091 mg/l, while values of chromium, mercury and vanadium are <0.001 mg/l. The Nigerian Standard for drinking water quality maximum limits are 0.3 mg/l, 3.0 mg/l, 1.0 mg/l, 0.05 mg/l and 0.001 mg/l, 0.05 mg/l and 0.001 mg/l respectively. The values for iron are elevated in all the boreholes except BH2 which is situated in Zarama. The elevation is attributed to the presence of lateritic overburden in the area through which precipitation infiltrates to recharged groundwater.

Table 4.12: Groundwater quality in the study area

PARAMETERS	RESULTS				
	BH1	BH2	BH3	BHC1	BHC2
Physico-chemical					
pH	5.74	5.97	6.75	7.70	5.46
Temperature, °C	30.40	31.40	30.90	30.20	30.00
E/Conductivity, µS/cm	128.40	393.20	81.80	106.50	47.60
Total Dissolved Solid, mg/l	68.05	208.90	43.35	56.60	26.23
Turbidity, NTU	63.40	96.40	13.30	63.20	116.00
Colour (LCU)	25	50	50	50	50
Dissolved Oxygen, mg/l	4.20	4.00	5.10	3.60	3.20
Oxidation –Reduction Potential, ± mV	-108.20	-116.00	-121.60	-104.20	104.40
Depth, ft	15.2	14.8	16.3	18.7	15.9
Bicarbonate (Alkalinity), mg/l	10.20	10.40	33.93	46.60	10.20
Biochemical Oxygen Demand (BOD), mg/l	6.40	7.40	5.00	7.50	7.60
Chemical Oxygen Demand (COD), mg/l	8.45	9.20	6.99	10.67	9.60
Total Suspended Solids, mg/l	30.00	90.00	50.00	40.00	58.20
Salinity(as chloride), mg/l	17.73	24.82	10.64	14.18	10.64

PARAMETERS	RESULTS				
	BH1	BH2	BH3	BHC1	BHC2
Cations, mg/l					
Potassium(K ⁺)	4.68	3.43	2.32	1.98	1.51
Sodium (Na ⁺)	11.86	9.20	4.72	3.60	2.47
Calcium(Ca ²⁺)	15.07	19.11	4.77	9.47	9.47
Manganese (Mn ²⁺)	2.86	1.90	<0.01	1.33	1.35
Magnesium(Mg ²⁺)	4.55	4.27	1.47	2.18	1.07
Anions, mg/l					
Ammonium (NH ₄ ⁺)	0.27	<0.01	0.60	0.28	<0.01
Nitrate (NO ₃ ⁻)	2.00	4.66	0.99	0.04	1.27
Nitrite (NO ₂ ⁻)	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate (PO ₄ ³⁻)	0.01	0.02	0.02	0.06	0.04
Sulphate (SO ₄ ²⁻)	3.39	1.66	0.94	1.09	0.15
Silica (SiO ₂)	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphite (SO ₃ ²⁻)	0.28	0.11	0.05	0.08	0.02
Organics, mg/l					
Total Hydrocarbon Content	<0.01	<0.01	<0.01	<0.01	<0.01
Oil & Grease	<0.01	<0.01	<0.01	<0.01	<0.01
Polynuclear Aromatic Hydrocarbon, (PAH)	<0.01	<0.01	<0.01	<0.01	<0.01
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy metals, mg/l					
Total Iron (Fe ²⁺ & Fe ³⁺)	2.27	0.51	0.86	1.36	1.06
Cadmium (Cd ²⁺)	0.02	0.07	0.07	0.09	0.09
Chromium (Cr ³⁺ & Cr ⁶⁺)	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel (Ni ²⁺)	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium (V ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (Pb ²⁺)	<0.01	<0.01	<0.01	0.01	<0.01
Zinc (Zn ²⁺)	0.16	0.14	0.13	0.16	0.30
Mercury (Hg ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu ²⁺)	0.18	0.20	0.23	0.28	0.14
Microbiology					
Total Heterotrophic Bacteria x 10 ² cfu/ml	1.60	1.18	1.35	1.07	1.50
Total Fungi, x 10 ² cfu/ml	1.15	1.10	1.05	1.03	1.00
Hydrocarbon Utilizing Bacteria x 10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil
Hydrocarbon Utilizing Fungi x 10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil
Total Coliform Count (MPN/100ml)	15	11	15	9	11
Feecal Coliform (MPN/100ml)	4	2	4	Nil	Nil

4.11 SOIL

Presented in Table 1.0a and 1.0b are summary of physical, chemical, heavy metals and hydrocarbon analysis results obtained in the topsoil and bottom soil collected from Uzu Field Development Project area respectively. Detail analytical results are given in Appendix 6 and 7

respectively for wet and dry season, while a summary is presented in Tables 4.13 and 4.14 respectively for the top and sub soil.

4.11.1 General Physicochemical Parameters

Soil pH

Soil reaction expressed as pH value is a measure of the free hydrogen ion (H⁺) concentration of soil solution. The soil pH values of the project area varied from very strong acid to weakly acidic in both wet and dry season (Tables 4.13 and 4.14). The topsoil pH values ranged from 4.1 -6.0 (mean, 4.9) and from 4.4 - 5.6 (mean, 4.8) in the wet and dry season respectively. In the bottomsoil, the pH values varied from 4.2-6.5 (mean, 5.2) in the wet season and from 4.1 - 6.0 (mean, 4.9) for the dry season. A number of soil pH values fell within the recommended range for pH values (4.8-9.5) for normal plant growth reported by Udoh, 1986.

Soil Colour

The colour of the soil generally ranged from brown at the top (surface level (0-15cm)) to dark brown at the bottom (subsurface level (15-30cm)). The dark colouration may be as a result of higher humus content at the topsoil.

Table 4.13: Summary of top soils physical properties of the project area and the control stations

Physico-chemical Properties	Wet Season			Dry Season		
	Project Area		Control Area	Project Area		Control Area
	Range	Mean Value	Mean Value	Range	Mean	Mean
pH	4.1 - 6.0	4.9	5.4	4.4-5.6	4.8	5.60
Electr. Conductivity, $\mu\text{S}/\text{cm}$	38.90 -742.00	159.28	135.00	41.50-604.00	153.85	174.00
Oxidation –Reduction Potential, $\pm \text{mV}$	60.5 - 333	22.91	218.25	41.20-279.00	24.29	31.45
Available $\text{PO}_4\text{-P}$, mg/kg	3.80-27.08	14.90	7.385	2.76-45.59	16.12	14.06
Total Nitrogen , %	0.01 - 0.06	0.03	0.01	0.01-0.63	0.05	0.05
Bulk Density, g/cm^3	0.80-1.98	1.12	1.14	0.53-1.26	0.98	1.06
Porosity, %	36.6-84.00	64.56	56.5	42.00-82.00	67.74	63.00
Permeability, cm^3	0.08-0.40	0.29	0.34	0.13 - 0.45	0.33	0.28
CEC, meq/100g	7.27-66.45	26.31	19.94	5.97 -80.82	28.18	40.73
Anions, mg/kg						
Ammonium (NH_4),	15.83-66.60	42.17	8.485	13.47 -71.20	44.96	47.54
Nitrate (NO_3)	7.35-60.06	17.93	1.68	2.05 -30.18	16.30	7.31
Nitrite (NO_2)	<0.02 -0.14	0.09	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	0.24 - 3.07	1.31	1.335	0.13 -4.53	1.39	1.17
Sodium (Na)	0.45 -26.25	2.67	1.22	0.54 -25.96	4.46	12.35
Calcium (Ca)	0.36 -42.96	16.49	15.05	1.28 -53.93	19.74	25.10
Magnesium (Mg)	0.58 -2.46	1.97	2.025	0.83 -2.58	2.15	2.12

Source. SPDC (2017). Uzu FDP EIA Fieldwork Data gathering and Laboratory Analysis Results

Table 4.14: Summary of bottom soils physical properties of the project area and the control stations

Physico-chemical Properties	Wet Season			Dry Season		
	Project Area		Control Station	Project Area		Control Station
	Range	Mean Value	Mean Value	Range	Mean	Mean
pH	4.2-6.5	5.2	5.1	4.1 - 6.0	4.9	5.6
El/ Conductivity, $\mu\text{S/cm}$	30.00 - 214.96	84.81	160.00	38.90 -742.00	159.28	194.7
Oxidation –Reduction Potential, $\pm \text{mV}$	17.30 -390.10	218.84	193.85	60.50 – 333.00	22.91	18.75
Available $\text{PO}_4\text{-P}$, mg/kg	0.26 -12.23	3.95	12.60	3.80 - 27.08	14.90	11.64
Total Nitrogen , %	0.001 - 0.046	0.01	0.02	0.01 - 0.06	0.03	0.025
Bulk Density, g/cm^3	1.03 -1.36	1.20	1.20	0.80 -1.98	1.12	1.12
Porosity, %	32.0 - 86.0	64.35	49.00	36.6 - 84.00	64.56	47.5
Permeability, ml/s	0.06 - 0.37	0.30	0.30	0.08 - 0.40	0.29	0.3
CEC, meq/100g	3.30 -7.79	5.54	16.74	7.27- 66.45	26.31	31.37
Anions, mg/kg						
Ammonium (NH_4),	1.40 - 23.40	14.59	8.57	15.83 - 66.60	42.17	41.42
Nitrate (NO_3)	0.17 - 13.92	2.20	4.97	7.35 - 60.06	17.93	12.71
Nitrite (NO_2)	<0.02	<0.02	<0.02	<0.02 - 0.14	0.09	0.095
Cations, meq/100g						
Potassium (K)	0.29 - 3.19	1.66	1.83	0.24 - 3.07	1.31	1.095
Sodium (Na)	0.54 - 2.29	1.18	1.23	0.45 - 26.25	2.67	1.43
Calcium (Ca)	0.04 - 2.81	0.55	11.61	0.36 - 42.96	16.49	27.255
Magnesium (Mg)	1.03 - 2.40	1.98	2.08	0.58 - 2.46	1.97	2.20

Source: SPDC (2017). Uzu FDP EIA Fieldwork Data gathering and Laboratory Analysis Results

Soil Texture

The texture of a soil determines the water absorption/infiltration rate, and water holding capacity. According to Udo, 1986, the soil texture also dictates the amount of soil aeration, ease of tilling and soil fertility. Basically, soil textural classification is defined by the amount of sand, silt, and clay fractions present in the soil. The soil texture of the project area varied between sandy loam, sandy clay, loam and clay loamy.

Soil Porosity and Permeability

In the wet and dry seasons, porosity of the topsoil of the project area varied between 36.6 and 84.00% and from 42.0 to 82.00% but bottomsoil had range of 32.0 -86.0% and 36.6-84.0% in the wet and dry seasons respectively. Porosity of a soil is the volume of all the open spaces (pores) between the solid grains of soil. Porosity is important as it defines the volume of water that can be held in a given volume of the soil. Soil permeability is the property of the soil pore system that allows fluid to flow. The permeability test on the topsoil of the project area revealed a range 0.08 -0.40 cm³/s in the wet season and 0.13-0.45 cm³/s in the dry season while for the bottomsoil, a range of 0.06 - 0.37cm³/s was recorded in the wet season and 0.08 – 0.40 cm³/s recorded in the dry season. Compaction associated with the movement of machinery can lead to significant reductions in porosity with negative consequences on agricultural production (Garjic, et al., 2004). Heavy machineries are commonly used for clearing and grading operations in major projects in the project area. Also, exposure of soils leads to compaction and reduction in porosity.

Electrical Conductivity (EC)

In the wet and dry season, electrical conductivity values of the topsoil in the project area ranged from 38.90 -742.00 μS/cm and from 41.50 to 604.00 μS/cm respectively while bottomsoil recorded a range of 30.00-21.96 μS/cm in the wet season and 38.90 -333.00 μS/cm in the dry season. The conductivities observed in the soils are low and correspond to fairly non-saline soils. According to Baker and Gourley, 2011, normal salinity recommended for agricultural soils for optimal crop growth is 200 μS/cm. Depending on the sensitivity of the plant, salt injury symptoms may occur when EC exceeds 500 μS/cm. As shown in Figures 4.11 a & b, quite a number of the sample stations recorded conductivity values below 200 μS/cm except for about eight points, including control stations.

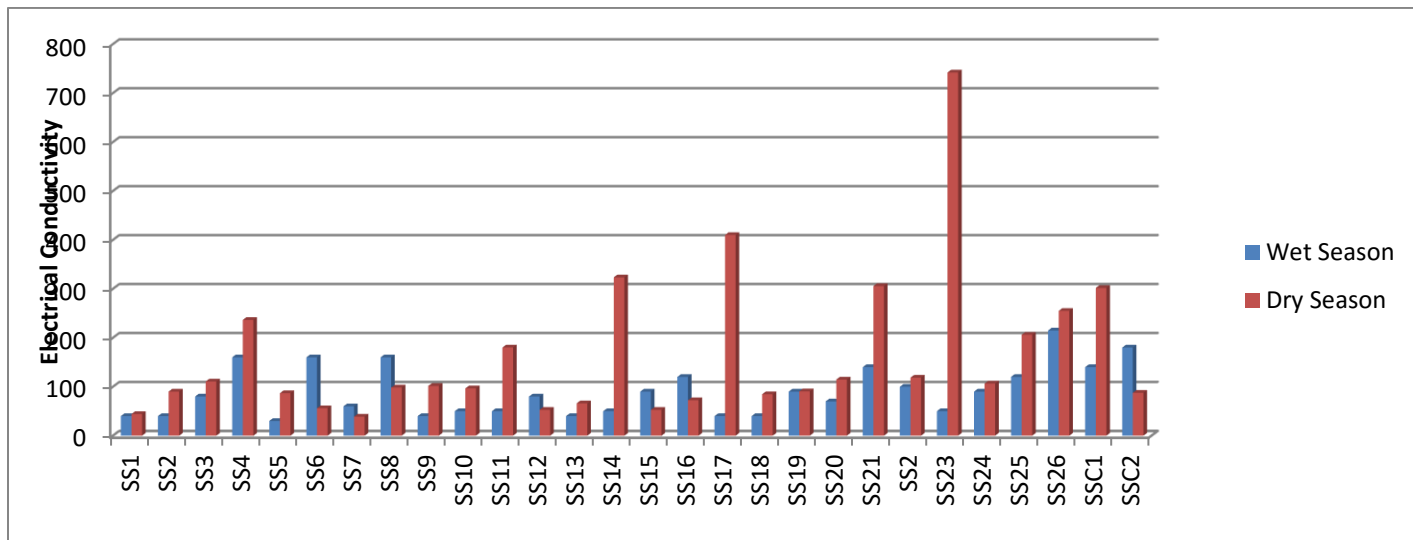


Figure 4.11: Spatial Distribution of Conductivities in Topsoil of the Study Area and Control Stations

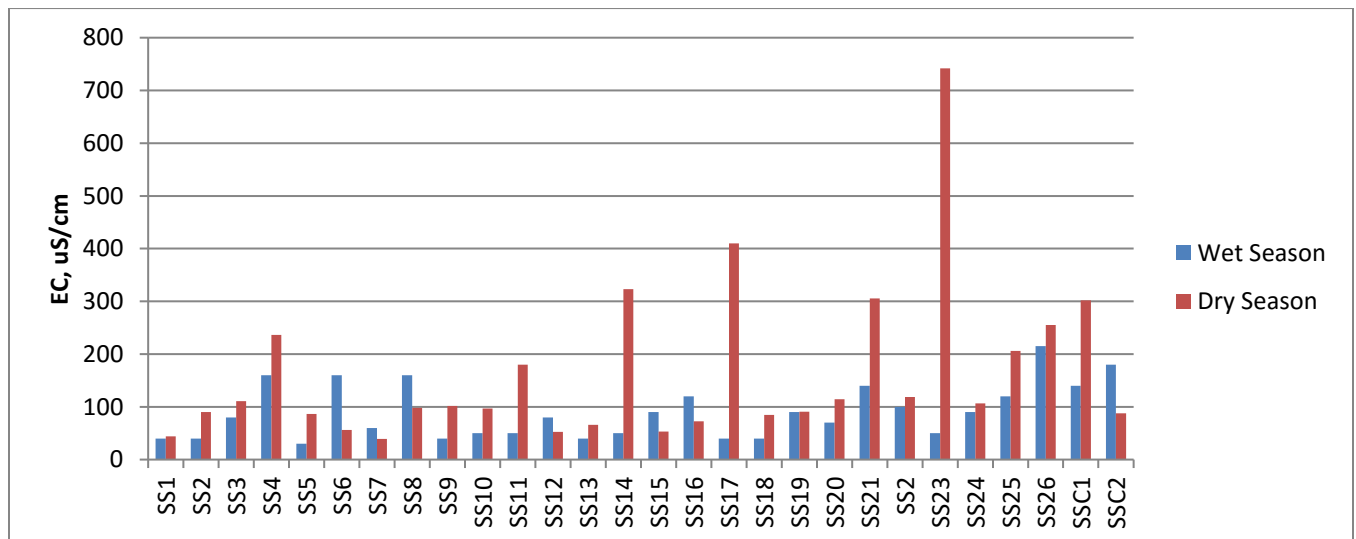


Figure 4.11b: Spatial Distribution of Conductivities in Topsoil of the Study Area and Control Stations

4.11.2 Nutrients

Total Nitrogen, Nitrate, Nitrite and phosphate

Of all other essential plant nutrients, Nitrogen is required in large quantity and is most frequently the limiting factor in crop productivity. The forms of nitrogen available for plant uptake are ammonium and nitrate. The topsoil mean concentrations of total nitrogen were 0.03% in the wet season and 0.05% in the dry season. Similarly, in the bottomsoil recorded mean values were 0.01% and 0.03% in the wet and dry seasons respectively. Measured total nitrogen levels of the soil in the project area and control stations were generally low (< 0.05%) according to Adebusuyi , 1985 (Refer to Table 4.15). In both wet and dry season, nitrate concentrations in the topsoil were

moderate with mean values of 17.93mg/kg and 16.30mg/kg respectively. Also, nitrate concentrations in the bottom soil ranged from 0.17 -13.92mg/kg (mean 2.20mg/kg) in the wet season and 7.35 -60.06mg/kg (mean, 17.93mg/kg) in the dry season. The nitrite content in the topsoil ranged from <0.02 to 0.14 mg/kg and <0.02meq/100g (i.e. below detection limit of the analytical instrument) in the wet and dry season respectively. A concentration range of <0.02 - 0.14meq/100g (mean, 0.09meq/100g) was recorded in the bottom soil during the dry season while nitrite was practically absent with concentration below the detection limit (<0.02meq/100g) of the analytical equipment in the wet season.

Available Phosphorus (P)

Phosphorus is an essential macro element required by plants for normal healthy growth. Phosphorus exists in three forms in the soil; solution phosphorus, active phosphorus, and fixed phosphorus. Plants take up phosphorus in the solution form. Available phosphate –phosphorus concentrations in the topsoil had a mean value of 14.90mg/kg and 16.12mg/kg in the wet and dry seasons respectively whereas bottomsoil had a mean concentration of 3.95mg/kg in the wet season and 14.90mg/kg in the dry season.

Exchangeable Bases and Cations Exchangeable Capacity (CEC) of the soil

As shown in rating scale for nutrient in soils (Table 4.15) the exchangeable Ca, Mg and K mean concentrations in both top and bottom soil could be classified as very high and this could be as a result of the fairly acidic value of the soil recorded in both wet and dry season. The cation exchange capacity of a soil is the capacity of the soil for ion exchange of cations between the soil and the soil solution. It is a measure of the fertility of the soil, nutrient retention capacity of the soil, and the potential of the soil for protecting the underlying aquifer from cation contamination. The cation exchangeable capacities (CEC) of the topsoil in the project area varied from 7.27 – 66.45meq/100g in the wet season and 5.97 -80.82 meq/100g in the dry season. Meanwhile, in the bottomsoil, CEC values ranged from 3.30 – 7.79meq/100g in the wet season and 7.27-66.45meq/100g in the dry season. Increase in CEC values recorded in both study area and the control sites confirm the significant leaching effect of soil acidity on soil nutrients (Ca, K, Na, and Mg) mostly occurring in the wet season than the dry season probably due to heavy rainfall of the region.

Table 4.15: Rating Scale for the nutrients in tropical region soil

Parameters	Very Low	Low	Moderate	High	Very High	Author
Soil pH	<4.0 - 5.0 (Strongly acid)	5.0 - 6.0 Moderately acidic)	6.0 - 6.9 (Slightly Acidic)	7.1 - 8.0 (Basic Slightly Alkaline)	8.0 - 9.0 Moderately Alkaline	
CEC,meq/100g	<4.0	4.0-8.0	8.0-16.0	16.0-24.0	> 24.00	Brady(1990)
TOC, %	<0.41	0.41 – 1.10	1.00 - 1.50	1.5 -3.0	> 2.00	FAO, 1979
Total Nitrogen, (%)	<0.05	0.15 – 0.30	0.15-0.20	0.25 -0.30	> 0.30	Aweto, 1981
Available Phosphate, mg/kg	<3.00	3.0 – 7.0	7.0-20.0	>200	-	Adebusuyi, 1985
Ca,meq/100g	<2.00	2.0 – 5.0	5.0 -10.00	10.0 – 20.00	> 20.00	Sobulo and Adepetu, 1987
Mg,meq/100g	<0.30	0.30-1.0	1.0 -3.0	3.0 -8.0	>8.00	Agboola and Ayodele, 1987
K, meq/100g	<0.20	0.20-0.30	0.3 -0.6	0.60-1.00	1.00 - 2.00	Adejuwon, 1974

4.11.3 Total Organic Carbon (TOC) and Hydrocarbons Content in Soil

Soil organic carbon consists of dead, decayed, and decomposing animals and plant remains and this serves as source of nutrients such as nitrate, phosphorus, sulphur and nutrients for soil microorganisms. The organic carbon of soil is an important element in maintaining physical conditions and significantly affects its productivity (Sposito, 1989). Total Organic Carbon levels in the topsoil varied from 0.08 – 1.84% (mean = 0.48%) and 0.04 - 2.98% (mean, 1.46%) in the wet and dry seasons respectively (Table 4.16a and 4.16b). Similarly, bottomsoil contained organic carbons in the concentrations range of 0.14 -1.04% and 0.06 - 2.69% in the wet and dry seasons respectively.

Total hydrocarbon content (THC) in the topsoils ranged from <0.02 – 1.82 mg/kg (wet season) while in the dry season it varied from 0.08 -3.20mg/kg but a concentration range of <0.10 – 0.19mg/kg was obtained in the wet season and 0.07-0.98mg/kg in the dry season for the bottomsoil. Hydrocarbons can be of petroleum or of recent biogenic origin. Natural plant and animal hydrocarbons are ubiquitous in the environment (Environment Canada, 1980). Obtained mean oil and grease contents in the topsoil were 0.52mg/kg and 0.51mg/kg in wet and dry seasons respectively while a mean value of 0.21mg/kg and 0.32mg/kg was recorded in the wet and dry seasons respectively in the bottomsoil. However, polynuclear aromatic hydrocarbon (PAHs) and BTEX levels were practically below the detection limits of the respective analytical equipment. Oil and grease values were generally lower during this study than was previously reported in the study area in 2003 (SPDC 2003)

Table 4.16a: Statistical summary of topsoil hydrocarbon concentrations of the study area

Physico-chemical Properties	Wet Season			Dry Season		
	Project Area		Control Station	Project Area		Control Station
	Range	Mean Value	Mean Value	Range	Mean	Mean
Percent Organic Carbon, %	0.08 - 1.84	0.48	0.20	0.04 - 2.98	1.46	0.33
Total Hydrocarbon Content, mg/kg	<0.02 - 1.82	0.35	2.41	0.08 - 3.20	1.70	0.32
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	
Oil & grease, mg/kg	0.17 -2.29	0.52	2.65	0.10 - 1.12	0.51	0.39
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Source: SPDC (2017). Uzu FDP EIA Fieldwork Data gathering and Laboratory Analysis Results

Table 4.16b: Statistical summary of topsoil hydrocarbon concentrations of the study area in the wet season

Physico-chemical Properties	Wet Season			Dry Season		
	Project Area		Control Station	Project Area		Control Station
	Range	Mean Value	Mean Value	Range	Mean	Mean
Percent Organic Carbon, %	0.14 - 1.04	0.44	0.355	0.06 -2.69	1.15	0.33
Total Hydrocarbon Content, mg/kg	<0.10 - 0.19	0.14	<0.02	0.07 -0.98	0.35	0.32
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	
Oil & grease, mg/kg	0.09 -0.41	0.21	<0.01	0.08 -0.85	0.36	0.39
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Source: SPDC (2017). Uzu FDP EIA Fieldwork Data gathering and Laboratory Analysis Results

4.11.4 Heavy Metals Levels in Soil

Presented in Tables 4.17a and 4.17b are the heavy metals concentrations in the top and bottomsoil of the project area. Iron levels in the topsoil were markedly high with a mean value of 2069mg/kg and 1966mg/kg in the wet and dry seasons respectively. In the bottom soil, Fe average levels were of mean value of 1931mg/kg in the wet season and 23.81mg/kg in dry season. These values were below the iron critical level of 15000mg/kg for plants' normal growth. The soils of the Niger Delta region have been reported to contain high concentrations of Iron (Adefemi, 2007).

Also, Manganese concentrations in the topsoil varied from 3.69 – 978.58mg/kg and 3.74 – 380.21mg/kg in the wet and dry season respectively while in the bottom soil, a concentration range of 17.10 - 982.10mg/kg was obtained in the wet season and 20.51 -323.55mg/kg was recorded for the dry season. Also, chromium contents of the topsoil ranged from 0.71-51.35mg/kg and 0.62 - 57.50mg/kg during the wet and dry seasons respectively. In the bottomsoil, Cr levels varied between 4.16-77.68mg/kg and 6.97 -105.45mg/kg for wet season and dry season respectively.

Table 4.17a: Summary of heavy metals concentrations (mg/kg, dried wt.) in topsoil of the project area and control stations

Parameter	Wet Season			Dry Season			Worldwide Median Values*	Upper continental Crust Mean Values **
	Project Area		Control Station	Project Area		Control Station		
	Range	Mean Value	Mean Value	Range	Mean	Mean		
Iron (Fe)	785.17 - 3197	2069	1838	25.35 - 2749	1966	2121	35000	30,900
Manganese, (Mn)	3.69 - 978.58	207.32	238.13	3.74 - 380.21	152.61	170.24	530.00	537.00
Cadmium (Cd)	0.52 -4.11	2.93	3.231	0.05 - 8.26	1.98	0.54	-	-
Chromium (Cr)	0.71 - 51.35	27.19	36.28	0.62- 57.5	30.37	27.99	-	-
Lead (Pb)	0.86 -19.05	6.12	10.00	2.68 - 48.13	30.60	22.12	17.00	14.80
Nickel (Ni)	1.24 - 44.09	27.13	10.69	7.40- 45.03	22.21	16.07	20.00	56.00
Vanadium (V)	<0.05	<0.05	<0.05	0.06 - 0.55	0.20	<0.05		
Zinc (Zn)	10.29 - 453.55	77.53	53.77	12.93 - 463.79	71.96	100.65	70.00	65.00
Copper (Cu)	0.193 - 42.84	15.02	22.04	1.43- 31.42	14.90	12.03	25.00	25.00

*Reimmann and De Caritat (1998); **Wedepohl (1995); Source. SPDC (2017). Uzu FDP EIA Fieldwork Data Gathering and Laboratory Analysis Results

Table 4.17b: Summary of heavy metals concentrations (mg/kg, dried wt.) in bottom soil of the project area and control stations

Parameter	Wet Season			Dry Season			Worldwide Median values*	Upper continental Crust Mean Values **
	Project Area		Control Station	Project Area		Control Station		
	Range	Mean Value	Mean Value	Range	Mean	Mean		
Iron (Fe)	1403 - 2146	1931	1503	1721 - 2900	2381	2209	35000	30,900
Manganese, (Mn)	17.10 - 982.10	213.37	207.89	20.51 - 323.55	146.66	151.50	530.00	537.00
Cadmium (Cd)	0.48 - 3.97	2.82	2.94	0.06 - 6.98	2.05	0.14	-	-
Chromium (Cr)	4.16 - 77.68	27.08	38.18	6.97 - 105.45	30.95	44.1	-	-
Lead (Pb)	0.29 - 13.69	5.99	16.94	4.27 - 44.53	33.05	23.50	17.00	14.80
Nickel (Ni)	0.99 - 47.01	25.58	17.14	7.17 - 45.38	20.68	14.87	20.00	56.00
Vanadium (V)	<0.05	<0.05	<0.05	0.16 - 0.42	0.29	<0.05		
Zinc (Zn)	20.04 - 223.78	54.78	98.35	8.77 - 406.71	49.03	134.7	70.00	65.00
Copper (Cu)	1.65 - 31.28	15.09	23.77	0.18 - 167.65	17.22	15.78	25.00	25.00

*Reimann and De Caritat (1998); **Wedepohl (1995); Source. SPDC (2017). Uzu FDP EIA Fieldwork Data gathering and Laboratory Analysis Results

Cadmium concentrations in the topsoil ranged from 0.52 - 4.11mg/kg and from 0.05 -8.26mg/kg during the wet and dry seasons respectively. Similarly in the bottomsoil, Cd levels varied between 0.48 -3.97mg/kg (mean = 2.82mg/kg) in the wet season, and 0.06 – 6.98mg/kg (mean = 2.05mg/kg) in the dry season at the bottomsoil level during the wet season (Table 4.0). The average values recorded during the wet season were higher than those recorded during the dry season.

Lead concentrations in the topsoil ranged from 0.86 - 19.05mg/kg and from 2.68 -48.13mg/kg in the wet and dry seasons respectively. Similarly, in the bottomsoil, Lead concentrations fluctuated from 0.29 - 13.69mg/kg, and from 4.27- 44.53 mg/kg in the wet and dry seasons respectively.

Nickel mean concentrations in the topsoil were 27.13mg/kg during the wet season and 22.21mg/kg in the dry season. In the bottomsoil, Ni mean contents were 25.58mg/kg and 20.68mg/kg in the dry and wet seasons respectively. Nickel mean concentrations of soil in the project area and the control station were below the critical levels of 50.00 mg/kg in the soil. In the topsoil, Zinc concentrations varied between 10.29 and 453.55mg/kg (mean, 53.77mg/kg) and from 12.93 - 463.79mg/kg (mean, 71.96mg/kg) in the wet and dry seasons respectively while in the bottom soil, Zn concentrations ranged from 20.04 - 223.78mg/kg and 8.77 - 406.71mg/kg in the wet and dry seasons respectively. All soil samples collected from the study area were generally below the critical limit of 250 mg/kg for Zn in soil.

Comparison of concentrations of metals in the soil collected from the study area with worldwide median values and upper continental crust mean values (Table 4.17 a & b) reveal that obtained Fe and Mn were within the global shale concentrations while quite a number of the samples had metals levels which exceeded the crust mean values. Vanadium was below the detection limit (<0.05mg/kg) of the analytical instrument and could therefore be described as practically absent in the soils of the project area.

4.12 Vegetation

The study area is located within the tropical humid broadleaved forests of the Niger Delta where the most important determinant of biological variation is its hydrology (Powell, 1995). This habitat enjoys an abundance of non-saline water supply resulting in more or less seasonal or perennial inundation. Vegetation within this type of ecosystem, consist of species with adaptation to unstable swampy terrain and prolonged anaerobic soil conditions. Although swamp vegetation also occurs in drier lowland rain forests, there, it occurs in small patches within the broader ecogregion: occurring mostly as high forest systems, near perennial water sources. But the predominance of this “hygrophilous evergreen forest” (Gbile et al., 1981) in the Delta region, influenced by the requisite natural ecological requirements, differentiates and defines its ecoregion as the Deltaic Fresh water swamp forest which can be described generally, as a vertically unstratified wooded wetland. The high groundwater table, low lying uneven terrain, the presence of only a very short dry spell of weather annually, and preponderance of thunderstorms and flash flooding, sustain the near all year-round abundance of soil water. In other to avoid the confusion that arises from the generic use of the word ‘fresh water swamp’ globally, it is standard practice to use descriptive epithets to differentiate the fresh water swamp ecosystem into natural units based on sub-generic structural peculiarities. In the EC – FAO funded Forest Resource Situation Assessment of Nigeria (Olufemi et al., 1999), subdivision is made of the broader Fresh Water Swamp Forest Ecosystem into “Forested (*woodland*) Fresh Water Swamp”, “Riparian Forest”, “Shrub/Sedge/Graminoid Fresh Water Marsh/Swamp”, and the “Graminoid/Sedge Fresh Water Marsh. Several other sub classes exist in literature.

The study area falls within the subdivision of the freshwater ecosystem described as the Flood Forest Zone (Figure 4.12). Two other sub habitats were identified within the considered influence zone of the proposed project (Figure 4.13). The Flood forest swamp component is observed to

make up about 70% of the vegetation cover: only about 15% of it is at regrowth stage due to agricultural activities; the remainder is more or less an agroecological flood forest system.

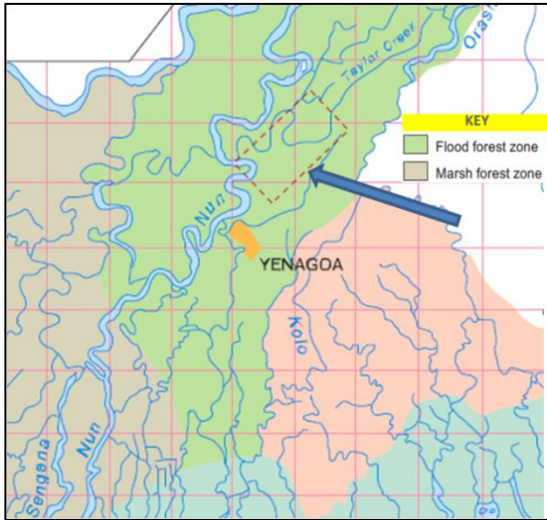


Figure 4.12: Situational map showing the ecological setting of the study area

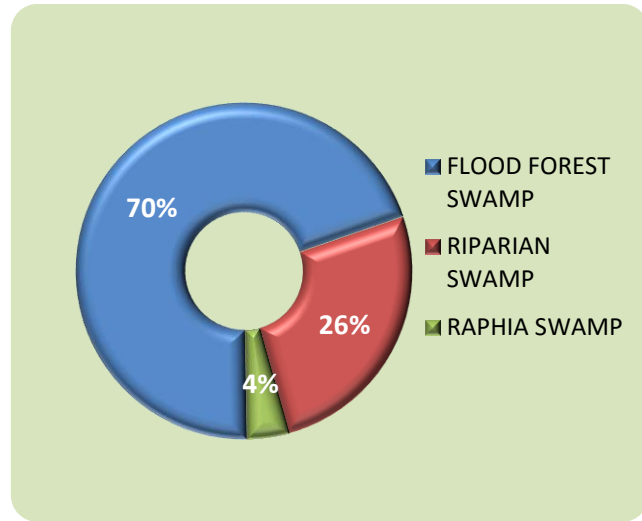


Figure 4.13: Vegetation cover composition

4.12.1 Vegetation Structure and Species Composition

The structure and floristic diversity of the entire vegetation cover is herein discussed under the four sub categories (the agricultural subset inclusive) in the following order:

1. Fresh Water Swamp forest (Niger Flood Forest Zone).
2. Riparian Swamp
3. Raffia Swamp Forest
4. Agricultural Farmlands and Home Gardens.

1. Fresh water swamp forest (Niger Flood Forest Zone):

It has been observed that in addition to precipitation, the major variation in the hydrological regime in parts of the Delta including the study area comes from the overflow of streams, rivers, and creeks during the Niger River flood season creating both spatial and seasonal variation in soil moisture conditions. This study area falls within this Niger Flood influence area and is supplied mostly by the Taylor creek, a tributary of the Nun River (an arm of the Niger River): both of which supply the area. The seasonal flooding leaves some areas very dry during the dry season, and mostly flooded swamp forest during the wet season. This type of swamp forest exhibits the characteristics of a transition belt between the drier lowland tropical rain forest, and the wetter Marsh swamp ecotype because of the extremes of moisture conditions that occur annually. The land is drier for longer time (particularly with increasing distance from the flood channels) than the typical freshwater swamp thus accommodating lowland rainforest species that can tolerate the flood season (and drier margins) as well as species of the fresh water swamp. This dynamics of surface water availability, abundance and distribution, consequently defines the overall structure

of this sub ecosystem of the deltaic freshwater swamp, supporting its own peculiar floral assemblage; this swamp forest ecotype has been previously described as the Niger Delta Flood Forest (Powell, 1995). This is the ecological zone within which the study area falls. Based on variation in hydrology, this habitat type is regarded as one of the three subdivisions of the deltaic fresh water swamp ecosystem (Roger, 2007). It is observed that the flood forest is fragmented by agricultural farmlands and only about 15% is uncultivated.

Vegetation Structure

Eight plant habit types were identified from the study area and they include Tree (36%), Tree Sapling (22%), Herbs (14%), Shrub (8.6%), and Liana (7%). Adapting Raunkiaer (1934) plant life form spectrum for the structural classification of vegetation cover and plant habitats, a total of 8 life form categories were identified (**Fig. 4.14**). The major life form categories identified in descending order are: Mesophanerophytes (29%), Nanophanerophytes (21%), Megaphanerophytes (19%), Microphanerophytes (10%), and Liana (7%). The dominance of the Mesophanerophytes, and large representation of Megaphanerophytes in the habitat is consistent with the Swamp forest woodland (flood forest) ecosystem; but the significant representation of Nanophanerophytic life form as well as Tree saplings and Herbs across the vegetation cover is indicative of a degraded flood forest vegetation ecosystem which is not mature; however based on the overall picture provided by the combination of species composition, habit, and life form structure, the forest can still attain its natural state of maturity, if left undisturbed. The vegetation cover is observed to be disturbed by anthropogenic activities; fragmented primarily by agricultural activities, and has a history of the harvest of timber resources for construction work or use as domestic fuel wood. Thus the vegetation is mostly open canopy forests with lone stands of emergent species towering above the *Elaeis guineensis* dominated canopy (**Plate 4.1**). The vegetation cover is generally stratified into two layers: the prominent lower layer (L1) with a mean height of 6 meters reaching 10 meters around SS 14, VG 5, SS 11, VG 1; and the upper oil palm dominated layer (L2) which ranges from 14 to 20 meters in height. An emergent layer of individual *Irvingia* trees is observed around SS 22, SS 11 and SS 9; which ranges from 25 meters to about 35 meters in height. Mature trees present consist mainly of protected economic non timber species, chiefly *Irvingia gabonensis*, *Elaeis guineensis*, and *Treculia africana* occurring sometimes gregariously. Vegetation ground cover varies from under 40% to about 70% while tree canopy cover is mostly under 40%.

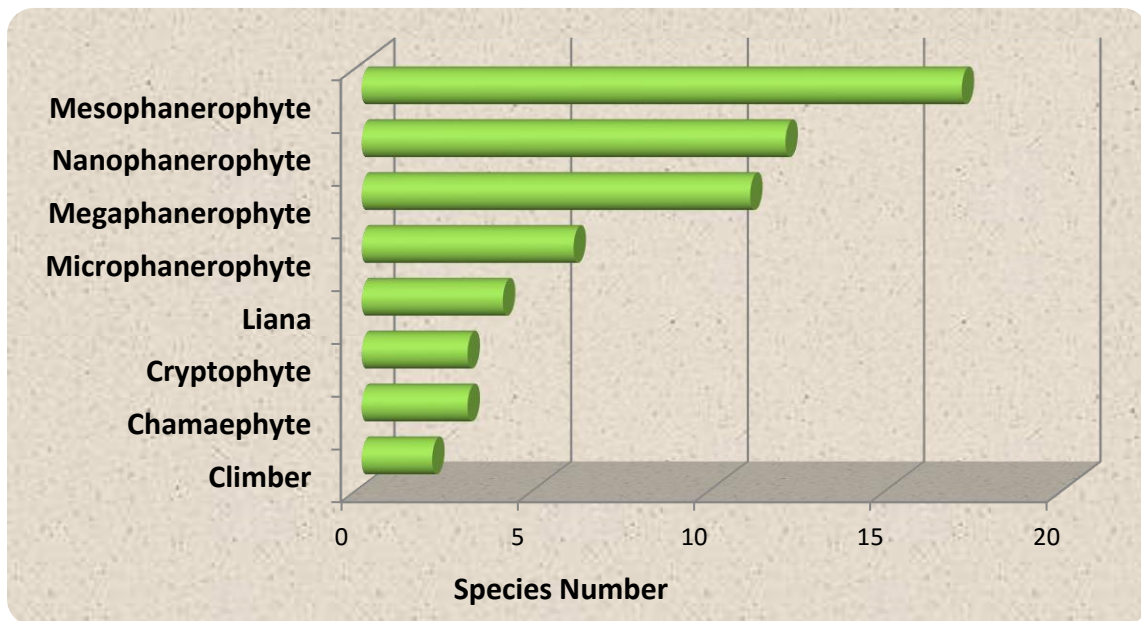


Figure 4.14: Life form spectrum of the Flood Forest

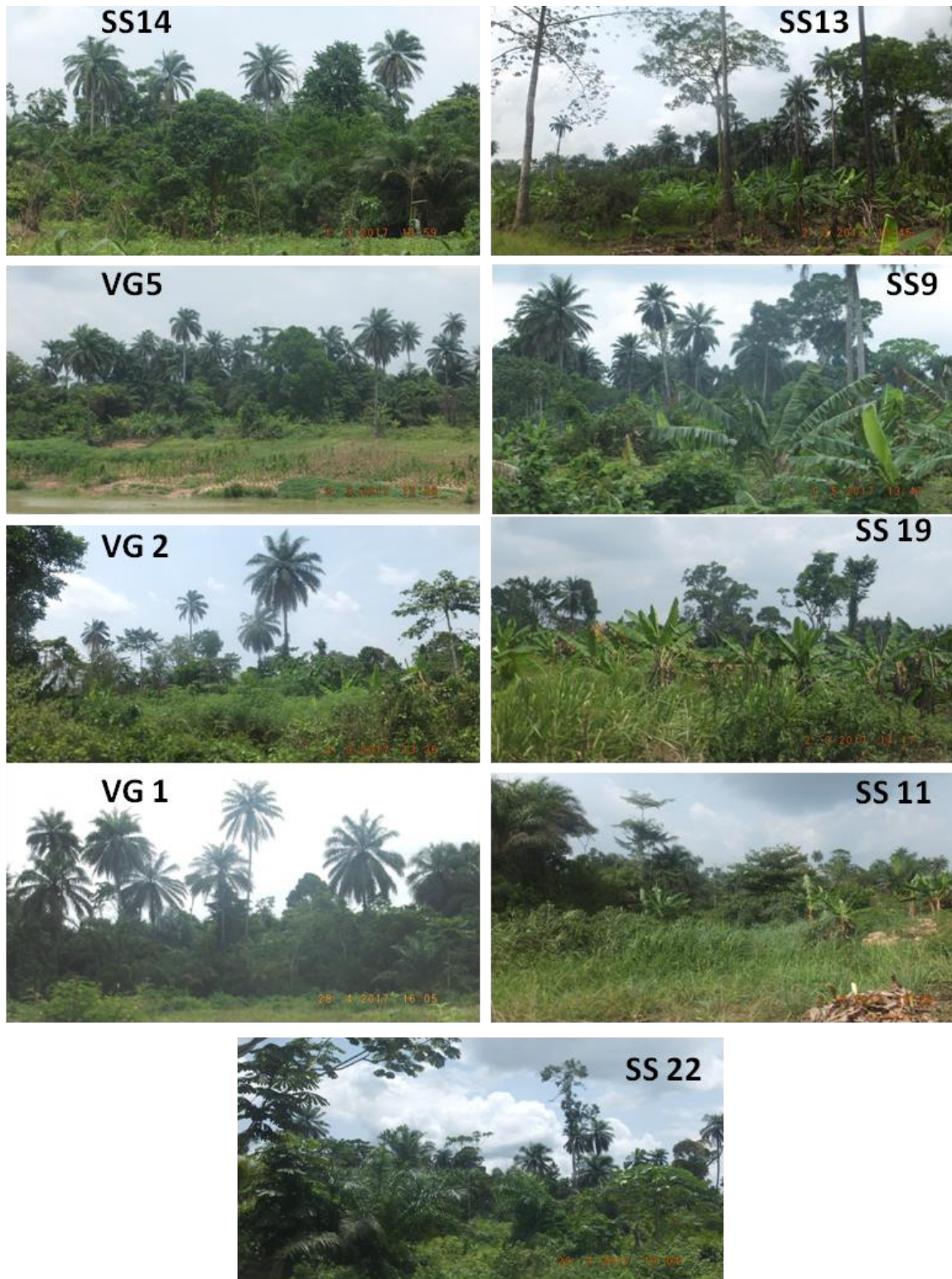


Plate 4.1: Vegetation cover profile of the flood forest

Species Composition

The Floristic composition is represented by 58 species in 35 plant families. The five biggest plant families in the study area, by species representation, in descending order are: MORACEAE (6) > PALMAE (4) > EUPHORBIACEAE (4) > RUBIACEAE, MALVACEAE (3). 22 families had only one species representation while 8 families had 2 species each. The dominant tree species of the study area are *Elaeis guineensis*, *Irvingia gabonensis*, and *Treculia africana*. The common species in the L1 stratum of tree saplings and shrubs include: *Elaeis guineensis*, *Musanga cecropioides*, *Cleistopholis patens*, *Pycnanthus angolensis*, *Alstonia boonei*, *Anthocleista nobilis*, *Anthocleista liebrechtsiana*, *Ficus exasperata*, *Bambusa vulgaris*, *Lophira alata*, *Fleroya ledermannii*, *Ricinodendron heudelotii*, *Spondianthus preusii*, *Vitex grandifolia*, and *Ceiba pentandra*. Dominant shrubs and herbaceous species are *Alchornea laxiflora*, *Costus afer*, *Chromolaena odorata*, *Aspilia africana*. Others include *Triumfetta cordifolia*, *Melanthera scandens*, *Thalia welwitschii*, *Dryopteris filix mas*. Climbers and Lianas are few and are represented by *Pueraria phaseoloides*, *Mucuna flagellipes*, *Dioscorea spp*, and *Tetracera potatoria*. The only Megaphanerophyte species emerging above the tree canopy is *Irvingia gabonensis*. An inventory of species identified within this study habitat is provided, along with the distribution and species classification in Appendix 8. The floristic composition across this ecological zone were in tandem with the baseline data (SPDC, 2003).

2. Riparian Swamp Forest:

Riparian Swamp is a subtype of the fresh water swamp ecosystem from which it is circumscribed; on the basis of vegetation structure and species composition. This kind of vegetation naturally occurs in areas saturated with water mostly permanently, such that it takes on the characteristics of a distinct ecosystem, becoming dominated by aquatic plants (Butler, 2010). As a wetter ecosystem, the riparian swamp habitat is particularly about the predominance of aquatic plants (chiefly grasses, shrubs, and trees with shrub-like habit) and not merely ‘flood tolerant species’ as occurs in the **generic** fresh water swamp high forest woodlands of the region; the term flood plain is sometimes used to further distinguish grass dominated riparian vegetation from this more or less shrub dominated variant. The Riparian swamp vegetation is mostly found in “... the immediate streamside area ... Including wetlands bordering streams and lakes” (Hewlett, 1982); is typically more homogenous in species composition, has distinctly low vegetation with much smaller trees and shrubs mostly less than 12 meters in average height. Vegetation is mostly closed canopy with Graminoid/Sedge Marsh occurring in open canopy areas. The vegetation is found within the study area around SS 10, 18, and 20.

Vegetation Structure and Species Composition

Terrain is usually flooded up to 2 meters during the wet season. According to the Raunkaier life form classification (1934), this habitat is observed to be Meso-phanerophytic. The vegetation cover is more or less stratified into two vertical layers (Plate 4.2). The lower layer is prominent, and dominated by *Pterocarpus santalinoides* having a shrubby habit and reaching a height of 10 meters in dense tangles around SS 12, 20 (in Zarama), SS 10 and less so at SS 18. *Alchornea laxiflora* and *Lonchocarpus sericeus* is common on the disturbed margins forming its own thicket (Near SS 9). The upper layer is more prominent around VG 24, 20, and stretches from 13 meters

up to a height of about 17 meters (VG 4); this layer is sparsely populated, dominated by *Treculiaafricana* which occur either gregariously up to 10 trees per acre (VG 4, 18), or as low as 4 trees per acre. The Oil palms are rare in this habitat. Open canopy areas punctuate the vegetation cover consisting of puddles or ponds populated by aquatic macrophytes dominated by *Sacciolepis africana* VG 18, or *Cyclosorus striatus* VG 4; similar vegetation is observed to occur along pipeline right of ways common in the area. The Riparian forest habitat structure at SS 12 is observed to be altered by the invasive rattan palm *Calamus deeratus*; virtually smothering the *Pterocarpus* forest. The floristic composition across this ecological zone were in tandem with the baseline data (SPDC, 2003).



Plate 4.2: Vegetation profile of the Riparian Swamp vegetation of the study area

3. Raffia Swamp Forest

The Raffia swamp forest is a type of fresh water swamp habitat that is circumscribed based on the species dominance pattern. This is a near homogenous population of *Raphia* species (Plate 4.3)

forming a vegetation community of its own and is common in fresh water swamp forests. It usually occurs fringing a river body, or an area under perennial flooding from a water source nearby. Species diversity is naturally very low here and in this case, the dominant species is *Raphia hookeri*. It occurs along the proposed pipeline RoW at Gbaran (SS15). The vegetation cover is over 80% with an average height of about 10 meters. *Treculia africana* is the only other tree species occurring in this habitat sometimes gregariously with up to 32 trees per acre, or virtually absent in parts of it. The *Treculia* canopy reaches 15 meters in height. A few shrubs present on the fringes of the habitat include *Alchornea laxiflora* and *Lonchocarpus sericeus* (Table 4.18). The floristic composition across this ecological zone were in tandem with the baseline data (SPDC, 2003).



Plate 4.3: Panoramic view of the Raffia Swamp Forest showing its vertical profile

Table 4.18: Checklist of Species of the Riparian Swamp Forest Habitat

Species	Common Name	Family	Habit	Life Form	R/Freq
<i>Treculia africana</i>	Bush Beans	Moraceae	Tree	MP	√√
<i>Pterocarpus santalinoides</i>		Fabaceae/Papilionoideae	Tree	mP	√√√
<i>Alchornea laxiflora</i>	Christmas bush	Euphorbiaceae	Shrub	mp	√
<i>Lonchocarpus sericeus</i>		Fabaceae/Papilionoideae	Tree	mP	√
<i>Sacciolepis africana</i>		Poaceae	Herb	np	√
<i>Dryopteris filix max</i>		Dryopteridaceae	Fern	np	√
<i>Cyclosorus striatus</i>		Thelypteridaceae	Fern	np	√
<i>Laccosperma secundiflorum</i>	Water Cane	Palmae	Liana	Liana	√
<i>Calamus deeratus</i>	Water Cane	Palmae	Liana	Liana	√√

KEY: Relative Frequency: √ = less than 25%; √√ = up to 50%; √√√ = Over 50%/Dominant/Cultivated.

np = Nanophanerophytes, **mp** = Microphanerophytes, **mP** = Mesophanerophytes, **MP** = Megaphanerophytes,

4. Agricultural Farmlands and Home Gardens

The vegetation cover of the study area is largely fragmented by agricultural activities. The forest physiognomy of the farmland and fallow areas is somewhat preserved due to the protection that the economic tree species of the wild enjoy. Cultivation of food crops is obviously the major

traditional occupation and appears to be very lucrative as they struggle to meet the increasing demand from the nearby state capital city; aggressive agriculture has left its mark on the vegetation cover (**Plate 4.4**). Agricultural activity is observed at most of the sample locations and is carried out underneath the forest cover in the drier flood forest habitat, and along the river bank. Within the forests, farm holdings are typically less than an acre size, shifting cultivation is the practice, and is non mechanised; follows the slash and burn system of land preparation with crude implements. Crops cultivated are mainly starchy staples including *root crops*: Cassava, Yams; *fruit*: Plantain; *Cereal*: Maize; and Melon (*Egusi*). Plantain, Cassava and yam are the dominant crops; the cultural practice is mostly mixed cropping with Plantain and Cassava; or Cassava and Maize; or Yam, Plantain and Maize simultaneously. Cocoyam and Melon is cultivated on a much lesser scale. River bank farming occurs along virtually the entire length of Taylor creek, and consists mostly of Yams, Cassava, and Potatoes cultivated in subsections of same plot (**Plate 4.5**). Generally, Yams and Cassava is cultivated mostly on small mounds of earth, planting of Yam, Cassava and Plantain is done with standard spacing. The floristic composition across this ecological zone were in tandem with the baseline data (SPDC, 2003).

Home gardens

This is very common throughout the study area and consists mostly of vegetables: including Bitter leaf, Pumpkin, Okro, and Sugar cane; fruit trees: including Breadfruit, Pawpaw, Native pear, Coconut, Avocado pear, Orange, Lime, Sour soup, Water apple. Spices: Pepper, lemon grass, and Sweet Basil leaves. At SS7 bitter leaf and White Yam is cultivated on a small commercial scale and a Cassava processing facility is sighted at SS7 as part of the cottage industry. Checklist of agricultural farmlands and home gardens is provided below (Table 4.19):

Table 4.19: Checklist of species of agricultural farmlands and home gardens

Category	Species Name	Family	Common Name	Major Class of Use
Farmlands	<i>Musa Paradisiaca</i>	Musaceae	Plantain	Staple; Edible fruit
	<i>Manihot esculenta</i>	Euphorbiaceae	Cassava	Staple; Edible root
	<i>Dioscorea alata</i>	Dioscoreaceae	Water Yam	Staple; Edible tuber
	<i>Dioscorea cayenensis</i> <i>subsp. Rotundata</i>	Dioscoreaceae	White Yam	Staple; Edible tuber
	<i>Zea mays</i>	Poaceae	Maize	Cereal
	<i>Colocasia esculenta</i>	Araceae	Cocoyam	Edible root
	<i>Citrullus colocynthis</i>	Cucurbitaceae	Egusi, Melon	Soup Staple; Edible seeds
Home Gardens	<i>Ipomoea batatas</i>	Convolvulaceae	Potatoes	Staple; Edible tuber
	<i>Vernonia amygdalina</i>	Asteraceae	Bitter leaf	Green leafy vegetable
	<i>Telfaria occidentale</i>	Cucurbitaceae	Pumpkin	Green leafy vegetable
	<i>Abelmoschus esculentus</i>	Malvoideae/Malvaceae	Okro	Vegetable
	<i>Saccharum officinarum</i>	Poaceae	Sugar cane	Edible stems
	<i>Artocarpus communis</i>	Moraceae	Breadfruit	Edible fruit

Category	Species Name	Family	Common Name	Major Class of Use
	<i>Carica papaya</i>	Caricaceae	Pawpaw	Edible fruit
	<i>Dacryodes edulis</i>	Burseraceae	Native pear	Edible fruit
	<i>Cocos nucifera</i>	Palmae	Coconut	Edible Fruit
	<i>Persea Americana</i>	Lauraceae	Avocado pear	Edible Fruit
	<i>Citrus sinensis</i>	Rutaceae	Sweet Orange	Edible Fruit
	<i>Citrus limon</i>	Rutaceae	Lime Orange	Edible Fruit
	<i>Annona muricata</i>	Annonaceae	Sour-sop	Edible Fruit
	<i>Syzygium samaragensis</i>	Myrtaceae	Water apple	Edible Fruit
	<i>Capsicum anuum</i>	Solanaceae	Fresh pepper	Vegetable
	<i>Ocimum gratissimum</i>	Labiatae	Sweet Basil	Medicinal herb / Spice
	<i>Cymbopogon citratus</i>	Poaceae	Lemon grass	Medicinal herb / Spice



Plate 4.4: Agricultural farmlands in the study area



Plate 4.5: A panoramic view of the River Bank Farms and Home Gardens

4.12.2 Forest Resources and Ecosystem Services

It is pertinent to state that this assessment is without prejudice to possible forest resources that may exist in areas considered to be part of the communities by the indigenes, but are outside the project foot print and the considered possible impact area. This should therefore not be misconstrued to be an underestimation of the forest resources and potentials of the peoples and their entire environment. The forests within the considered influence zone of the project provide key resources that sustain the cottage industries in the study area and provides livelihood for the people. A number of Non timber forest resources that were observed, occur in commercial quantities in the area and they include *Treculia africana* locally called Bush beans or *Oyein* in the local dialect. The fruits are collected by the male folk, left to ferment, processed by the women and children (Plate 4.6A, B, D). The seeds are cooked and eaten just like beans is locally. It can also be roasted and eaten as groundnut; especially by non indigenes who visit the area to purchase the seeds in commercial quantity. Sustainable supply of the fruits of *Irvingia gabonensis* and Oil palm is ensured by the protected status that these trees enjoy. The fruits of Oil Palm sustains its own industry, as harvested bunches(Plate 4.6C) are processed and oil expressed out of them using a combination of crude processes and locally fabricated equipment, to produce the Palm Oil that is highly sought after locally and regionally. Small Palm oil mills were observed to be present within the forests (Plate 4.6E); though some locals complain that this traditional occupation is under threat as it is increasingly being abandoned for ‘more lucrative’ white collar crude oil related jobs. The seeds of *Irvingia* (*Okpukpa* = Ijaw; *Ogbono* = trade name) is obtained and used as a staple soup thickener, a delicacy locally and regionally (Plate 4.6F). The leaves of *Thalia welwitschii* is harvested and used in wrapping condiments and food traditionally (Plate 4.6I). Rattan appears to be underutilized in the area (Plate 4.6H). The limited availability of timber sized tree species has reduced the potentials of lumbering and timber forest resources, however, saw mills exist where wood from the forest hinterlands is processed into wood products for construction and domestic use. The Sap of *Raphia* is readily tapped from the *Raphia* trees (Plate 4.7) by the locals and sold as wine; or brewed into local gin that is not only sold commercially but used in the preparation of most traditional medicines. The floristic composition across this ecological zone were in tandem with the baseline data (SPDC, 2003).

Table 4.20a: Provisioning Ecosystem Services offered by plants in the project area

SPECIES NAME	LOCAL / COMMON NAME	Provisioning services
<i>Albizia spp</i>	Albizia	Timber / domestic fuel wood
<i>Alchornea spp</i>	Christmas Bush	Medicinal
<i>Alstonia boonei</i>	Stool wood/Alstonia	Timber: Soft wood:
<i>Anthocleista spp</i>		Roots Medicinal: Antihypertensive, Cure erectile dysfunction, Antidiabetic
<i>Bambusa vulgaris</i>	Bamboo	Construction
<i>Calamus deeratus</i>	Water Cane; Rattan	Cane furniture, and domestic handicraft
<i>Ceiba pentandra</i>	Silk Cotton	Timber: Soft wood: Carvings, light construction, ply wood, veneer, particle boards, hand dug canoe

SPECIES NAME	LOCAL / COMMON NAME	Provisioning services
<i>Chromolaena odorata</i>	Awolowo, Shell company	Wound healing, Antimalarial
<i>Chrysophyllum giganteum</i>	Ochi = Ekpeye	Timber: Hand dug canoe, Paddle, Construction of Oil Milling canoe
<i>Cleistopholis patens</i>		Timber: Light wood
<i>Cnestis ferruginea</i>		Medicinal
<i>Cola gigantean</i>	Monkey kola	Edible fruit
<i>Cola nitida</i>	Kola nut	Stimulant, traditional/cultural/religious ceremonies
<i>Costus afer</i>	Monkey Sugar Cane	Antidehydrant, forest snack.
<i>Cylicodiscus gabunensis</i>		Timber: Hard wood; twigs for Fuel wood
<i>Elaeis guineensis</i>	Oil Palm	Fruit: Palm Oil; leaf for thatch/ broom making; sap wine, brew local gin
<i>Zanthoxylum lemairei</i>		Timber: Furniture
<i>Ficus exasperata</i>	Sand paper tree	Leaf: Medicinal, Abrasive
<i>Fleroya ledermannii</i>	Abura	Timber Commercial: Soft wood, light furniture
<i>Garcinia kola</i>	Bitter cola	Medicinal nuts, stimulant
<i>Hevea brasiliensis</i>	Rubber	Latex sap; Timber; Construction reinforcement
<i>Irvingia gabonensis var. Excelsa</i>	Ogbono	Seeds used for staple soup base
<i>Irvingia gabonensis var. Gabonensis</i>	Bush Mango; Ogbono	Edible fruit
<i>Klainedoxa gabonensis var. Oblongifolia</i>		Timber: Heavy Hard Wood
<i>Laccosperma secundiflorum</i>	Water Cane; Rattan	Domestic handicraft: Cane Chair, baskets, etc
<i>Leucaena leucocephala</i>	Owolowa= Ekpeye	Yam stake
<i>Lonchocarpus sericeus</i>		Timber: Hard wood; durable under water
<i>Lophira alata</i>	Adikolo = Ekpeye; Iron wood; Ekki	Hard Heavy wood: Hand dug Canoe, and paddle; Favourite for hand dug Oil milling Canoe; durable under water
<i>Lovoa trichilioides</i>	African walnut	Timber: Commercial
<i>Mangifera indica</i>	Mango	Bark Medicinal; Fruit Edible
<i>Milicia excels</i>	Diork = Ekpeye; Iroko;	Boundary Marker; Timber Commercial Hard wood
<i>Nauclea diderrichii</i>		Commercial Timber; Durable hard wood
<i>Newbouldia laevis</i>		Medicinal
<i>Oldfieldia africana</i>	African Oak	Timber: Commercial hard wood
<i>Pentaclethra macrophylla</i>	Ugba	Soup Condiment
<i>Pentadesma butyracea</i>		Timber: Hard wood, Rough construction

SPECIES NAME	LOCAL / COMMON NAME	Provisioning services
<i>Piptadeniastrum africanum</i>		Timber: Heavy Hard Wood
<i>Psyrax subcordatum</i>		Paddle construction, Poles; Fuel wood
<i>Pterocarpus santalinoides</i>		Roasted seeds edible; young leaves vegetable
<i>Pycnanthus angolensis</i>		Timber: Light wood, Ply board , Cabinet work
<i>Rauvolfia vomitoria</i>		Medicinal
<i>Spondianthus preussii</i>		Timber: Commercial Hard Heavy wood
<i>Spondias mombin</i>		Edible fruits
<i>Symphonia globulifera</i>		Timber: Construction
<i>Trichoscypha arborea</i>		Fuel wood, and poles
<i>Uapaca guineensis</i>		Timber: Commercial Hard Wood durable
<i>Vitex grandifolia</i>		Timber: Light Construction, Veneer

Table 4.20b Regulatory services offered by some plant species in the study area

Regulatory Services	Species
Carbon sequestration and storage	<i>Dioscorea cayensis</i> <i>Treulia africana</i> <i>Pterocarpus santalinoides</i>
Local climate regulation (air quality)	<i>Colocasta esculenta</i> <i>Alchomea laxiflora</i> <i>Lonchocarpus sericeus</i>
Regulation of water flow	<i>Raphia holkeri</i> <i>Lonchocarpus sericeus</i> <i>Laccosperma secundiflorum</i>
Erosion prevention and maintenance of soil fertility	<i>Calamus deeratus</i> <i>Sacciolepis africana</i>
Moderation of extreme events such as storm and shorelines	<i>Pycnanthus angolensis</i> <i>Raphia</i>

Table 4.20c Supporting services offered by some plant species in the study area

Supportive Services	Species
Nutrient Cycling	<i>Thalia welwitschii</i> <i>Chromolaena odorata</i>

	<i>Alchornea laxifora</i>
Habitat Mediation	<i>Calamus deeratus</i> <i>Treculia africana</i> <i>Raphia hookeri</i>

4.12.3 Plant Pathology

The vegetation of the study area is observed to be luxuriant and free of disease epidemics. The crops on the farmlands were healthy with the exception of cassava leaf mosaic which was encountered on some farms. This disease is caused by the African Cassava Mosaic Virus of the genus *Begomovirus*. Minor incidences of the fungal brown leaf spot disease (caused by *Cercosporidium* sp) was observed on other cassava farms and on *Alchornea* spp

4.12.4 Phytochemistry

Plant leaf tissue samples from the sample points were screened to determine the baseline levels of key chemical elements and organic compounds falling into four categories: Nutrient elements, Hydrocarbon compounds, potentially toxic trace heavy metals, and Non-essential heavy metals. The detailed results are provided in Appendix 8 while the summary is presented in Table 4.20. The results showed seasonal variation in concentration levels such that the dry season tissue concentrations were generally lower than in wet season whereas the reverse should have been the case. It is arguable however, that the flood regime may be a significant contributor to heavy metal concentrations in the habitat; particularly aiding the spread of such contaminants from the huge dumpsites around the Etelebou axis. In the Wet season tissues, Zinc levels, were observed to be within toxic concentration range for plant tissue (100 – 400 mg/kg; Fifield and Haines, 2000) in all the samples excluding the sample from VGC 2 sample station. Mean Copper levels were at the threshold of toxicity for both seasons (above 20mg/kg). Copper and Manganese are present at toxic concentrations at VG 5 in wet and dry season samples respectively. Toxic concentrations were observed in samples from VG C2 for Nickel and Chromium in dry and wet season tissue samples respectively. Manganese and Chromium were at toxic levels in VG 2 wet season samples. VG 5 and C2 sample points were observed to be located at high anthropogenic impact zones within residential areas. Toxic heavy metals and hydrocarbon compounds were not present within equipment detectable limits for dry season samples, while Chromium, Cadmium and Lead were present at elevated levels in wet season samples. The samples did not indicate nutrient deficiency for the nutrient elements sampled.



Plate 4.6: Ethnobotanical resources of the study area

Table 4.21: Summary of result of photochemical screening of plant tissue

PARAMETERS (Mg/kg)	WET SEASON	DRY SEASON
Micronutrients / Trace Heavy Metals		
Iron (Fe)	253.31 (121.96 – 452.19)	187.80 (135.99 – 300.18)
Manganese, (Mn)	205.85 (44.37 – 447.80)	126.84 (11.08 – 396.34)
Nickel (Ni)	53.89 (40.49 – 65.43)	30.55 6.98 – 148.78
Zinc (Zn)	217.65 30.34 – 282.36	29.90 13.37 – 53.80
Copper (Cu)	21.31 15.63 – 40.88	13.64 8.36 – 19.88
Non Essential Heavy Metals		
Chromium (Cr)	9.28 1.639 – 19.877	<0.001
Cadmium (Cd)	2.496 1.809 – 3.069	<0.005
Lead (Pb)	29.357 22.52 – 35.175	<0.002
Vanadium (V)	<0.001	<0.001
Hydrocarbon Compounds		
Total Petroleum Hydrocarbon	<0.031	<0.031
PAHs	<0.05	<0.05
Nutrient Elements		
Potassium (K)	2696.29 (1958 – 3627)	2164.86 (2086 – 2199)
Sodium (Na)	267.57 (117.80 – 355.87)	369.09 (306.28 – 573.63)
Calcium (Ca)	5189.29 (3462 – 6329)	3971.57 (1429 – 6339)
Magnesium (Mg)	258.62 (207.20 – 282.54)	238.82 (215.36 – 251.09)



Plate 4.7 showing the collection of *Raphia* wine sap by a palm wine tapper.

4.13 Wildlife

4.13.1 Wildlife Composition and Biodiversity

Information from native hunters and observations of key indicators of animal presence show that the project area harbours at least 40 Species of animals belonging in 30 Families; cutting across 3 classes of the Phylum Chordata (including Mammalia, Reptilia and Aves), and a single representative of the Phylum Mollusca (Gastropoda). The most diverse category of wildlife identified in the study area is the Aves with species from 10 different orders. The diversity by species number among the identified Cordates, in decreasing order is: Mammalia (15 species) > Aves (14 species) > Reptilia (13 species). It is observed that the Rodents and Bovidae make up a large part of the species 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 the birds sightings were very common and easily documented in pictures (**Plate 4.8**) while the sighting of *Varanus* sp by members of the crew at SWSD2 bank of the Nun River, did not give room for pictorial documentation. The activity of Porcupines and Grasscutters was observed around SS 16 on a cassava farm where they damaged cassava stems. Very common birds in the area include the yellow billed kites and the Great Blue Turaco. Within the study area a very localised population of the white headed vulture is resident at SS 1 and the refuse sites in that area; similarly a flock of white-faced whistling duck (about ten birds is sighted near SS 12. It is reported that there are crocodiles particularly the dwarf crocodile in the Etelebou area, and elsewhere, around the inland water bodies in the Riparian forests. The giant African snails are abundant in the Flood forests and are commonly hunted.

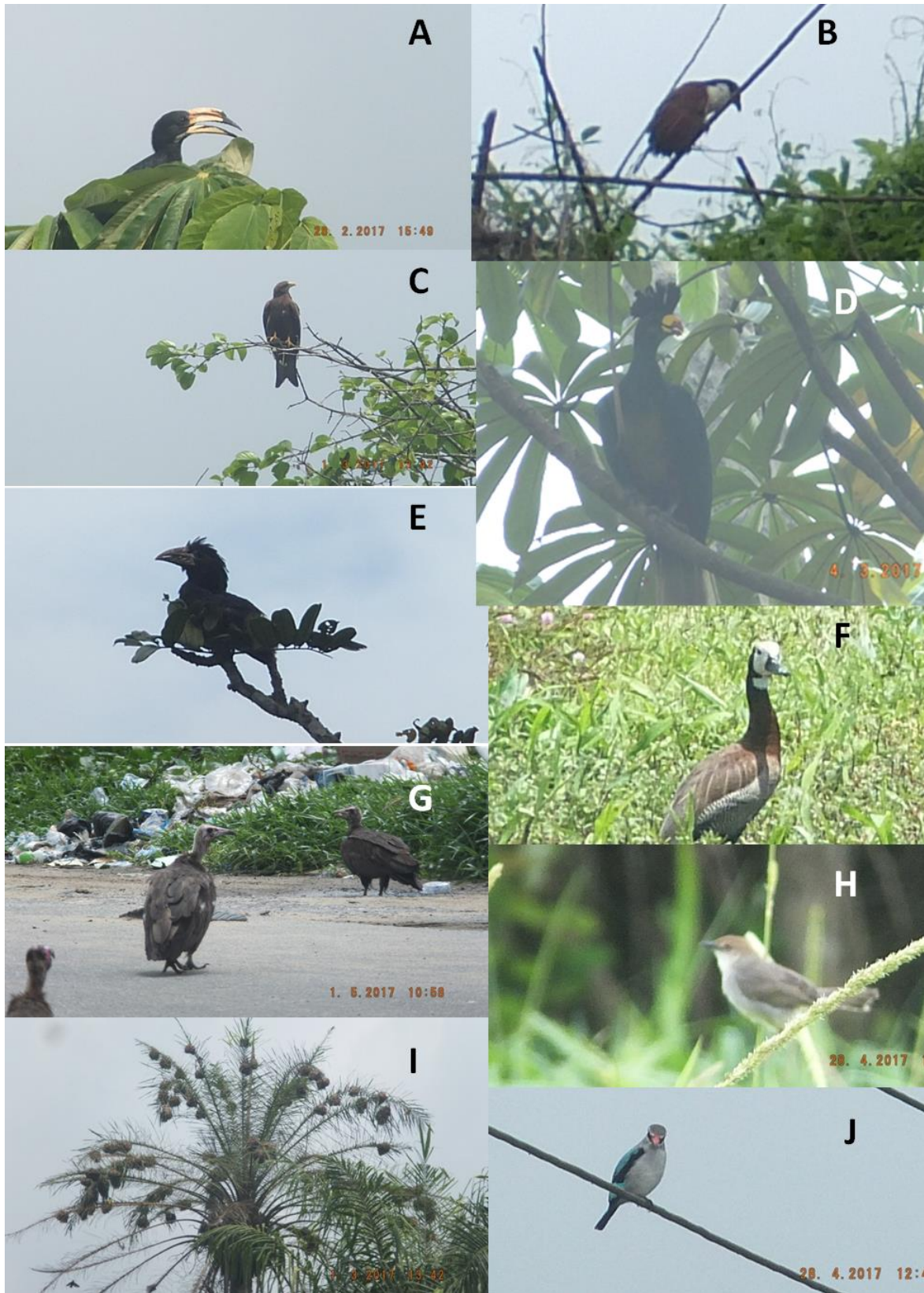


Plate 4.8: Birds of the study area

4.13.2 Conservation Status

The Nigerian National biodiversity report (2010) on the conservation status of wild life species in Nigeria categorises 6 of the identified species as Nationally Endangered, 2 Threatened and 2 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 are locally threatened, while the Rock Python is 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. A few of these species become locally common during the flood season. While the species that are herein classified as 'common' in the study area are among the animals easily killed every other week during hunting; while the 'Very common' = weekly catch; and the 'Abundant' = Daily catch. 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 here. Conservation status of these species is assessed using the IUCN, Decree 11, and Nigerian Biodiversity Report (2010). Decree 11 is a legislation enacted on 20th April 1985, entitled the "Endangered Species Decree" (Control of international Trade and Traffic). It prescribes two levels of controls in the conservation of wild life, particularly endangered species. The first Schedule lists wildlife for which capture and or killing is absolutely prohibited while the second schedule lists species that require 'License' or 'Permit' before capture or trade.

4.13.3 Conservation Challenges

The increase in the rate of abandonment of traditional occupations like hunting and increased literacy levels has led to a decline in the local awareness of wildlife species and even their local names; descriptive epithets are given which are often too generic. Ambiguous claims include the presence of gorillas in the area, and white eagles which are hunted with frog baits; both species are suspected to be the Red capped Mangabey, and a Pelican (probably the Great white pelican *Pelecanus onocrotalus*) More challenging however is the situation where the locals view every interview session as an opportunity to say that their land has been eroded of all its wildlife species by oil exploratory activities to the extent that many locals claim that there are no animals in their forests anymore contrary to opinions from a few disabused minds. **Table 4.22 (a-c)** provides the check list of wildlife and their taxonomic treatments as well as conservation status of the species.

Table 4.22: Check list of animals in the study area.

Class	Order	Family	Common names	Scientific names	Abundance status	Conservation status
Mammalia	Primates	Lorisidae (potto)	Potto	<i>Perodicticus potto</i>	Rare	Endangered
			Angwantibo	<i>Arctocebus calabarensis</i>	Common	Least Concern
		Galagidae (bushbabies)	Dwarf Galago	<i>Galagoides demidovii</i>	Rare	Endangered
		Cercopithecidae (monkeys)	Mona monkey	<i>Cercopithecus mona</i>	Rare	Threatened
			Sclater's Monkey	<i>Cercopithecus sclateri</i>	Rare	Vulnerable
			Olive Colobus	<i>Procolobus verus</i>	Common within its range	Near Threatened
	Pholidota (Pangolins)	Manidae	Tree Pangolin	<i>Manis tricuspis</i>	Rare	Endangered
	Insectivora	Erinaceidae	Hedgehog	<i>Erinaceus albiventris</i>	Common	Vulnerable
		Soricidae (Shrews)	Forest Shrew	<i>Crocidura odorata</i>	Common	Not Threatened
	Rodentia (rodents)	Anomaluridae	Beecroft's Flying-squirrel	<i>Anomalurus beecrofti</i>	Rare	Endangered
		Hystriidae	Brush-tailed Porcupine	<i>Atherurus africanus</i>	Abundant	Endangered
		Cricetidae	Emin's Giant-rat	<i>Cricetomys emini</i>	Abundant	Vulnerable
			Gambian Giant Rat	<i>Cricetomys gambianus</i>	Abundant	Vulnerable
		Thryonomidae	Greater Cane Rat	<i>Thryonomys swinderianus</i>	Abundant	Vulnerable
		Sciuridae	Giant Forest Tree-squirrel	<i>Protexerus stranger</i>	Rare	Threatened
			Red-legged Sun-squirrel	<i>Heliosciurus rufobrachium</i>	Rare	Threatened
		Muridae	Black Rat	<i>Rattus rattus</i>	Abundant	Not Threatened
			Multimammate Mouse	<i>Mastomys natalensis</i>	Common	Not Threatened
			Pygmy Mouse	<i>Mus minutoides</i>	Common	Not Threatened

Class	Order	Family	Common names	Scientific names	Abundance status	Conservation status
			Three-striped Mouse	<i>Hbyomys trivirgatus</i>	Common	Not Threatened
	Carnivora (Carnivores)	Viverridae (civet, genets & mongoose)	African Civet	<i>Viverra civetta</i>	Rare	Threatened
		Nandiniidae	Two-spot Palm Civet	<i>Nandinia binotata</i>	Common	Endangered
			Forest Genet	<i>Genetta poensis</i>	Rare	Threatened
		Herpestidae	Marsh Mongoose	<i>Atilax palidinosus</i>	Rare	Threatened
			Egyptian Mongoose	<i>Herpestes ichneumon</i>	Rare	Threatened
	Artiodactyla	Suidae (pigs)	Red River-hog	<i>Potamochoerus porcus</i>	Rare	Threatened
		Bovidae (Antelopes)	Bushbuck	<i>Tragelaphus scriptus</i>	Common	Threatened
			Sitatunga	<i>Tragelaphus spekii</i>	Rare	Threatened
			Maxwell's Duiker	<i>Cephalophus maxwelli</i>	common	Threatened
	Cetartiodactyla	Suidae	Bushpig	<i>Potamochoerus larvatus</i>	Rare	Threatened
	Sirenia	Trichechidae	African Manatee	<i>Trichechus senegalensis</i>	Uncertain	Vulnerable

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.

NBR (2010): * Endangered; ** Threatened; *** Rare / Terminated **UM**

Table 4.23a: Check list of animals in the study area. – Contd.

Class	Order	Family	Common name	Scientific name	Status
Reptilia	Chelonia	Pelomedusidae	West African Black Forest Turtle	<i>Pelusios niger</i>	Rare
		Testudinidae	Serrate Hinge-back tortoise	<i>Kinixys erosa</i>	Rare
	Crocodylia	Crocodylidae	Dwarf Crocodile	<i>Osteolaemus tetraspis</i>	rare/extinct
			Nile Crocodile	<i>Crocodylus niloticus</i>	Extinct
	Squamata	Agamidae	Agama lizard	<i>Agama agama</i>	Abundant
		Gekkonidae	Wall Gecko	<i>Hemidactylus brooki</i>	Common
		Scincidae	Skinks	<i>Mabuya sp</i>	Common
				<i>Lygosoma sp</i>	Common
				<i>Melanoceps sp.</i>	Common
		Varanidae	Nile Monitor	<i>Varanus niloticus</i>	Rare

Class	Order	Family	Common name	Scientific name	Status
		Boidae	Royal Python	<i>Python regius</i>	Rare
		Colubridae	Common File Snake	<i>Mehelya crossi</i>	Common
			Lined House Snake	<i>Boaedon lineatus</i>	Common
			Common Hedge Snake	<i>Philothamnus irregularis</i>	Rare
		Elapidae	Black Cobra	<i>Naja melanoleuca</i>	Abundant
		Viperidae	common vipers	<i>Vipera sp.</i>	Abundant
Amphibia		Pipidae	Tongueless frog	<i>Hymenochirus boettgeri</i>	Rare
		Bufo	Toads	<i>Bufo regularis</i>	Abundant
		Ranidae	True frogs	<i>Hylarana albolabris</i>	Rare
				<i>Dicroglossus occipitalis</i>	Abundant
		Rhychophoridae	Treefrogs	<i>Afraxalus dorsalis</i>	Rare
				<i>Hyperolius guttulatus</i>	Rare

Table 4.23b: Check list of animals in the study area.

S/N	BIRDS / AVES		LOCAL NAMES	STATUS		
				Local	IUCN	DCr 11
	ORDER ANSERIFORMES					
	Family Anatidae					
1	White-faced Whistling Duck	<i>Dendrocygna viduata</i>		Flock spotted		2
	ORDER ACCIPITRIFORMES					
	Family Accipitridae					
2	Yellow-billed Kite	<i>Milvus aegyptius parasites</i>		Abundant		1
3	White-headed Vulture	<i>Trigonoceps occipitalis</i>		Very Common/ Localised: Gbaran		
	ORDER PASSERIFORMES					
	Family Passeridae					
4	Southern Gray-headed Sparrow	<i>Passer diffusus</i>		Very Common		
	Family Corvidae					
5	Pied crow	<i>Corvus albus</i>		Common		
	Family Ploceidae/Passeridae					

S/N	BIRDS / AVES		LOCAL NAMES	STATUS		
6	Orange weaver	<i>Ploceus aurantius</i>		Spotted		
	Family Pycnonotidae					
7	Common bulbul	<i>Pycnonotus barbatus</i>		Common		
	ORDER PSITTACIFORMES					
	Family Psittacidae					
8	Congo African Grey Parrot	<i>Psittacus erithacus*</i>		Common	Vulnerable	1
	ORDER CHARADRIIFORMES					
	Family Jacanidae					
9	African Jacana	<i>Actophilornis africanus</i>		Spotted		-
	ORDER COLUMBIFORMES					
	Family Columbidae					
10	Laughing dove	<i>Stigmatopelia senegalensis</i>		Sighted	LC stable	-
	ORDER CORACIIFORMES					
	Family Alcedinidae					
11	Woodland King fisher	<i>Halcyon senegalensis</i>		Common		
	ORDER CUCULIFORMES					
	Family Cuculidae					
12	Senegal Coucal	<i>Centropus senegalensis</i>		Sighted		
	ORDER MUSOPHAGIFORMES					
	Family Musophagidae					
13	Great Blue Turaco	<i>Corythaeola cristata</i>		Very Common		
	ORDER BUCEROTIFORMES					
	Family Bucerotidae					
14	African Pied Hornbill	<i>Tocus fasciatus</i>		Abundant		

Table 4.23c: Check list of animals in the study area.

Family	Species
Achatinidae	<i>Archachatina marginata</i> <i>Archachatina papyracea</i> <i>Limicolaria flammea</i> <i>Lignus</i> sp.
Streptaxidae	<i>Gonaxis camerunensis</i> <i>Gulella germaini</i> <i>Gulella io</i> <i>Gulella monodon</i> <i>Gulella opoboensis</i> <i>Gulella pupa</i> <i>Ptychotrema aequatoriale</i> <i>Ptychotrema shagamuense</i>
Subulinidae	<i>Curvella feai</i> <i>Kempiochoncha</i> sp. <i>Pseudopeas</i> sp. <i>Subulina striatella</i> <i>Subulina</i> sp. <i>Subulona patalus</i> <i>Subulona</i> sp.
Succineidae	<i>Quickia</i> sp.
Urocyclidae	<i>Trochozonites talcosus</i> <i>Trochozonites</i> sp
Veronicellidae	<i>Pseudveronicella liberiana</i>



Plate 4.9: A Mamba of the Elapidae Spotted at VGC 2 during the survey

Ethnozoology - Economic valuation of wildlife.

Data obtained from wildlife interview with natives and existing literature and previous studies in the area (Rapid validity survey of the Nun River and Egedi Creek by SPDC, indicate that animals in the area have considerable ethnozoological values as shown in Table 4.24 .Although the efficacy of some of these indigenous knowledge have been swept under the carpet they could be subjected to scientific investigations to detect the medicinal component which is responsible for the cure for which they are locally known.

Table 4.24: Ethnic value of animals in communities around the study area

Animal	Part	Uses
Bush-pig	Teeth	Tying the teeth on the neck of child lacking appetite increases his appetite.
Antelope	Horn	This is ground to powder form and then rubbed on the head a dullard to improve his intelligence.
Tortoise	Whole animal	When a pregnant woman feels no kicking of the foetus, a young tortoise is hung her neck (like necklace) to increase foetal kicking frequency
Grasscutter / cane rat	Feecal droppings	For a small boy that is growing too lean, it is added in pomade. As he rubs this mixture, his growth improves.
Python	Oil	Used in massaging away serious pains. Also used to suppress growth of keloids in healing wounds.
Python	Head	Immersed in Native Gin (Kai-kai) neutralizes poisons
Pangolin	Scale	It is tied round the neck of a pregnant woman whose foetus is always folding or turning too frequently to make the foetus seat properly in the womb. It makes the foetus also to grow big.
Maggot	Whole body	After soaking in water, the extract is given to a very tiny baby, for rapid growth in size.
Cockroach	Whole body	Used for treatment of boil. Simply roast the insect in fire and place it on the boil.
Wall gecko	White part of feaces	Placed on boil, it extracts pus from the boil until it dries.
Tortoise	Carapace	This is ground to powder and given to a pregnant woman whose foetus is not kicking to lick.
Nile Monitor	Bile	It is immersed in local gin (kai-kai); and the extract is given to treat cough.
Snake	Blood	To neutralize the effect of snake venom in a victim of snake bite; the same snake is killed and the blood given to the victim to drink.
Lung fish (Protopterus aethiopicus)	Bile	The extract of bile immersed in native gin (kai-kai) and given to a victim of snake, or scorpion, etc. to neutralize the poisonous effect of their venoms.
Antelope	Skin	Used for making drums; in chieftaincy and wrestlers decorations.
Antelope	Horn	Used in designing flutes
Civet cat	Skin	Used in chieftaincy and wrestlers decorations.

Threat to the biodiversity in the study area

The major threats to vegetation in the study area can be summarized into:

- i) Uncontrolled, disorderly and uncoordinated poaching of timber products and wildlife
- ii) Anthropological causes e.g. need for expansion of residential and other facilities
- iii) Form of agriculture e.g. cultivation of yams, which require cutting of young trees for stakes
- iv) Exploitation for cash

Excessive poaching of wildlife, timber products, wild fruits, vegetables and spices in the project area has been identified as the major threat to biodiversity confronting the area. The worst impact on the forest is due to excessive, indiscriminate and abusive harvest of timber plants. Premature timber plants with girth less than 50 cm diameter are now being felled and sawed for planks. Such planks though comprising of sapwood is not of good market quality but, they are being presently harvested and sawed for cash. Since such trees could hardly yield enough timber, many premature trees are sawed in order to obtain reasonable quantity of planks.

Due to increase in the population of host communities, there is pressure for land-take building of houses to expand residential facilities. There is pressure also for agricultural land-take for more farmland to feed the growing population. The rise in population also calls for more schools and other social facilities and infrastructure. Young saplings of tree plants also suffer a peculiar problem. They are frequently harvested for use as stakes in yam farms. The indiscriminate harvest of young stands of tree plants for staking yam has a potential for speedy depletion of tree plants and decimation of the forest. Another threat to the conservation value of some useful plants in the forest is caused by gathering of forest products for cash. Some of the species which suffer this problem most are: *Irvingia gabonensis*, *Treculia africana*, and wild spices such as *Piper guineense*, *Gongronema latifolia*, and *Gnetum spp* etc. The fruit of *Irvingia gabonensis* is seasonally collected for extraction of its seed, Ogbono or Ogbolo, which serves as soup thickener. The fruit of *Treculia africana* is also gathered for its edible seeds. The collection of fruits of these species is extensive and does not allow for germination and development of younger plants that would replace the mature and aging trees. Wild spices are choice items in the market and as such yield a lot of cash. For this reason, people enter deep into the forest looking for these forest products. *Piper guineense* is worse hit among others because its fruits and leaves are edible spices. Hence it is almost completely harvested once encountered in the forest.

4.14 Hydrobiology

Hydrobiological /ecological parameters studied include phytoplankton, zooplankton, benthic invertebrates and fisheries.

4.14.1 Phytoplankton

A checklist of the phytoplankton within Uzu Field in both the dry and wet season are presented **Appendices 9 and 10** while **Figs 4.15** and **4.16** are graphs showing the contribution each of the major families of phytoplankton. Five major families of phytoplankton were recorded; namely

Baccillariophyta, Cyanophyta, Dinophyta, Chlorophyta, and Euglenophyta. Baccillariophyta were the dominant family and constituted 55% of the total number of phytoplankton in the dry season and 60% in the control points.

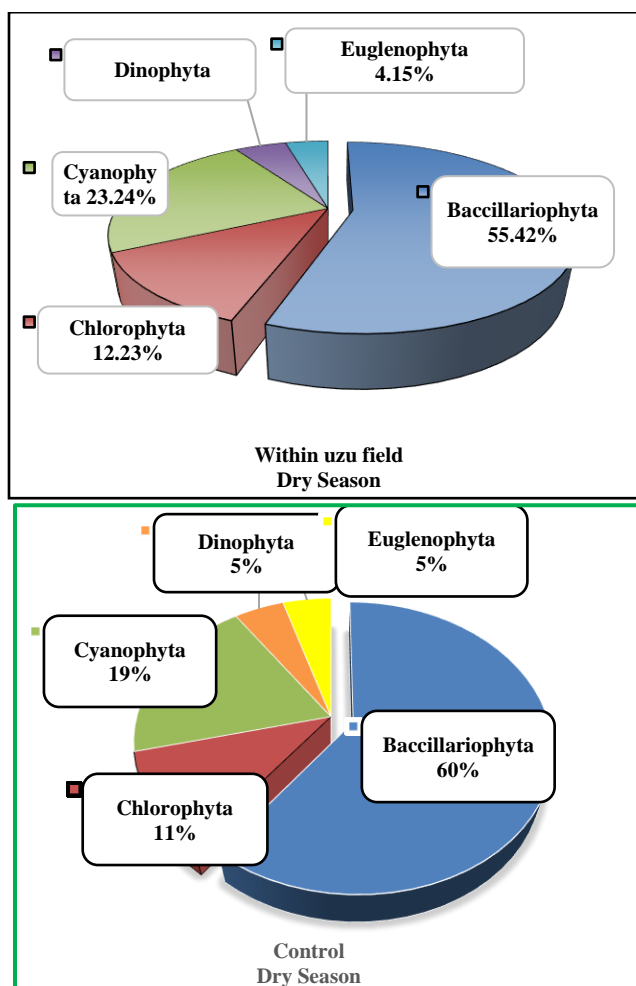


Fig 4.15: Relative Abundance of phytoplankton in Uzu Field (Wet Season)

In the wet season, 54% of total phytoplankton count in the study area and control belonged to the bacillariohyta division (Fig 4.16). In the control points. The dominance of Bacillariophyta is characteristic of the phytoplankton community structure in the Niger Delta of Nigeria and this has been severally reported by Ogamba *et al.* (2004) Davies *et al.* (2009), Emmanuel and Onyema (2007), Allison and Otene (2012).

The second dominant group of phytoplankton was the Cyanophyta, which contributed 23 % of the total number of phytoplankton in the dry season and 20% in the wet season. They were represented by 15 species. The dominant Cyanophyta species in the dry season were *Isocystis sp.*(2.34%), *Phormedium tenue* (2.12%), *Oscillatoriabonnamaisonii* (1.59%), *Anabaena flos-aquae* (1.50%)

and *O. pseudomina* (1.37%) as shown in **Appendix 9**. In the wet season, dominant phytoplankton species include *Aphanozemenun flos-aquae* (1.35%), *Oscillatoria pseudomina* (1.22%) and *Phormedium forseolarum* (1.20%).

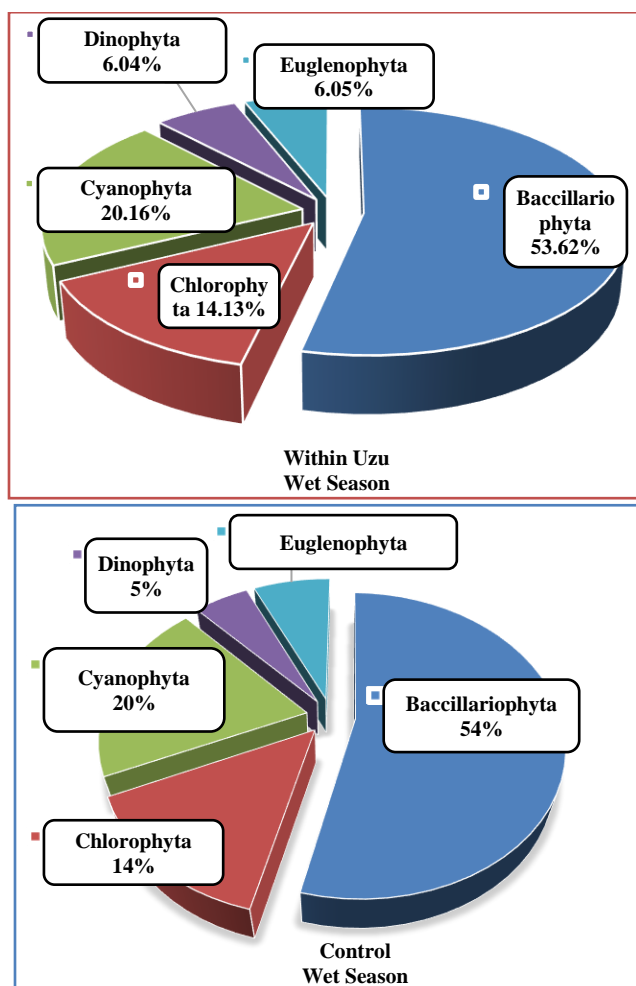


Fig 4.16: Relative Abundance of phytoplankton in Uzu Field (Wet Season)

About 12-14% of the total number of phytoplankton count in both the dry season and wet season were contributed by chlorophyta. Twelve (12) species were represented in this division. In the dry season, major representatives of chlorophyta include *Phacolus* (1.53%), *Staurastrum seligerum* (1348%) and *Pandorina* (1.23%). In the wet season, dominant members of this division include *Staurastrum seligerum* (1.89%), *Eudorina sp* (1.57%), *Halosphaera viridis* (1.49%), and *Scenedesmus acuminatus* (1.48%). In all the dominance pattern of the various families of phytoplankton was, Bacillariophyta > Cyanophyta > Chlorophyta > Dinophyta > Euglenophyta. In the dry season, the number of phytoplankton in the various stations ranged between 2016×10^3 organisms per liter (SW 3) to 2874×10^3 organisms per liter in SW 2 (**Fig 4.17**). Similarly, in the wet season, phytoplankton density ranged from $2182-2959 \times 10^3$ organisms per liter (**Fig 4.17**).

These data indicate that phytoplankton densities in the dry season were comparable to those in the wet season.

Dahlin *et al.* (1985) had published similar values for other aquatic systems in the Niger Delta and the result obtained here conforms to this literature (Dahlin et. al 1985). However, Nwandiario and Ezefili (1986), Davies and Abowei (2009). Allison and Otene (2012) recorded considerable variations in the number of phytoplankton in different aquatic systems in the Niger Delta.

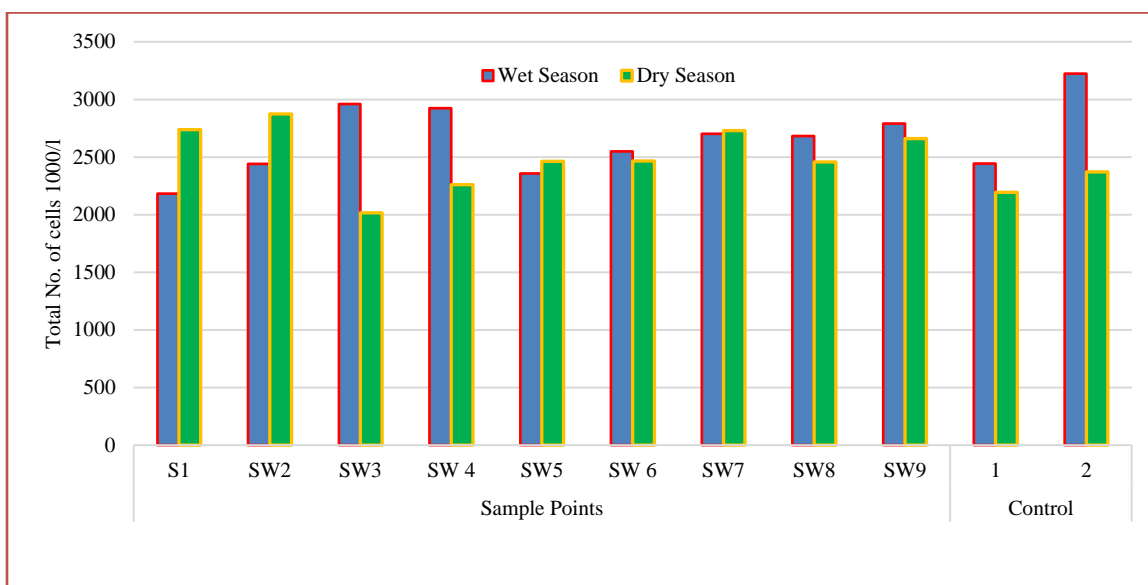


Fig 4.17: Variation in number of population density of phytoplankton

In the dry season the number of species of phytoplankton (**Fig 4.18**) ranged between 66 (SW 4) and 86 (SW 7). In the wet season, this parameter was least (74) in SW 1 and highest (86) in SW 2. In the wet season the number of species of phytoplankton fluctuated between 74 in SW1 and 89 in SW 2. In the control points, number of species was 71-75 (dry season) and 76-89 (Wet Season). The number of species of phytoplankton in the study area was comparable to those in the study area.

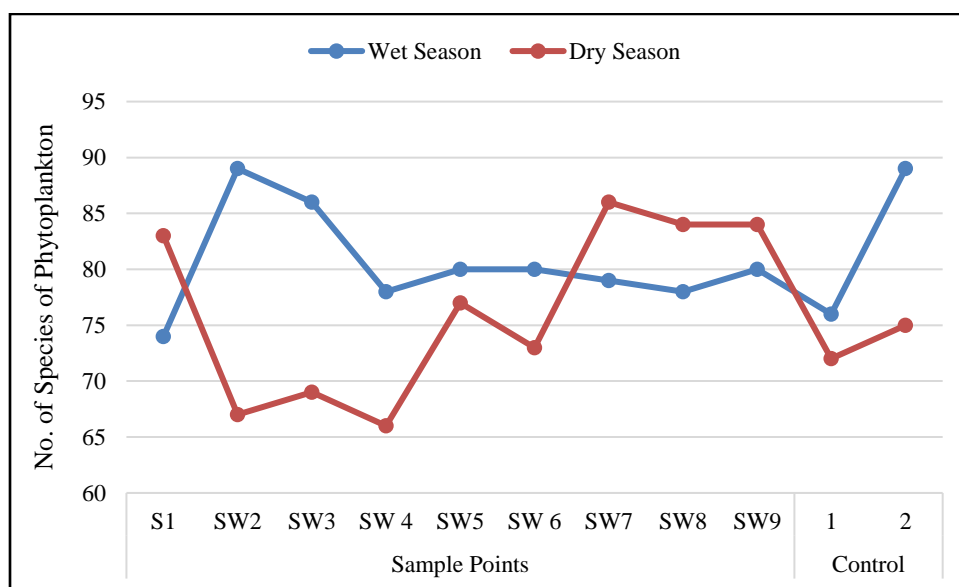


Fig 4.18: Variation in number of species of phytoplankton

A total of 117 species of phytoplankton were identified in the study area in both seasons of the study (Table 4.22). Sixty-five (65) species or 55.56% of the phytoplankton belong to the family Bacillariophyta, while fourteen (14) species (12%) were of the chlorophyta division. About Twenty-one per cent (21.37%) of the number of phytoplankton were cyanophyta. Seven (7) species or 5.98% of the number of species of phytoplankton were the dinophyta (Table 4.22).

Table 4.23D: Number of species in each of the major phytoplankton in Uzu

Phytoplankton Division	No. of Species	%Number
Bacillariophyta	65	55.56
Chlorophyta	14	11.97
Cyanophyta	25	21.37
Dinophyta	7	5.98
Euglenophyta	6	5.13
Total	117	

Another indicator of the diversity of phytoplankton within the study area are, species richness index (Margalef's Index) and Menhinick's index of diversity index and the spatial variations in these indices are presented in Figs 4.19 and 4.20 respectively. In the dry season, Margalef's index with respect to phytoplankton diversity in Uzu Feild fluctuated ranged from 8.29 in SW2 to 10.74 in SW7. In the wet season, Margalef's index ranged from 9.45 in SW1 to 11.28 within the study area. In the control, values ranged from 9.23 to 8.52 in the dry season and 9.61 to 10.81 in the wet season (Fig 4.19). Margalef's index values in the study area was comparable to those in the control. On the other hand, diversity was generally higher in the wet season especially in SW2, SW3, SW4, SW5 and SW6.

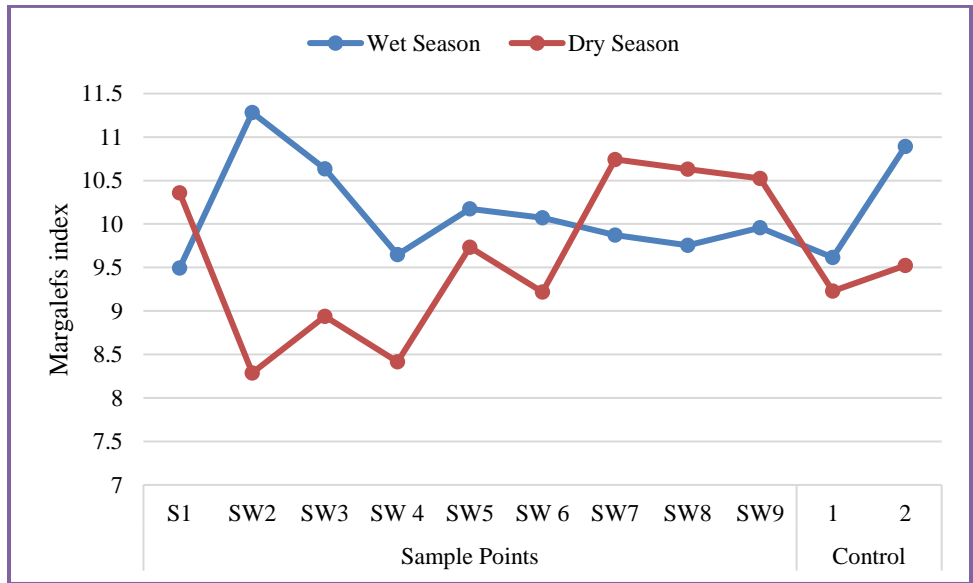


Fig 4.19: Variation in diversity of phytoplankton sing Margalef’s index

In the dry season Menhinick’s index varied from 1.25 in SW2 to 1.69 in SW8 and in the wet season, this index fluctuated between 1.44 and 1.80 (Fig 4.20). These values indicate that there was no distinct seasonal and spatial variation in Menhinick’s index of phytoplankton.

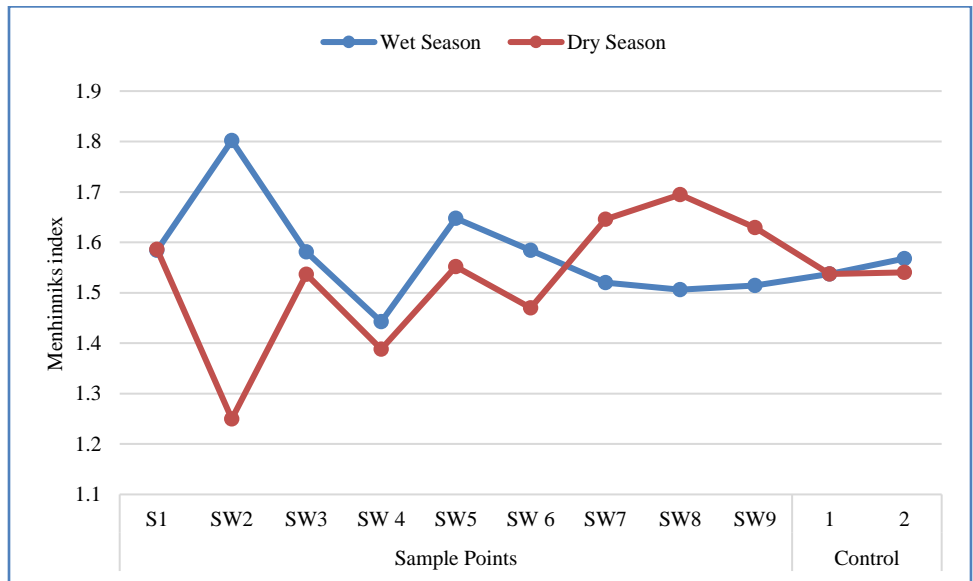


Fig 4.20: Variation in diversity of phytoplankton in Uzu Field using Menhinick’s index

4.14.2 Zooplankton

Zooplankton Abundance: A checklist of the zooplankton species recorded in Uzu Field in the dry and wet season are presented in Appendices 11 and 12 respectively. The identified zooplankton fauna was categorized into rotifers, brachiopods, copepods, and larval forms of fish and insects

(Appendices 11 and 12). The percentage composition of each of these major zooplankton groups is presented in Fig 4.21. In the dry season, copepods were the dominant zooplankton with respect to density and members of this family constituted 44-47% of the zooplankton in both Uzu Field and control. Prominent copepods species in the dry season include *Centropages sp*, *Acartia clausii*, and *Paracalanus species* with a relative abundance of 8.84, 8.16, and 7.39% respectively. Rotifers were the second dominant group in Uzu Field in the dry season with a relative abundance of 42% within Uzu and 29% in the control area. Key rotifer species in Uzu in the dry season include *Keratella tropica*, *Trichocerca*, and *Brachionus fulcatus*.

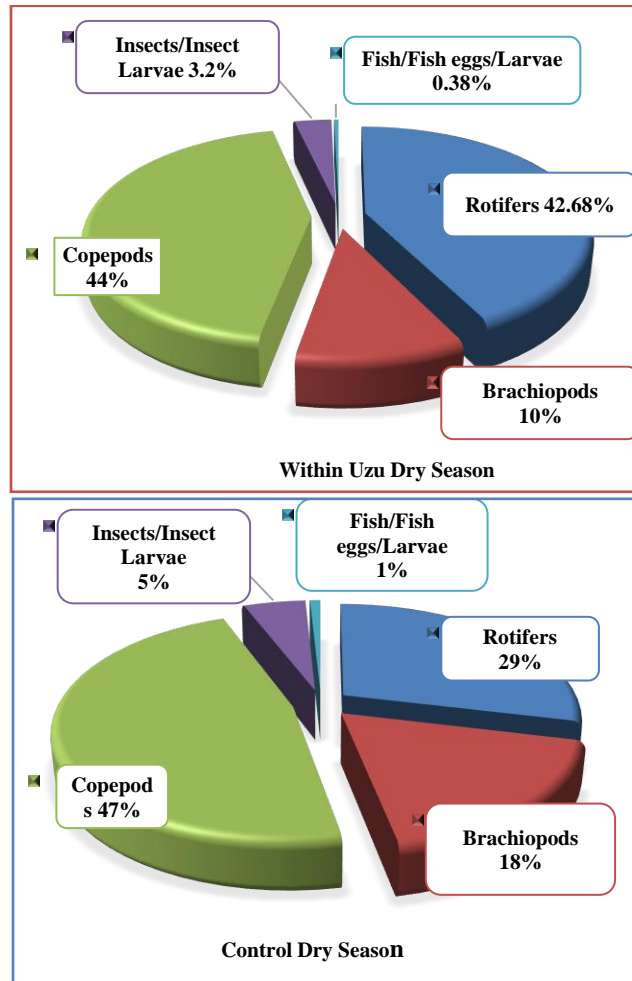


Fig 4.21: Relative Abundance of zooplankton in Uzu Field (Dry Season)

In the wet season, rotifers were the dominant zooplankton with a relative abundance of 42% within Uzu field and 33% in the control area (Fig 4.22). *Keratella longispina* (7.57%), *Brachionus fulcatus* (7.26%), *Keratella tropica* (6.70%) and *Ceptialodella* (6.65%) were dominant species of rotifers. Copepod crustaceans were the second dominant zooplankton and contributed 36% of the zooplankton in the wet season within Uzu Field and major copepods include *Arctodiaptomus* (10.28%), *Acartia clausii* (7.16%), and *Tropodiaptomus* (6.03%) (Appendix 12).

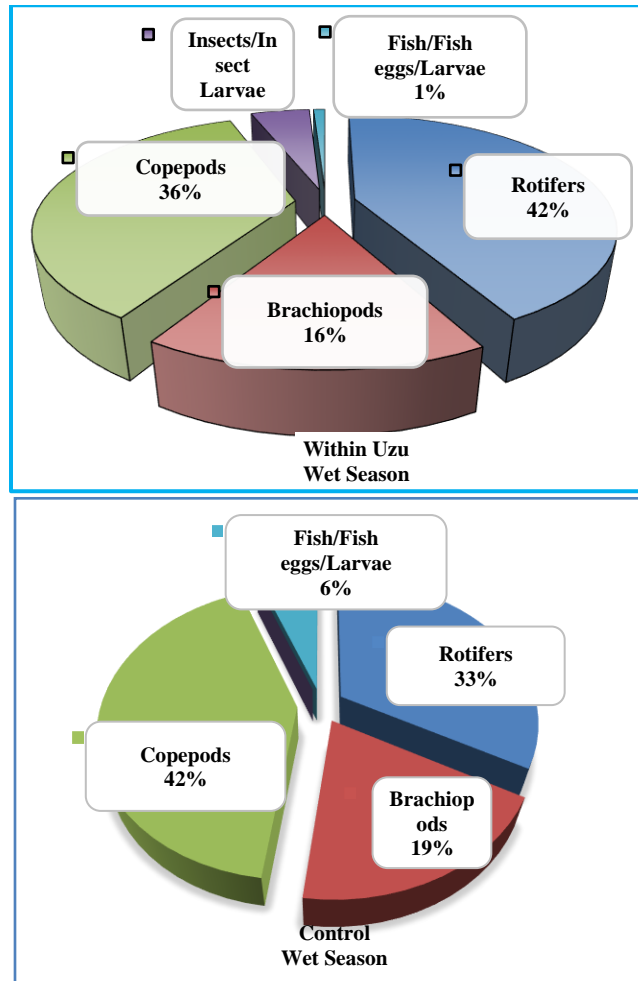


Fig 4.22: Relative Abundance of zooplankton in Uzu Field (Wet Season)

Spatial variation in the population density of zooplankton in Uzu Field in the dry and wet seasons is presented in Fig 4.23. In the dry season, the minimum zooplankton density of 68×10^2 organisms/l was recorded in SW4 and the highest count of 185×10^2 organisms/l was recorded in SW6. In the wet season, zooplankton densities ranged from $184-721 \times 10^2$ organisms/l within the study area. Dry season zooplankton densities were generally lower than wet season densities. According to GESAMP (1993), UNEP (1990), Nwankwo (1993) and Davies *et. al.* (2009) density and diversity of zooplankton are governed by a number of factors which include high influx of allochthonous and autochthonous materials within the riparian grounds. These materials could be alternative food resources for the zooplankton. In this study, it does not appear that the influx of organic matter from the riparian grounds influenced the density of zooplankton.

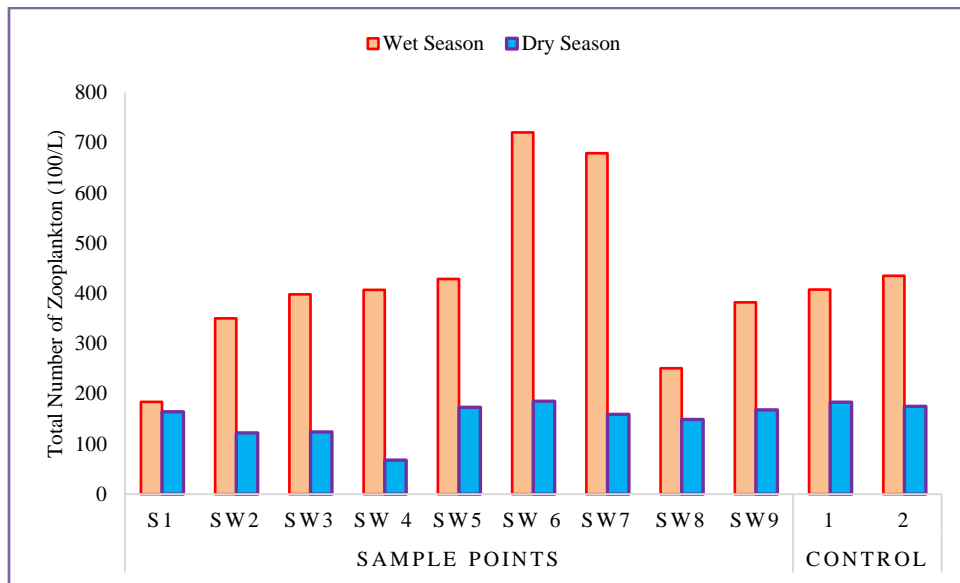


Fig 4.23: Variation in number of population density of zooplankton

Variation in number of species of zooplankton in the study area is presented in Fig 4.24. In the dry season, a total of 10 species of zooplankton were recorded in SW8 while 17 species were recorded in SW5. In the wet season, the numbers of species of zooplankton ranged from 13 to 17 (Fig 4.24).

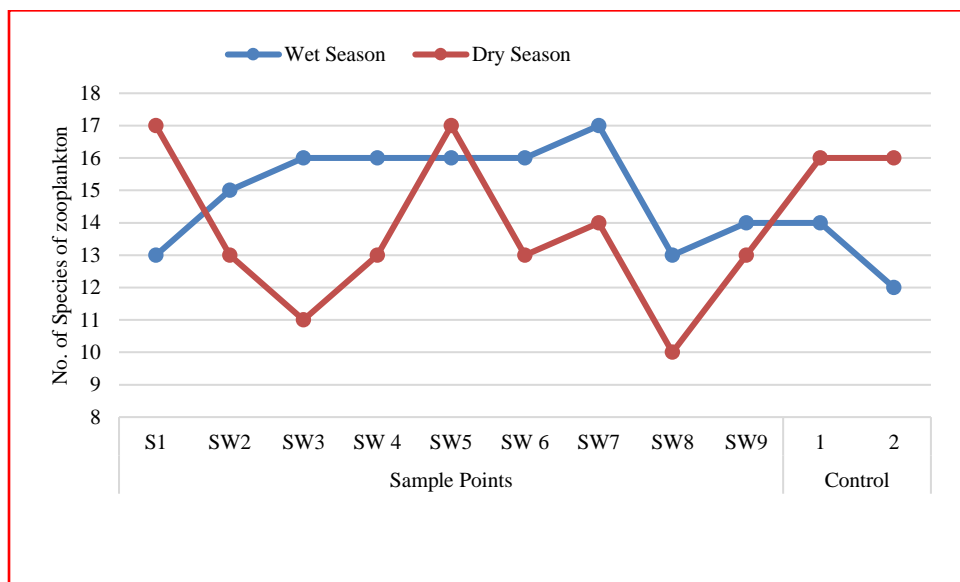


Fig 4.24: Variation in number of species of phytoplankton

Variation in diversity of species of zooplankton as estimated using Margalef's index is presented in Fig 4.25. In the dry season Margalef's index varied from 1.79 – 3.14 while in the wet season, this index ranged from 2.16 to 2.50 within the study area (Fig 4.25).

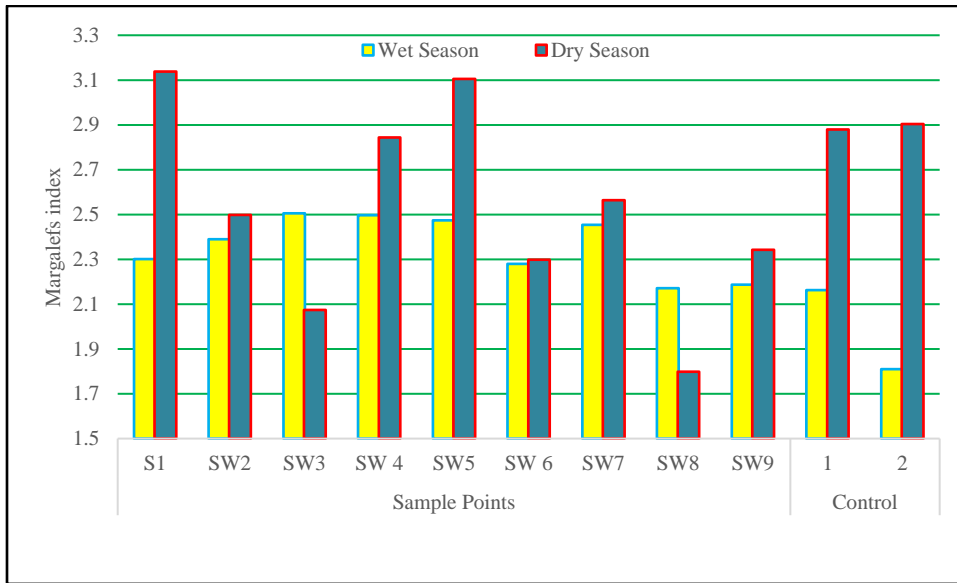


Fig 4.25: Variation in diversity of zooplankton using Margalef's index

Dry season Menhinick's diversity index values ranged from 0.74 to 1.45. In the wet season, this index ranged from 0.73 to 1.46 (Fig 4.26). Wet season diversity as shown by Menhinick's is generally higher than in the dry season.

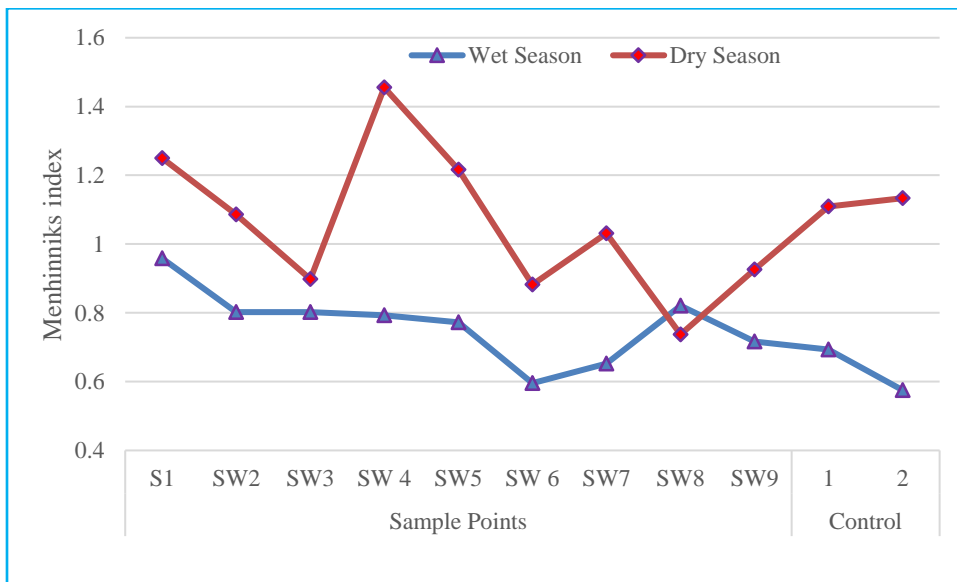


Fig 4.26: Variation in diversity of zooplankton in Uzu Field using Menhinick's index

4.14.3 Benthos

Benthos Population and Abundance: The checklist of the benthic fauna in aquatic systems around Uzu Field in both the dry and wet seasons are presented in **Appendices 13 and 14**, while **Figs 4.27 and 4.28** show the relative abundance of each of the major taxonomic groups that were recorded during the study. In the dry season, six hundred and forty-eight (648) organisms were encountered during the study while a total of three hundred and five (305) were recorded in the

wet season. Benthic fauna encountered in the study belong to seven (7) major taxonomic groupings namely annelids, decapod crustaceans, and larval forms of ephemeroptera, odonata, hemiptera and diptera. In the dry season, annelids with a relative abundance of 43-44% were the dominant benthos within the study area and control. Major species of annelids include *Chaetogaster*, *Branchiura* and *Lumbriculus*. The second dominant benthic group were the members of odonata and key members of this insect order include *Branchiura*, *Lumbriculus* and *Tubifex* (**Appendix 13**).

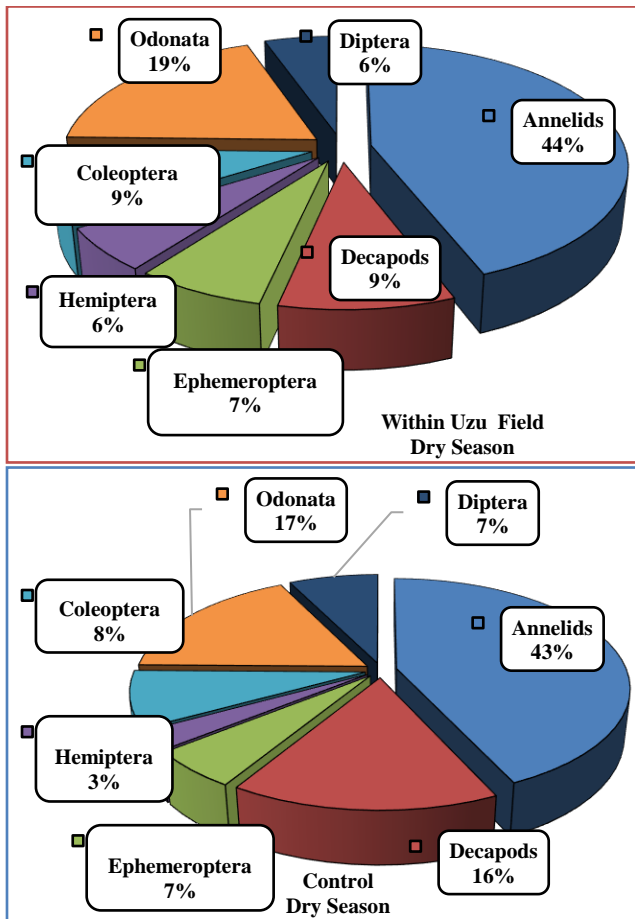


Fig 4.27: Relative Abundance of benthos in Uzu Field (Wet Season)

In the wet season, decapod crustaceans constituted 37% of the total count of benthos. However, it is significant to note that larval forms of insects particularly odonatans, hemipterans and coleopteran with a relative abundance of 13, 11 and 10% respectively were the prominent group of benthos. Larval forms constituted about 72% of the benthos in the control area.

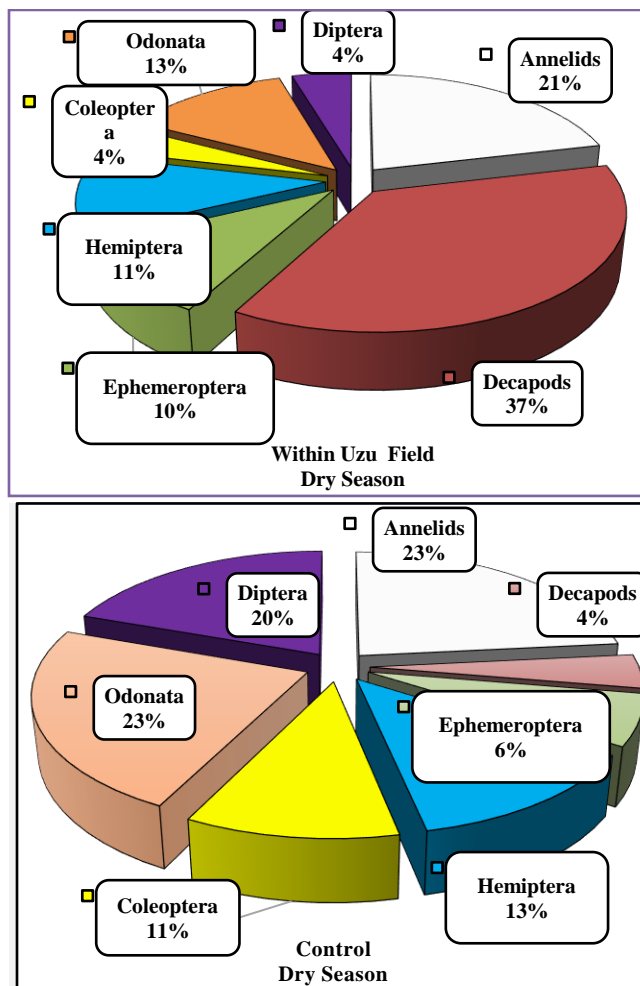


Fig 4.28: Relative Abundance of benthos in Uzu Field (Dry Season)

The spatial and seasonal variation in the total number of benthos in the study is graphically presented in **Fig 4.29**. In the dry season, the number of benthos fluctuated between 24 organisms per m² (SW1) and 122 organisms per m² (SW6). In the wet season, population density of benthos was generally lower in the wet season and it ranged from 12 to 74 organisms per m². The population density in each station was generally high as compared with literature report in Nigeria (Victor and Ogbeibu, 1985; Olomukoro and Ezemonye, 2007; Emere and Nasiru, 2008). This may be due primarily to the fact that the sediment was suitable site for the breeding of larval forms of insects. This may be due to the high influx of organic material from the riparian grounds. Another possible explanation for the high density of benthos during the study is attributable to level of organic material or detritus in the sediment. These organic materials are food sources for the benthic organisms which are largely degraders of organic material.

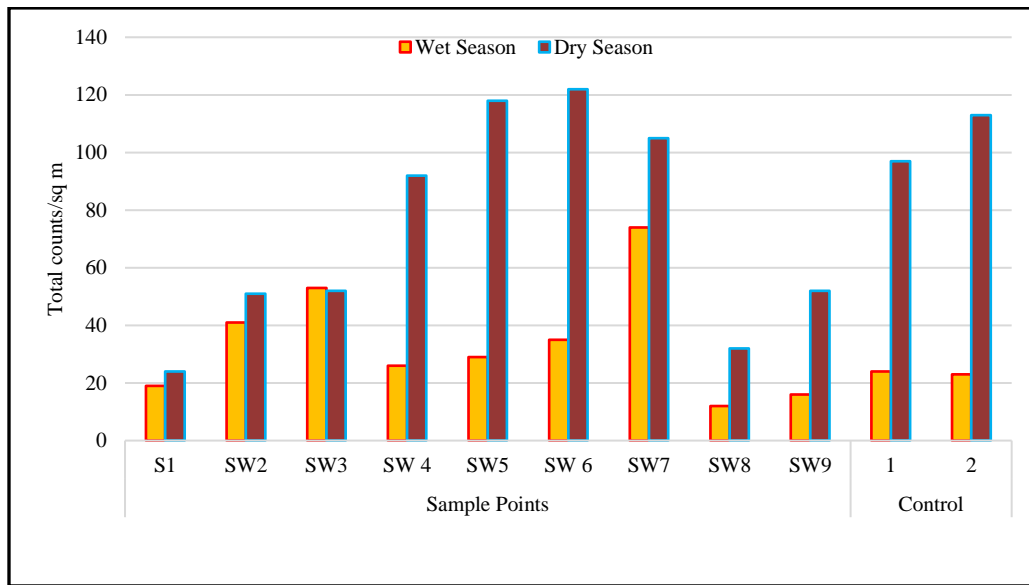


Fig 4.29: Variation in population density of Benthos in aquatic systems around Uzu Field

In both the dry and wet seasons, the number of species of benthos ranged from 6 to 12 (**Fig 4.30**). These values further support the fact that the degree of habitation of the sediment by benthos were relatively high when compared with literature (Victor and Ogbeibu, 1985, Olomukoro and Ezemonye, 2007; Emere and Nasiru 2008).

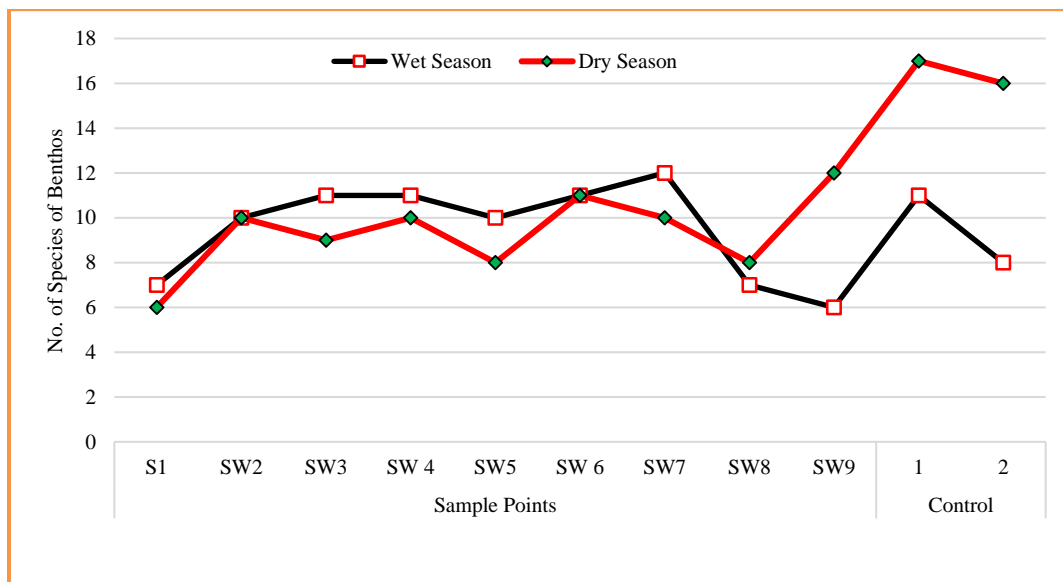


Fig 4.30: Variation in population density of Benthos in aquatic systems around Uzu Field

Variation in diversity of species of benthic fauna as estimated using species richness index (Margalef's) is graphically presented in **Fig 4.31**. Dry season values for Species richness index (Margalef's) varied from 1.45 – 2.29 while wet season values ranged from 2.04 to 3.07. Diversity as shown by Margalef's is higher in the wet than in the dry season.

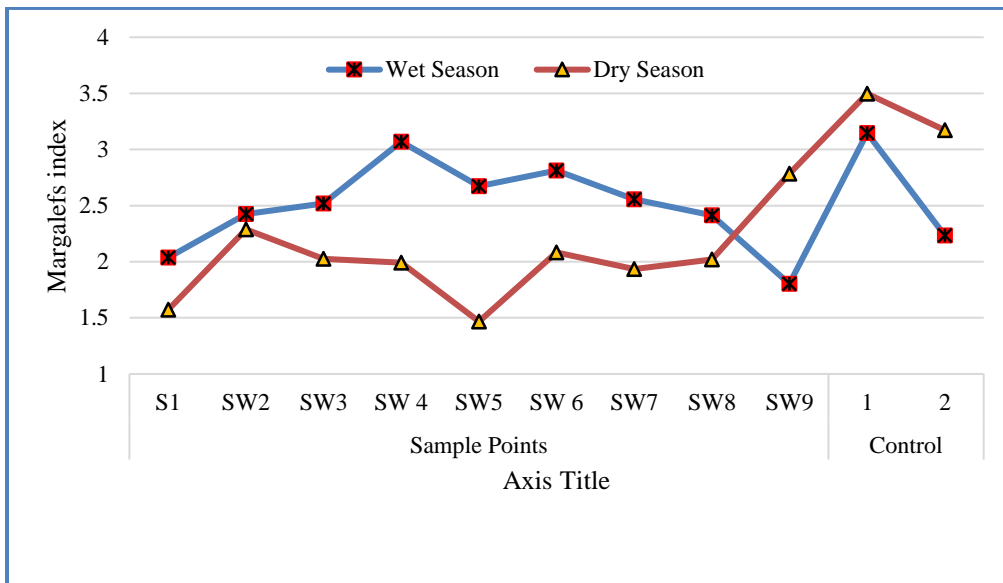


Fig 4.31: Variation in diversity of Benthos using Margalef's, index in aquatic systems around Uzu Field

Variation in Menhinick's index of benthos in Uzu Field in the dry season was between 0.74 in SW5 and 1.66 in AW9 while in the wet season it was between 1.39 and 2.16. indicating that there was no significant seasonal variation in Menhinick's (Fig 4.32).

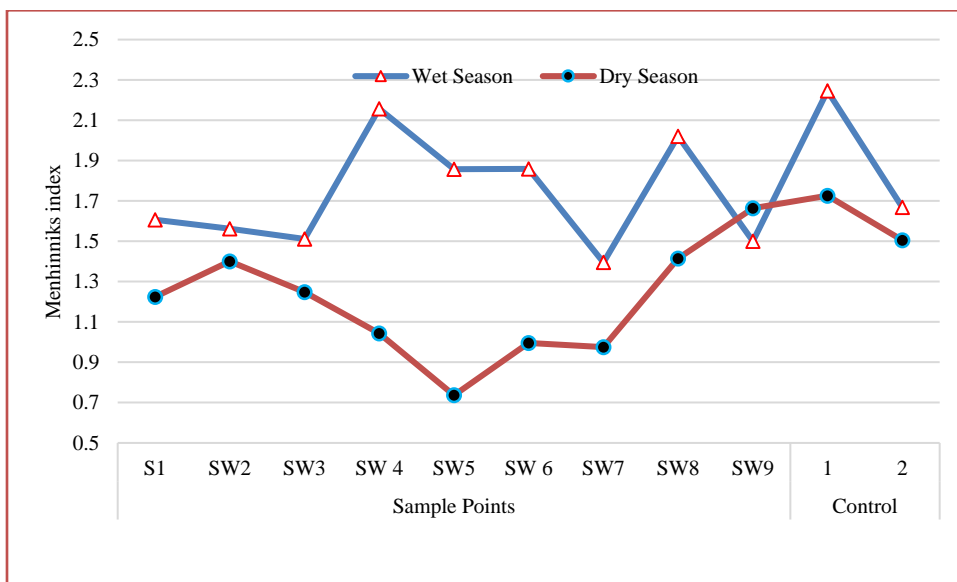


Fig 4.32: Variation in diversity of Benthos using Menhinick's index in Uzu Field

4.14.1.4 Fisheries Studies

Artisan fishers or small-scale fishers dominate the fishery of the study area (Uzu Field). They operate in dug-out wooden canoes which may or may not be motorized. Fishing gears are largely made of long setlines, circling nets and seine nets of different mesh sizes varying between ½”, 1”, 1½”, 2”, 2½ and 3” (1.0mm to 5.0mm). Gears measure 6-12m in length and 2-4 meters in width. Nets are manually operated. They are set and allowed to stay for up to one hour before they are removed with the catch. When the net is set and before it is removed another net is also set. Catch rates are seasonally dependent and varied between 4-7 kg/day. The pelagic fish species identified in the landings of these some fishers and some fish mongers in the areas presented in the Table 4.23. In the dry season, a total of 34 species of fish belonging to 21 families of fin fishes and shellfishes were recorded while in the wet season there were 34 species. Ekeke *et al.* (2008) had recorded 51 species of fin and shellfishes in the study area. Chindah and Osuamkpe (2008) recorded 57 species in 25 families in the fish assemblage of the Niger Delta. These differences may be due to differences in intensity, time and duration of sampling

Table 4.23e: Checklist of Fin Fish species recorded in Uzu Field

Family/Species	Common Name	Abundance Rating	
		Dry Season	Wet Season
		33	
FAMILY OSTEOGLOSSIDAE			
<i>Heterotes niloticus</i>		1	1
FAMILY CLARIIDAE			
<i>Clarias gariepinus</i>		3	2
<i>C.anguillaris,</i>		1	-
<i>C.isheriensis</i>			1
<i>Heterobranchus bidorsalis</i>		2	2
FAMILY POLPTERIDAE		-	
<i>Polypterus anectens</i>	Bichirs	2	1
<i>Calamoichthys calabricus</i>		1	2
FAMILY CYPRINIDAE			
<i>Labeo coubie</i>	African carp	-	1
<i>L. pseudocoubie</i>		2	-
<i>L. senegalensis</i>			3
FAMILY ANABANTIDAE			
<i>Ctenopoma kingsleyae</i>	Leaf fish	1	2
<i>C. petherici</i>		1	1
FAMILY HEPSETIDAE			
<i>Hepsetus odoe</i>	African pike	2	-
FAMILY BAGRIDAE			
<i>Bagrus bayad</i>	Okpo	-	2
<i>B. filamentosus</i>	Okpo	2	3
<i>Clarotes laticeps</i>		1	1

Family/Species	Common Name	Abundance Rating	
<i>C. macrocephalus</i>		1	-
<i>Parauchenoglanis ansorgii</i>		1	1
FAMILY CITHARINIDAE			
<i>Distichodus brevipinis</i> (Gunther)	Grass eater	1	2
<i>D. rostartus</i> (Gunther)		1	2
<i>Citarinus latus</i> (Muller & Froschei)	Moon fish	2	1
<i>C. distichodus</i> (Pelligrini)		-	2
FAMILY CARANGIDAE			
<i>Trachinotus goreensis</i>	Thread	1	-
FAMILY CENTROPOMIDAE			
<i>Lates niloticus</i>		1	3
FAMILY CHANNIDAE (OPHICEPHALIDAE)			
<i>Ophiocephalus obscura</i>	Snake head	-	2
<i>O. africanus</i>	Mud fish	1	-
FAMILY CHARACIDAE			
<i>Hydrocynus brevis</i>	Tiger fish	1	1
<i>H. lineatus</i>		1	1
<i>H. forskalii</i>	Tiger fish	2	2
<i>Alestes nurse</i>		3	4
<i>A. brevis</i>		-	3
<i>A. dentex</i>		1	2
<i>A. baremose</i>		2	-
<i>A. longipinnis</i>		1	1
<i>Micralestes acutidens</i>		1	3
FAMILY CICHLIDAE			
<i>Hemichromis bimaculatus</i>	Tilapia (Egu)	2	1
<i>H. fasciatus</i>	Tilapia (Egu)	-	-
<i>Pelmatochromis guentheri</i>	Tilapia (Egu)	3	1
<i>Tilapia zillii</i>	Tilapia	2	2
<i>Sarotherodon galilaeus</i>	Tilapia	3	2
<i>Tilapia heudeloti</i>	Tilapia	-	-
<i>T. mariae</i>	Tilapia	4	3

Shrimp Fishery

The following shellfish species were identified in the stock of fish mongers in the study area.

- *Macrobrachium felicinum*
- *Macrobrachium vollenhovenii*
- *Macrobrachium macrobrachion*

Heavy Metals in Fish Tissue

The heavy metals in fish tissue in Uzu Field are presented in **Table 4.24**. This Table shows that Fe, Mn, Cd, Cr, Pb, Ni, Zn, and Cu were recorded in various concentrations in all the fish tissues that were sampled. Fish tissues were free (<0.005mg/kg) from Vanadium (V). The concentration of Fe in fish tissue ranged from 57.24mg/Kg in *Coptodon zilli* to 197.58mg/Kg in *Macrobrachium*. The level of Cr was 24.04-29.72mg/Kg in sampled fish species while the concentration of Pb was 7.64-50.36mg/kg (**Table 4.24**).

Table 4.24: Summary of heavy metals concentration in fish in Uzu Field

Parameter (mg/kg)	<i>Heterotis niloticus</i>	<i>Coptodon zilli</i>	<i>Parachanna obscura</i>	<i>Gymarichus niloticus</i>	<i>Macrobrachium</i>
Iron (Fe)	84.91	57.24	147.45	83.66	197.58
Manganese, (Mn)	20.36	14.73	11.30	12.72	42.03
Cadmium (Cd)	0.87	1.34	8.34	1.76	1.93
Chromium (Cr)	24.04	25.99	28.96	26.57	29.72
Lead (Pb)	7.64	14.82	50.36	2.59	6.57
Nickel (Ni)	19.81	21.42	39.32	20.34	27.28
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	90.54	120.47	88.30	105.30	184.73
Copper (Cu)	8.35	9.79	9.05	10.13	94.76

Organics in Fish Tissue

The concentrations of organics in fish tissue in Uzu Field are presented in **Table 4**. This Table shows that TPH, PAH and BTEX were not recorded in all the fish tissues that were sampled. TPH levels were not recorded at detection level of <0.03mg/kg. Similarly, PAH and BTEX were not detected at <0.05 and <0.01mg/kg respectively (**Table 4.25**).

Table 4.25: Summary of organics in fish in Uzu Field

Parameter (mg/kg)	<i>Heterotis niloticus</i>	<i>Coptodon zilli</i>	<i>Parachanna obscura</i>	<i>Gymarichus niloticus</i>	<i>Macrobrachium</i>
Total Petroleum Hydrocarbon	<0.03	<0.03	<0.03	0.62	<0.03
PAH	<0.05	<0.05	<0.05	<0.05	<0.05
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01

Minerals in Fish Tissue

The concentrations of minerals in fish tissue in Uzu Field are presented in **Table 4.26**. Potassium, sodium and magnesium were recorded at various levels in all the fish tissues that were sampled.

All the studied fish species contained an appreciable amount of sodium, calcium, magnesium and potassium that are capable of meeting the nutritional requirements of human beings.

Table 4.26: Summary of macro-nutrients in fish in Uzu Field

Parameter (mg/kg)	<i>Heterotis niloticus</i>	<i>Coptodon zilli</i>	<i>Parachanna obscura</i>	<i>Gymnarichus niloticus</i>	<i>Macrobrachium</i>	Recommended Daily Intake (FAO/WHO 2001)
Potassium (K)	1928	2639	1894	2537	2201	3500
Sodium (Na)	487.07	539.27	448.89	631.98	470.23	2400-2500
Calcium (Ca)	5306	3186	2044	4755	14157	1000
Magnesium (Mg)	136.26	135.84	132.32	136.24	139.74	350

4.15. Microbiology

4.15.1 Surface Water Microbiology

The microbiological properties of the surface water are presented in Table 4.27. In the dry season, Total Heterotrophic Bacteria (THB) population densities varied from 1.03 to 1.63×10^2 cfu/ml (Mean 1.28×10^2 cfu/ml) while Total Heterotrophic Fungi (THF) loads ranged from 1.00 to 1.35×10^2 cfu/ml with a mean value of 1.21×10^2 cfu/ml. Also in the wet season THB ranged from 1.03 - 3.25×10^2 with a mean value of 2.14×10^2 cfu/ml while THF ranged 1.00 – 1.15×10^2 cfu/ml with a mean value of 1.07×10^2 cfu/ml. Hydrocarbon degraders were absent from the population during the dry season but present in the wet season which confirms the fact that petroleum hydrocarbon may be present in quantities below 0.1 mg/l detection limit of the analytical instrument in dry season. Presence of petroleum hydrocarbon degraders suggests effective degradation of petrogenic hydrocarbon if spilled into the waterbodies during activities at the proposed project site. Total coliform loads in the surface water were of the mean values of 26MPN/100ml and 34.89MPN/100ml in the dry and wet seasons respectively. However, faecal coliform population ranging from 9 – 19MPN/100ml was obtained in the dry season; while a range of 9 - 20 MPN/100ml was recorded in the wet season. Obtained values compared favourably with values from Control points in both season. Presence of the faecal coliform reveals direct human defecation into the waterbody.

Table 4.27: Summary of microbiological properties of the surface water in the area

Microbiology	*Dry Season			Wet Season			DPR Limit	FMEnv Limit
	Range	Mean	Control	Range	Mean	Control		
THB, x10 ² Cfu/ml	1.03 - 1.63	1.28	1.275	1.03 - 3.25	2.14	2.38	N/A	N/A
THF, 10 ² Cfu/ml	1.00 -1.35	1.21	1	1.00 - 1.15	1.07	1.04	N/A	N/A
HUB, 10 ² Cfu/ml	Nil	Nil	Nil	1.90 - 2.68	2.33	1.90	N/A	N/A
HUF, 10 ² , Cfu/ml	Nil	Nil	Nil	1.00 - 1.44	1.08	1.02	N/A	N/A
Total Coliform, MPN/100ml	20-29	26	25	23.00 - 43.00	34.89	22.00	Nil	Nil
Faecal Coliform, MPN/100ml	9 - 19	13.55	14	9.00 - 20.00	16.33	17.50	Nil	Nil

Source: *Thermosteel Nigeria Limited (Dry Season (February 2017)); Wet season (April, 2017)*

4.15.2 Sediment Microbiology

Table 4.28 presents the population densities of the heterophilic and hydrocarbonoclastics bacteria and fungi present in bottom sediment collected from the waterbody in the area. Total heterotrophic bacteria loads ranged from 1.30 - 3.00x 10⁴cfu/g (mean value of 1.97 x 10⁴cfu/g) in the dry season and from 1.52 - 3.7 x 10⁴cfu/g (mean value of 2.27 x 10⁴cfu/g) in the wet season. Also, Total Fungi (THF) populations varied between 1.10 – 2.25 x 10⁴cfu/g and 1.10 – 2.35 x 10⁴cfu/g during the dry and wet season respectively. Hydrocarbon Utilising Bacteria (HUB) ranged from 1.07 - 1.43 x 10²cfu/g (mean value of 1.14 x 10²cfu/g) in the dry season and 1.90 - 3.65 x 10²cfu/g (mean value of 2.70 x 10²cfu/g) in the wet season. The population densities of the hydrocarbon utilising fungi (HUF) ranged from 1.00 - 1.03 x 10²cfu/g (mean =1.01 x 10²cfu/g) in the dry season and 1.00 - 1.05 x 10²cfu/g during the wet season. The high population density of the microbes recorded in this environment is an indication of a viable community with capacity to mineralise organic matter. Thus, low levels of mineral petroleum hydrocarbon recorded in the environment may be linked to degrading capacity of the hydrocarbonoclastics bacteria and fungi.

Table 4.28: Summary of Microbiological Measurements in Sediments of the Study Area

Microbiology	Dry Season			Wet Season		
	Range	Mean	Control	Range	Mean	Control
THB, cfu/g x10 ⁴	1.30 - 3.0	1.97	1.20	1.52 - 3.7	2.27	4.50
THF, cfu/g x10 ⁴	1.10 -2.25	1.29	1.13	1.10 - 2.35	1.80	3.23
HUB , cfu/g x10 ²	1.07 - 1.43	1.14	1.05	1.90 - 3.65	2.70	2.78
HUF, cfu/g x 10 ²	1 - 1.03	1.01	1.01	1.00 - 1.05	1.02	1.13

Source: *Thermosteel Nigeria Limited (Dry Season (February 2017)); Wet Season (April 2017)*

4.15.3 Soil Microbiology

The summary of the microbial loads in the soils of the proposed area are presented in Tables 4.29 and Table 4.30 for topsoil and bottomsoil respectively. The Total Heterotrophic Fungi (THF) load in the topsoil during the dry season ranged from 1.00×10^4 – 4.20×10^4 cfu/g with an average of 1.61×10^4 cfu/g while THF population densities in the bottom soil ranged from 1.00×10^4 – 3.50×10^4 cfu/g with a mean of 1.58×10^4 cfu/g. The microbial load recorded in the topsoil is expectedly high and this may be due to its relatively high organic matter load, which serves as source of energy and nutrients for microbes' growth. Also in the dry season, THB population ranged from $1.10 - 3.75 \times 10^4$ cfu/g in the topsoil while bottomsoil recorded a range of $1.05 - 1.85 \times 10^4$ cfu/g. In the wet season, THF population varied from $1.03 - 4.50 \times 10^4$ cfu/g in the topsoil while a range of $1.03 - 3.58 \times 10^4$ cfu/g was obtained in the bottomsoil. Similarly, THB was of population range of $1.15 - 6.00 \times 10^4$ cfu/g (mean = 3.05×10^4 cfu/g) in the bottomsoil and a range of $1.07 - 6.00 \times 10^4$ cfu/g (mean = 3.01×10^4 cfu/g) was obtained in the topsoil. The hydrocarbon degraders (HUF and HUB) population densities were relatively low and their HUF and HUB population percentage were far below 10%, indicating very negligible petrogenic hydrocarbon pollution in the soil of the study area.

The Total Heterotrophic Fungi (THF) load in the topsoil during the dry season ranged from 1.00×10^4 – 4.20×10^4 cfu/g with an average of 1.61×10^4 cfu/g while THF population densities in the bottom soil ranged from 1.00×10^4 – 3.50×10^4 cfu/g with a mean of 1.58×10^4 cfu/g. The microbial load recorded in the topsoil is expectedly high and this may be due to its relatively high organic matter load, which serves as source of energy and nutrients for microbes' growth. Also in the dry season, THB population ranged from $1.10 - 3.75 \times 10^4$ cfu/g in the topsoil while bottomsoil recorded a range of $1.05 - 1.85 \times 10^4$ cfu/g. In the wet season, THF population varied from $1.03 - 4.50 \times 10^4$ cfu/g in the topsoil while a range of $1.03 - 3.58 \times 10^4$ cfu/g was obtained in the bottomsoil. Similarly, THB was of population range of $1.15 - 6.00 \times 10^4$ cfu/g (mean = 3.05×10^4 cfu/g) in the bottomsoil and a range of $1.07 - 6.00 \times 10^4$ cfu/g (mean = 3.01×10^4 cfu/g) was obtained in the topsoil. The hydrocarbon degraders (HUF and HUB) population densities were relatively low and their HUF and HUB population percentage were far below 10%, indicating very negligible petrogenic hydrocarbon pollution in the soil of the study area.

Table 4.29: Statistical description of microbiological loads in the topsoil of the study area.

Microbiology	Dry Season			Wet season		
	Range	Mean	Control	Range	Mean	Control
Total Heterotrophic Bacteria,x10 ⁴ cfu/g	1.10 - 3.75	2.05	5.99	1.07 - 6.0	3.01	5.99
Total Heterotrophic Fungi,x10 ⁴ cfu/g	1.00 -4.20	1.61	1.63	1.03 -4.50	1.85	1.63
Hydrocarbon Degrading Bacteria,x10 ² cfu/g	1.02 - 1.85	1.39	2.75	1.03 - 3.50	1.45	2.75
Hydrocarbon Degrading Fungi,x10 ² cfu/g	1 - 1.20	1.03	1.04	1 - 1.68	1.06	1.04

Source: *Thermosteel Nigeria Limited (Dry Season (February, 2017)); Wet season (April 2017)*

Table 4.30: Statistical description of microbiological loads in the bottom soil of the study area

Microbiology	Dry Season			Wet season		
	Range	Mean	Control	Range	Mean	Control
Total Heterotrophic Bacteria,x10 ⁴ cfu/g	1.30 - 4.50	2.10	2.63	1.15 - 6.00	3.05	6.25
Total Heterotrophic Fungi,x10 ⁴ cfu/g	1.00 - 3.50	1.58	2.36	1.03 - 3.58	1.57	1.63
Hydrocarbon Degrading Bacteria,x10 ² cfu/g	1.05 - 1.85	1.34	1.35	1.00 - 3.75	1.48	4.25
Hydrocarbon Degrading Fungi,x10 ² cfu/g	1 - 1.20	1.05	1.05	1 - 1.10	1.04	1.04

Source: *Thermosteel Nigeria Limited (Dry Season (February, 2017); Wet Season (April, 2017)*

4.15.4 Ground Water Microbiology

Table 4.31 presents the population densities of the heterotrophic and hydrocarbonoclastics bacteria and fungi present in borehole water collected from the study area. Total heterotrophic bacteria loads ranged from 1.18 - 1.60x 10⁴cfu/g (mean value of 1.37 x 10⁴cfu/g) in the dry season and from 1.05 - 5.70 x 10⁴cfu/g (mean value of 3.14 x 10⁴cfu/g) in the wet season. Also, Total Fungi (THF) populations varied between 1.05 – 1.15 x 10⁴cfu/g and 1.02 – 1.10 x 10⁴cfu/g during the dry and wet season respectively. Hydrocarbon Utilising Bacteria (HUB) ranged from 2.15 - 2.65 x 10²cfu/g (mean value of 2.42 x 10²cfu/g) in the wet season and HUF ranged from 1.00 - 1.03 x 10²cfu/g (mean value of 1.01 x 10²cfu/g) also in the wet season. The population densities of the hydrocarbon utilising fungi (HUF) and hydrocarbon utilising bacteria (HUB) in the dry season is nil showing no hydrocarbon pollution of the environment. The population density of the microbes (THB and THF) recorded in this environment is an indication of a viable community with capacity to mineralise organic matter. Thus, low levels of mineral petroleum hydrocarbon recorded in the environment may be linked to degrading capacity of the hydrocarbonoclastics bacteria and fungi.

It is noteworthy that faecal coliform level was also low or completely absent indicating a relatively clean environment.

Table 4.31: Summary of Microbiological Measurements in Borehole of the Study Area

Microbiology	Dry Season			Wet Season		
	Range	Mean	Control	Range	Mean	Control
THB, cfu/g x10 ⁴	1.18 - 1.60	1.37	1.28	1.05 - 5.70	3.14	3.28
THF, cfu/g x10 ⁴	1.05 - 1.15	1.05	1.02	1.02 - 1.10	1.05	1.53
HUB, cfu/g x10 ²	Nil	Nil	Nil	2.15 - 2.65	2.42	2.17
HUF, cfu/g x 10 ²	Nil	Nil	Nil	1.00 - 1.03	1.01	1.15
Total Coliform Count (MPN/100ml)	11.00 – 15.00	13.67	10.00	9.00 – 12.00	10.66	8.00
Feacal Coliform (MPN/100ml)	2.00 – 4.00	3.30	Nil	0 - 15	8.00	3.00

Source: *Thermosteel Nigeria Limited (Dry Season (February 2017); Wet Season (April 2017)*

4.16 Social Profile

4.16.1 Stakeholder's Communities

The identified stakeholder's communities in the Uzu Field Development are Okolobiri, Kumbo-ama, Ogboloma, Negugo, Agbia, Ayama, Okotiana, New Jerusalem, Nyambiri, Epie-Zarama, Igbogene and Obungha communities. These twelve communities were visited during the EIA exercise. The communities are of the Ijaw ethnic nationality. Each of the communities is autonomous but have historical links. They all come under the administrative jurisdiction of the Yenegoa Local Government Area (YELGA) of Bayelsa State.

4.16.2 Settlement History

Most of the stakeholder's communities are descendant of Gbaranwei, the founder of Gbaran clan. Be that as it may, most of the communities still claim to have distinct history but all narrative still point to Gbaranwei as founder of the Gbaran Kingdom. Okolobiri community migrated from Kabou-wei from Kumbo clan. They settled in present day Okolobiri primarily for fishing and farming because of the perceived fertility of the land. Kumbo-ama community on the other hand said Gbaranwei is their founding father, who beget Ogoro and Ogoro beget five children, namely Okolobiri, Agbin, Akinima, Odudun. However, of recent, Agbin, Akinima and Odudun opted out of Okolobiri to form Kumbo-Ama community. It was observed that most of the communities in Gbaran Kingdom, which happened to exist as one community have now, become autonomous communities. However, the fact remains that they still trace their ancestry to the same founding father (Gbarawei) according to oral history. Zarama is another clan in the Uzu FDP which comprises Epie-Zarama, Nyambiri, and New Jerusalem communities

The stakeholder's communities proposed field development are permanent communities. The communities are rural and linear settlement. The housing pattern, type and structure of the

settlements reflect very much a rural setting of the project environment. Houses, it is said, are built according to family/lineage ties and transportation and communication routes. It's important to know that before now, land was not that an issue...the major influence on the pattern of settlements was basically the kinship/lineage ties and land ownership right. Even though, Uzu Field stakeholder's communities are rural, that cultural affinity to family ties still plays a vital role on how houses are built (Plate 4.10).



Plate 4.10: Some Uzu Field Development stakeholder's communities traversed by tarred roads and internal streets/quarters; also the housing pattern and stock (housing type/quality), showing a typical rural environment.

4.16.3 Religion, Customs, Belief System and Heritage

The Uzu Field Development stakeholder's communities are mainly Christians by religion. On the average, over 95% of the respondents across the surveyed communities claim to be Christians as against the few who claimed to be practitioners of African Traditional Religion (ATR). A fewer number claimed to be muslims. The people celebrate Uzu as their festival. Uzu festival is celebrated annually; during the festival, all sons and daughter of Gbarawei far and near comes home for the celebration. Uzu festival according to the people serves as a unifying factor to the people. There were also churches like (The Anglican Church, Catholic Churches, Assemblies of God Church, Redeemed Christian Church and Living Faith (Winners Chapel), Christ Apostolic Church, and white garment churches etc) in the communities.

Sacred shrines exist either within the community's centre or are located far out in the forests/bushes or close to streams/rivers/water-courses. There was also mention of the sacred sites located at the Abani and Kalama bush at Kumbo-Ama community. Kumbo-Ama was the only community that disclosed their sacred forests while other communities could not have mentioned names but said such sacred sites exist in their milieu. Field visit showed that such traditional places of worship are cultural heritage centers, although not much attention is given to them these days. More often than not, trespasses without the required permission can cause outrage which attracts financial reparation. Seasonal cultural festivals and dances at revered shrines have been reportedly jettisoned by some members of the communities due to the Christian religion.

The stakeholder communities of the Uzu Field Development project have rich and well established cultural and traditional institutions. The community folklore and songs of its

inhabitants, as depicted in the numerous cultural societies of its men and women which practice a healthy competition in folk dances, songs and religious serenades are examples.

Social maladies such as incest, adultery, stealing, fighting with knife or cutlass, bottles or gun, having sex with a woman in the bush are according to the the customs and beliefs of the people taboos and any offender is severely dealt with, either by paying of fines or appeasing the gods and/or ancestors. Polygamy is a practiced form of matrimony, inheritance is partrilineal and payment of pride price and dowry on girls intended for marriage is also a custom among the people of the Uzu Field Development stakeholder's communities.

4.16.4 Political Structure and Governance

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 stakeholder communities in the Uzu FDP are still being governed on the principles of gerontocracy where considerable executive, legislative and judicial functions are vested in the oldest man and his cohorts. As a result, in majority, if not all of the communities concerned, the traditional governance and power structure is organized into hierarchies from the clan level to the individual village/community down to the quarters that constitute each settlement.

The Royal Highness (The Amayanabo) in Ijaw land, the Council of Chiefs/Elders, the Town Union and the well-known Community Development Committee (CDC), the quarter chairmen, the youth group, and the women's forum respectively constitute the local and traditional administrative structures of the Uzu Field Development stakeholder's communities (Fig. 4.33). Depending on the clan and the system of administration, the King or clan head is called Amayanabo in Ijaw, and such title may be hereditary in some clans. While the kingship system maintained a highly centralized type of government with the King assisted by a council of chiefs, the clan head (in the rule by the elders system) is assisted in the day-to-day administration of the polity by titled holders selected from the various age grades recognized in the clan. Due to political expediency and Kingship in modern day Nigeria, the number of Ijaw clans adopting the Kingship system has increased. Today, the traditional political system operates side by side with the Western system.

In the communities surveyed, the rung of power follows thus; Clan head (Monarch) and Council of Village Chiefs, Village Head (Paramount Chief) and Village Council, Elders/Councils of Chiefs, Community Development Committee (CDC), Women, Youth group, and other community members takes decision collectively with the clan head. The Clan head in Ijaw oversees his clan while the village head takes charge of their respective village and report to the clan head. Also, the Elders Council serves as advisers while the committee Development Committee takes charge of developmental issue; the youth serves as law enforcers. Meanwhile, in the formal traditional power structures, there are several organizations, including those representing social and business

interests like the farming, trading and co-operative societies for men, women and youth respectively.

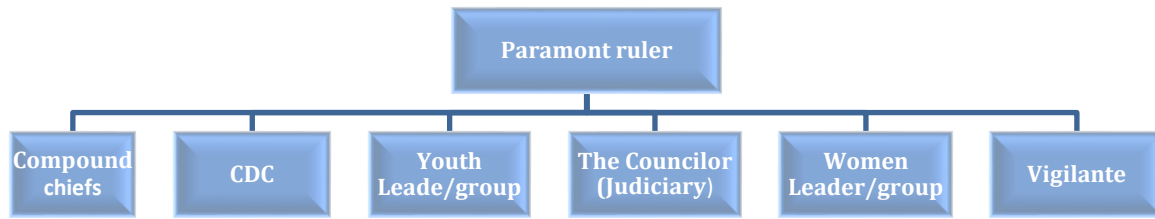


Fig. 4.33: Typical Traditional Leadership structures in Ijaw community

4.16.5 Conflicts and Conflict Resolution

Conflicts and contentious issues are often resolved in the clan or community through the joint efforts of the traditional head (*Amayanabo*), the Council of Chiefs/Elders, the Village Heads, Community Development Union or Committees (CDU/CDC), the Youths as well as Women groups (Table 4.32). The rungs of power are many as revealed by the well-organized leadership structures from the family heads, quarter heads, all through the various organs and ends at the feet of the paramount chief (clan head). In the event that a community member goes contrary to the law, the issue is handled from the lower organs like the youth or women group and whoever that is find guilty is punished according to the level of the offence. Whilesmaller crimes could attract payment of fines, serious crimes if not successfully resolved at the community level are handed over to the police.

Table 4.32: Traditional Governance/Power Sharing and Community Structure in Uzu Field Development Stakeholder’s Communities

Community	Community and Traditional Power Structures
Ijaw community	<ul style="list-style-type: none"> ✓ Community is one of the many constituent villages of the clan; the Amanayebo (His Royal Highness) of the Kingdom is the traditional head of the clan ✓ The Royal Majesty (Oversees individual community that makes up the clan ✓ The Council of Chiefs are the Royal Highness cabinet that helps in making decisions in the Kingdom ✓ The CDC Chairman and his cabinet – takes charge of the day-to-day running of the community, ✓ The Youths Presidents and its cabinet – these people helps the community when necessary and enforce the law of the community ✓ The women leader and her cabinet – take care of the community women interest and sometimes assigned to clear the water front.

Source: Field Survey Data, February 2017.

4.16.6 Population and Socio-Demographic Characteristics

Bayelsa State is one of the nine States created in 1991, excised from the present Rivers State. At its inception, it had eight (8) Local Government Areas (LGAs). Bayelsa State as revealed in 2006 census had a population of *1,704,515*, comprises of *874,083* males and *830,432* females, distributed into about *352,025* households. It also encompasses a landmass or area of over *9,415.76 km²* and this shows an average density of *181.0* persons per *km²* (NPC 2006).

Going by the 1996 National population census, the stakeholder communities had a population of 27,551 people made up of 14,548 (53%) males and 13,003 (47%) females. Using an annual growth rate of 3.5% and the exponential growth model, the population of the stakeholder communities as at 2017 is projected to be 64,669. By 2030, the population of the stakeholder communities is expected to have grown to 101,139 people, everything being equal (Table 4.33). Out of the 12 stakeholder communities, Okolobiri stands out as the most populous followed by Ayama, Igbogene, Nedugo/Agbia, Obunagha, Ogboloma, etc; in that order. The least populous stakeholder community is New Jerusalem (Table 4.33). It should be noted that the communities that do not have population figures were not reckon as autonomous communities at the time of the 1996 national population census. For example, Agbia was part of Nedugo/Agbia as at 1996 when the census was conducted while Kumbo-ama is an emergent autonomous community.

Table 4.33: Actual and Projected Population of the Stakeholder Communities 1996 -2030

Communities	Males	Females	Both_Sexes	1996_Proj	2002_Proj	2017 Proj	2030 Proj
Okolobiri	3103	2955	6058	7169.44744	8487.520209	14219.55706	22238.7624
Ogboloma	1252	1036	2288	2707.77414	3205.587032	5370.476486	8399.18925
Nedugo	1922	1810	3732	4416.70153	5228.693533	8759.885596	13700.0762
Agbia						0	0
Ayama	3015	2550	5565	6586	7796.805871	13062.3696	20428.9721
Okotiamama	282	308	590	698.245954	826.615537	1384.869373	2165.87485
Kumbo-ama						0	0
New Jerusalem	168	105	273	323	382.3955732	640.6459764	1001.94216
Nyambiri	883	873	1756	2078.16931	2460.232005	4121.746813	6446.23091
Epie-Zarama	582	493	1075	1272.2278	1506.121529	2523.278943	3946.2974
Igbogene	1960	1576	3536	4184.74185	4954.089049	8299.827296	12980.5652
Obunagha	1381	1297	2678	3169.32655	3751.993912	6285.898614	9830.86923
TOTAL	14,548	13,003	27,551		38,600.05	64,668.56	101,138.78

Source: Computed from NPC 1996 Census Figures

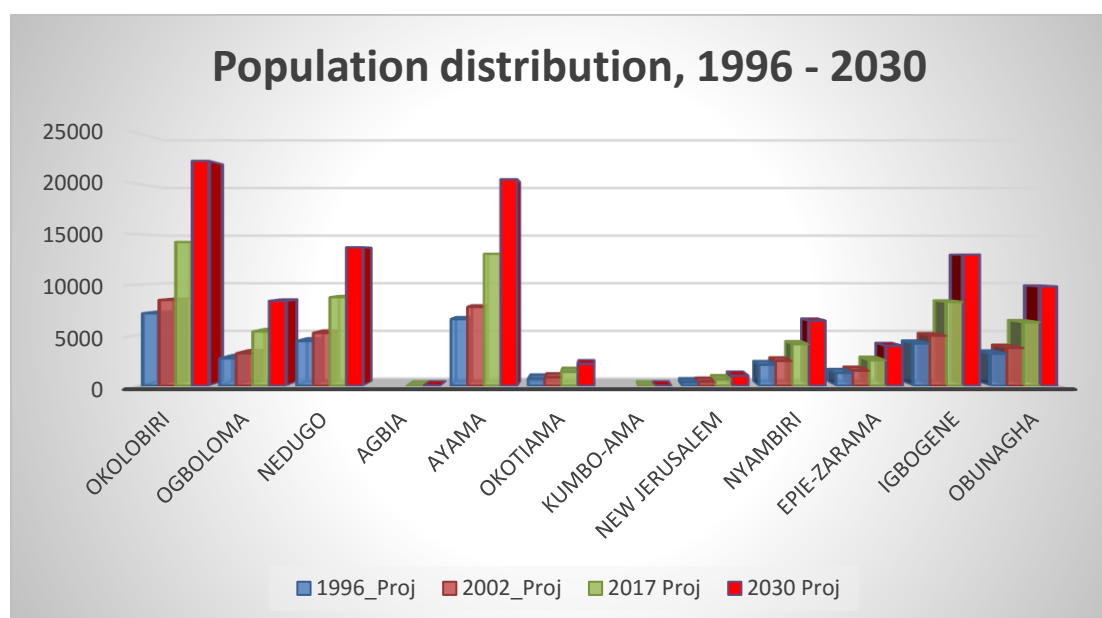


Figure 4.33: Population of Stakeholder Communities, 1996 – 2030

4.16.7 Household Size and Marital Status

The sizes of households vary from community to community and are influenced significantly by the cultural attitude of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. 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.

Marriage in the stakeholder communities is a socio-cultural norm that is highly recognized and those that marry do so sometimes at a relatively early age. Some men marry more than one wife (ie polygamy) as well as other concubines they keep. On the average, about 59.9% of the respondents claimed to be married while about 28.6% claimed to be single. Those divorced/separated are 5.4%, and those widowed account for 6.1% of the respondents). Details of the marital status of respondents in each of the stakeholder communities in the Uzu FDP are furnished in **Fig 4.34**.

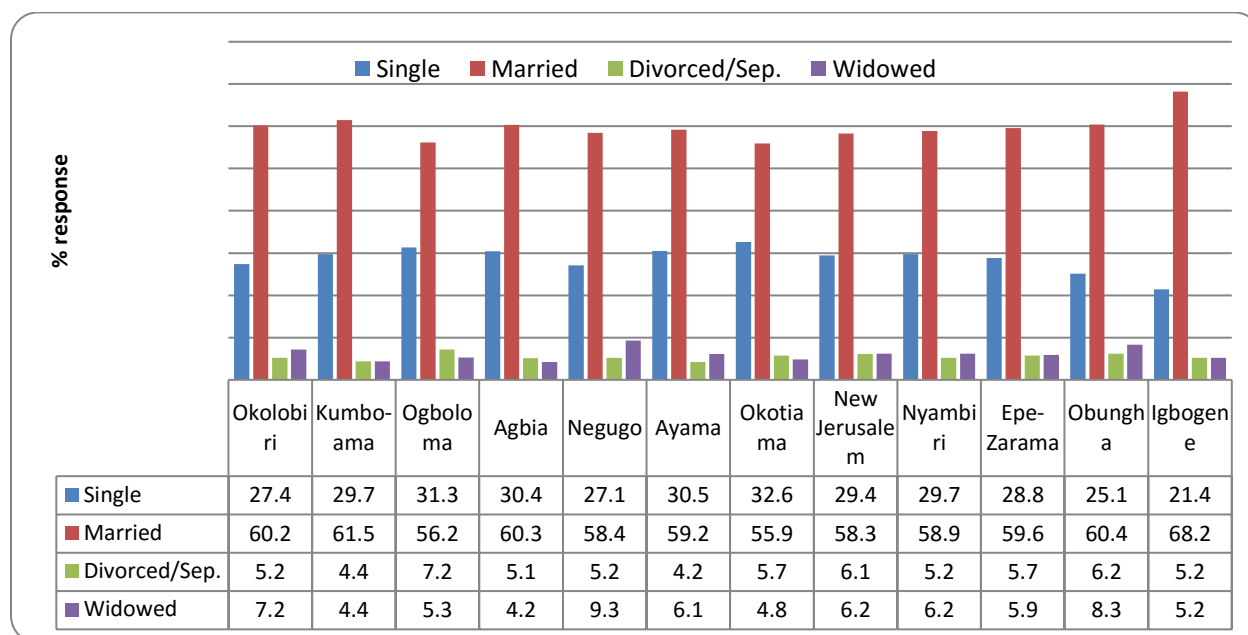


Fig. 4.34: Marital Status of Respondents

4.16.8 Age and Sex Distribution/ Population Structure

The age distribution of respondents shows the typical pyramidal structure with a broad base and a tapered apex. That is, the younger ones in the population are predominant and the aged ones fewest. On the average, children aged 0-4 years constitute 11.6%, those aged 5-12 years account for 12.3% of the household members and children aged 13-18 years (secondary school age) makes-up about 15.1% of the population. The age range of 19-25 years constitute 19.2% and that of 26-59 years constitute 26.2% (both active working proportion), those aged 60-69 years account for 10.3% while those that are 70 years and above account for 5.3% of the respondents (**Fig. 4.35**). These results suggest that the population of the stakeholder communities is a young and growing one with a likely high dependency ratio. It also calls for investments in education and other children and youth development programmes and facilities.

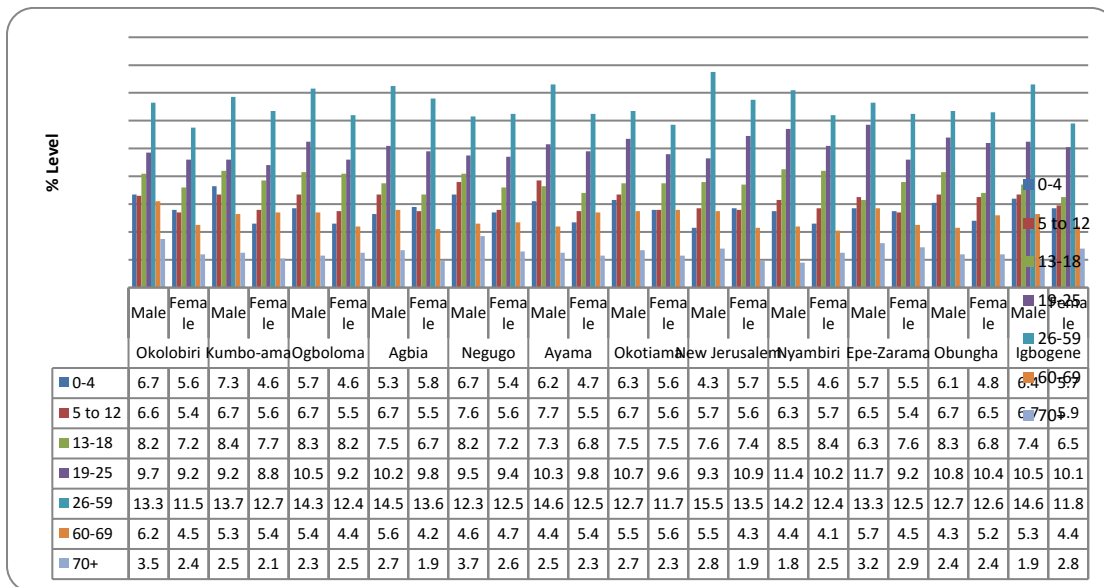


Fig. 4.35: Age and sex structure of sampled households

Sex distribution of respondents in the stakeholder communities shows a disproportionate sex structure. The field survey revealed that the males are more in number constituting approximately 63.3% to the females’ 36.7% of the population, which is in line with the community’s’ population structure (Fig. 4.37). According to the 2006 census, the males (71,345,488) out-numbered the females (69,086,302) with the male-female ratio as almost equal at 50.8% males to 49.2% females. Surveys carried out in the course of the Niger Delta Master Plan development process also show that there are actually more males (54%) than females (46%) in the Region.

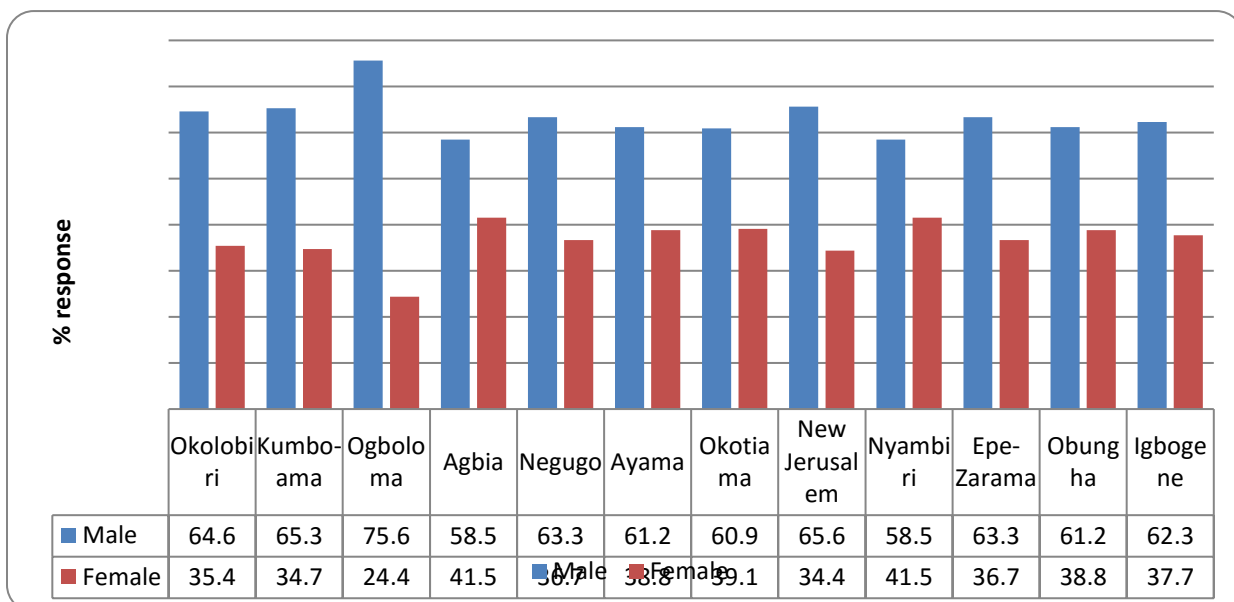


Fig. 4.36: Sex of respondents

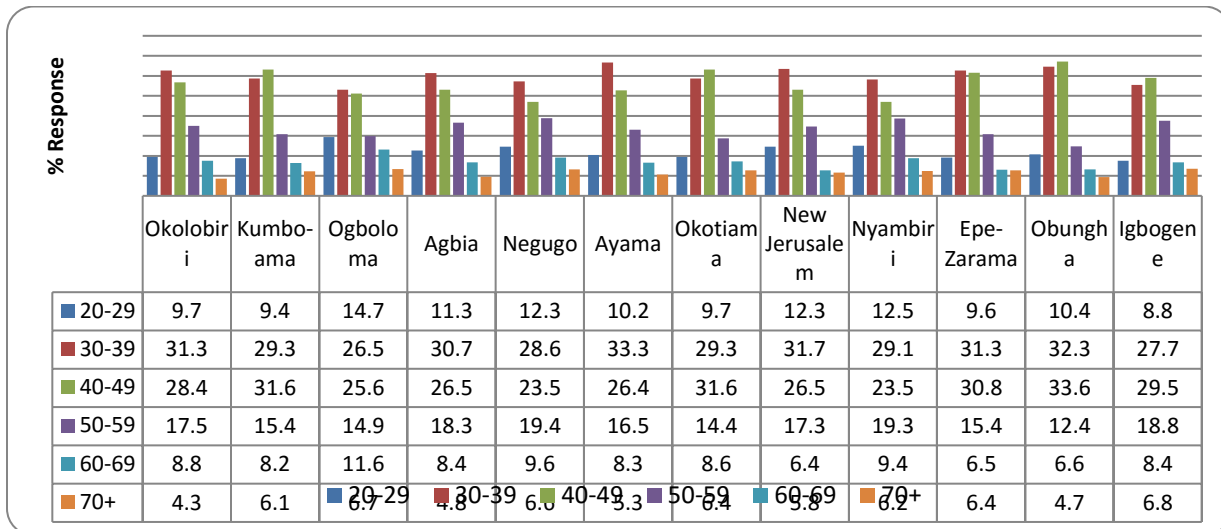


Fig. 4.37: Age Distribution of Respondents

4.16.9 Formal Educational Attainment of Respondents

Majority of the respondents surveyed claimed to have acquired some level of formal education. For example, 93.85% of the respondents claimed to have attained some form of formal education. Only 7.8% said they have not acquired any level of formal education. People who have attained secondary school education constituted the modal class of 62.4%. This is followed by those who attained primary school education (have primary school leaving certificates, 30.7% have senior school certificate, 18.5% have acquired vocational training, 15.1% have tertiary certificate; 7.8% do not have any formal educational training (NFE), and 4.4% others, **Fig. 4.38, 4.39**. Meanwhile the possession of degree certificate was found to be lower with no respondents possessing master/Ph.D. It can be said that, 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. Literacy and educational attainment of respondents' children in the households showed that about 53.45% of the boys and 46.55% of the girls are presently attending various schools within and outside the community. Analysis further showed that 63.45% of the household have secondary education while 36.55% have post-secondary education.

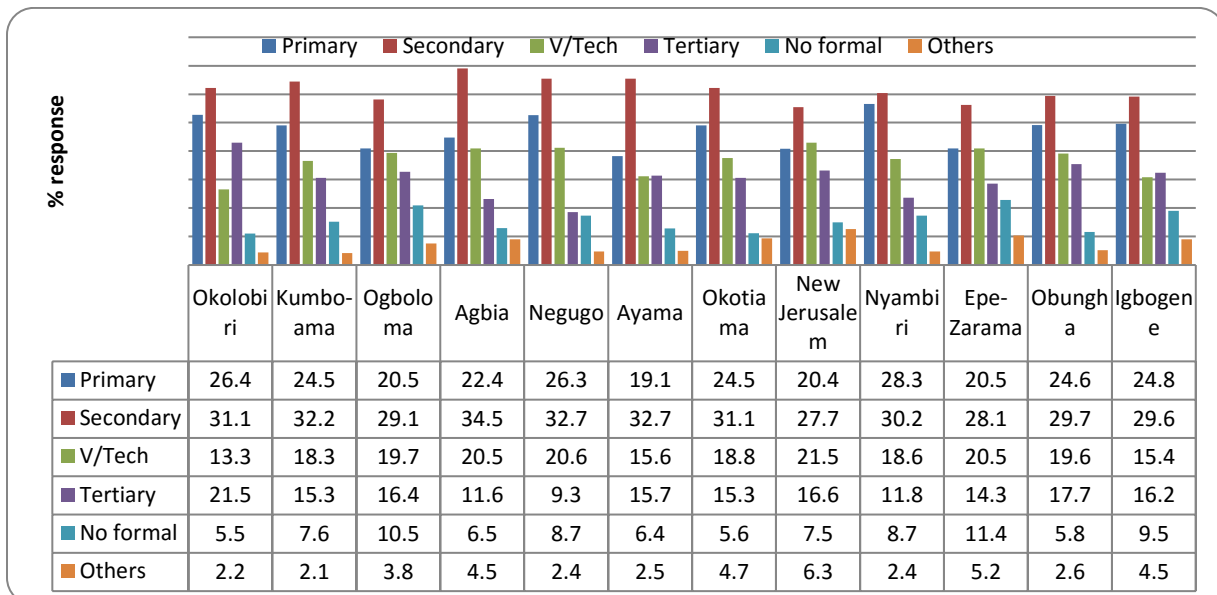


Fig. 4.38: Education level of respondents

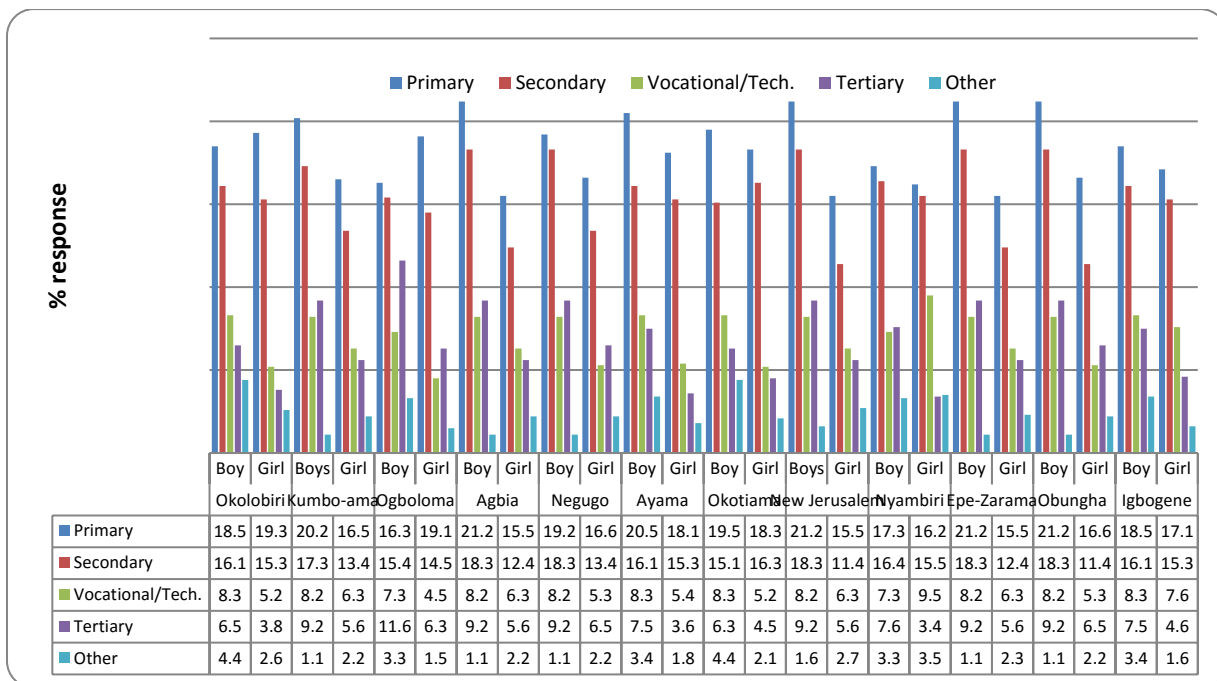


Fig 4.39: Education attainment of household

4.16.10 Livelihood and Microeconomy

Responses from survey analysis and focus group discussions (FGDs) revealed that the inhabitants of the surveyed communities are predominantly farmers. Paid employment, trading, business/contracting, artisans to a large extent form part of the economic mainstay of the greater proportion of the adult population (male and female). The average response shows that, farming 12.6%, fishing 28.7%, and trading 9.8% account for the primary occupation of the people

respectively (Fig 4.40). Also, 9.4% of the population engages in technical/artisan jobs. Other economic activities include Business/Contracting 7.4% and unemployment 19.5%. Also 8.3% of the sampled populations are civil servants, students/apprentice 8.3%, industrial works 3.7% and others 2.1%. The 19.5% unemployment shows that employment issues are of serious concerns in the host communities

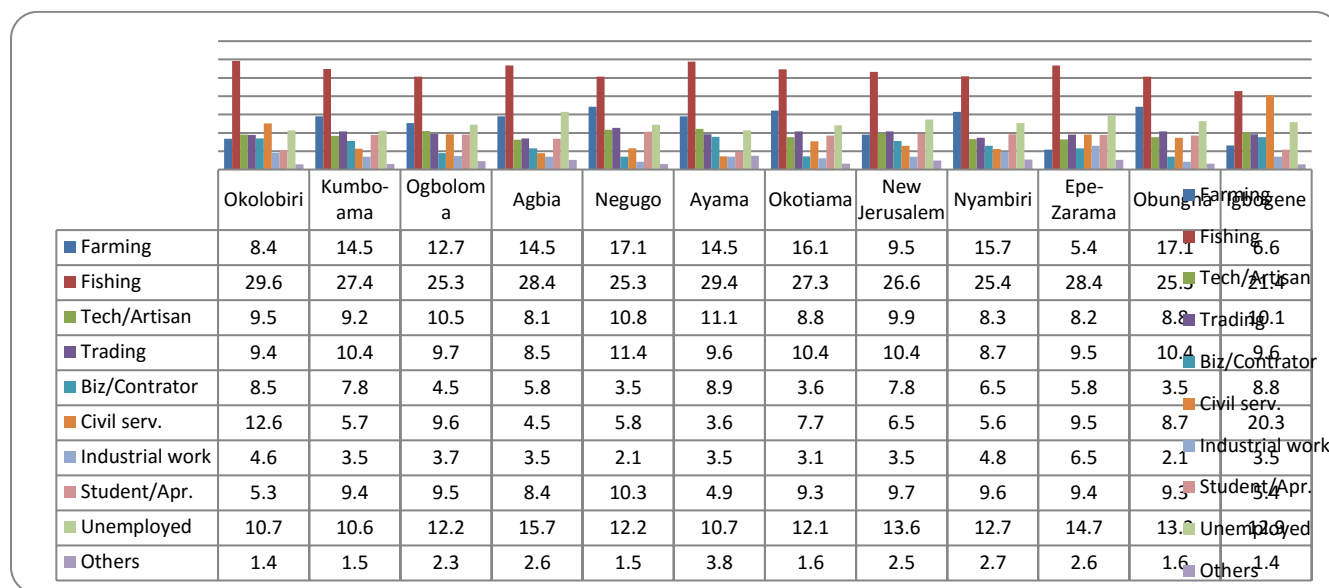


Fig. 4.40: Occupational Distribution of Respondents

4.16.11 Land Use and Management

Generally, land is Nigeria’s most important long-term resource base and in areas where this finite resource is in short supply can be very contentious. Practically everywhere therefore, Nigerians share land as a common denominator wherein lie most of their hopes and most of their problem. Land means many things, and the manner in which it is acquired, owned, used, and transferred is referred to as *land tenure* (NEST 1991, Igbozurike 1978). Before rights can be exercised over land, it has to be acquired in one of six principal methods of land acquisition, namely, inheritance, purchase, lease, pledge, exchange, and gift.

Land is the base for all human activities, including agricultural and industrial development. Meanwhile, land is a finite resource .in other words, it is fixed in supply. Therefore, with a fast growing population as we have it in the study area land for all kinds of uses has become smaller with each passing year . By providence, land resource availability is limited in Uzu Field Development stakeholder’s communities due to bordering water-courses and overwhelming influence of hydrology leaving very limited land space either for habitation or cultivation. As such, the little available land is held in very high value. Of course, since land on which oil wells and facilities are located yields huge benefits to the land-owning individual, family or community land tend to be protected by all means.

Land in Nigeria falls under four broad ownership classes, regardless of who the law says holds the land in trust for whom. They are individually-owned, family-owned, communally-owned, and government-owned land. Two forms of land-ownership are common in the study area, namely, *family inheritance* and *communal land ownership*. Land in the community according to narratives are owned by the founding families in the community and the power is vested in the eldest man in the family, while some portions are equally owned by the entire community. This implies that land is passed down the generations and acquired through family inheritance. In recent times however, and due to urbanization, private ownership of land is increasingly becoming common, through the sale of land especially to non-indigenes. Land made available to government and corporations (oil companies) for major public projects/utilities (schools, hospitals/clinics for example) come out of communally owned land as well as lands used by the community to set-up civic centers/town hall, markets, schools, places of religious worship).

In the study area, arable land is used for cropping for between 2 and 5 years thereafter, the land is allowed to fallow so it could regain nutrients and fertility naturally through the use of shifting cultivation. Virgin land is cleared for cassava, yam, plantain, sweet potatoes, maize, melon and pepper and cocoa yam in the dry season in a mixed farming system. Be that as it may, bush fallow system is on the decline for it is usually between 4-5 years before a farmer returns to its original land to cultivate/plant. However, these days, lands are hardly left to fallow beyond three years. This could be attributed to the increase in population and other competing uses such as land take for industrial (oil and gas) activities and urban development. This is why land takes by oil and gas pipelines, flow-stations, oil wells and processing facilities, waste management plant can and do have substantial effects on cultivable land.

4.16.12 Agricultural Produce/Fisheries and Productivity

Agriculture, including fishing is the major occupation of the inhabitant population in Uzu Field Development stakeholder's communities. The principal crops planted by the people are yam, plantain, sweet potatoes, cassava, oil palm, cocoyam, banana, maize, pepper and vegetables (Plate 4.11). Agricultural yield in the surveyed communities showed a drastic reduction over the years, a significant percentage of the respondents (65.3%) agreed of a reduction in crops harvest as against about 34.7% who have witnessed no reduction. Different reasons were attributed for the reduction, but 'oil spillage' and 'infertility of the soil' are the most frequently mentioned. 'Inadequate/lack of capital' continued use and reliance on local technology (poor technology and/or the use of local tools and methods) and again oil spillage/pollution are perceived as constraints inhibiting effective farming/high productivity.



Plate 4.11: Harvested palm fruit gathered for processing; Harvested palm fruit; pelagic resource (periwinkles); & harvested plantain for sale in the communities.

4.16.13 Market system

Even though, the livelihood system is mainly subsistent, excess produce from the farms and fishing are often taken to the markets for sale to earn incomes. The marketing system in the studied communities is such that individual stakeholder's community has a daily market. However, the clan has a central market at Gbarain where all the communities cluster usually congregate every eight (8) days, which is when the market is held. In the communities, market goods/articles can be found on display in numerous shops along the major streets and roads. Market structures or not, traders in the communities with known market days also take their wares to nearby markets like Yenagoa, Mbiama, and Ughelli where both the population and market value are perceived to be higher.

4.16.14 Income Sources and Levels

Income is an important variable that influences socioeconomic status of individuals and its distribution pattern 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 many people do not keep records and are therefore uncertain of the gross or net amount actually earned from self-endeavors. Many household members are also engaged in several income-generating activities and the respective contributions of economic activities cannot be accounted for. The result being that income of the household members in the community are not reliable. The studied communities' income calculation was difficult to obtain.

The income levels were found to be meager and variable had 6.5% earning less than NGN 5,000 in a month, 9.5% of the population had income in the bracket of NGN5001-10,000, 9.7% earn between NGN10001-15000. Also, 11.4% and 10.2% earn between NGN15001-NGN20000 and NGN20001-NGN25000 respectively. While 9.7% also earn between NGN25001-NGN30000, 8.7% earn NGN31001-NGN35000, 8.2% earn between NGN35001-NGN40000, 7.1% earn NGN40001-45000 and 8.1% earn NGN450001-NGN50000 while 10.9% earn N50000 and above per month. Residents who are into Business/Contracting however, earn better incomes (Figure 4.41).

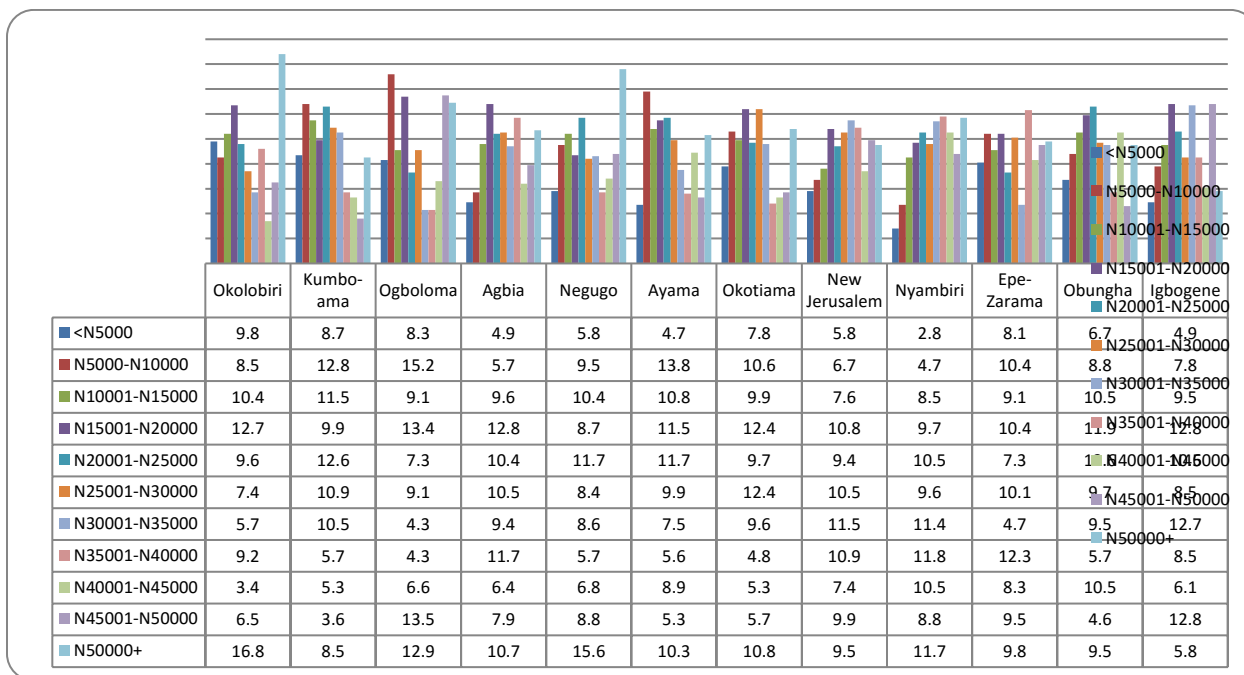


Fig. 4.41: Respondents income estimate/month

4.16.15 Infrastructural Facilities and Quality of Life

The number of infrastructure and social amenities available and functional in any area or community has direct relationship with the quality of life and therefore the willingness of people to live and remain there. Again, it influences other socio-cultural and economic variables in the area. However, our rural areas have always been found to be deficient in this respect. More often than not, some infrastructures can be found, but they are usually either non-functional or in disrepair and need rehabilitation. The Uzu Field Development study environment and constituent communities are generally lacking of basic amenities. Educational institutions available are inequitably distributed and the few available are lacking basic teaching and learning materials, including teachers. Access to potable water; about 95% of the communities have existing boreholes but not functional; while primary health care services are in limited service. Electricity are constant only at Obungha community even as Okolobiri, Kumbo-ama, Igbogene, Okotiana, Epe-Zarama, Nyambiri, Agbia, Ayama etc have power but complained of epileptic supply.

(a) Educational and Social Infrastructural Facilities

The stakeholders' communities have government owned primary and secondary schools. However, these schools need upgrading and staffing with appropriate incentives to enable the staff put in their best in educating the pupils. The low number of educational institutions or facilities in the area may be responsible for the generally low level of literacy in the community as well as high school drop-out (Table 4.33).

Table 4.33: Summary of Infrastructures and Social Amenities Available in Uzu Field Development Stakeholder’s Communities

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Okolobiri	<ul style="list-style-type: none"> ✓ Has primary school by the Bayelsa State government. ✓ Has a secondary school by the state government 	Has access to energy (electricity) through but supply is epileptic	Access to community is via tarred road through Opolo-Gbaran road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Kumbo-ama	<ul style="list-style-type: none"> ✓ Has public primary school by the Bayelsa State government. ✓ Share secondary school with their sister’s community, Okolobiri. 	Has access to energy (electricity) through but supply is epileptic	Access to community is via tarred road through Opolo-Gbaran road.	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly mud houses with zinc, Mud with thatched roof, with few concrete/block house with zinc roof, and plywood/zinc roof
Ogboloma	<ul style="list-style-type: none"> ✓ Has Primary school by the Bayelsa State government but no secondary school. The children and wards go for their secondary education in the neighboring community and most at Yenogoa. 	Has no power supply	Access to community is via tarred road through Opolo-Gbaran road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Negugo	Has both primary school by the Bayelsa state government and secondary school.	Has power supply but epileptic in supply.	Access to community is via tarred road through Opolo-Gbaran road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Agbia	Has no primary school, shares primary school with Oknotiama community by the Bayelsa state government and secondary school.	Has power supply but epileptic in supply.	Access to community is via tarred road through Opolo-Gbaran road	Has access to potable water supply by MDG. There are other boreholes but not functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Ayama	Has no primary and secondary school. They share primary school with Oknotiama community by the Bayelsa state government and secondary school.	Has power supply but epileptic in supply.	Access to community is via tarred road through Opolo-Gbaran road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Okotiamama	Has primary school by the state government but no secondary school.	Has power supply but epileptic in supply	Access to community is via tarred road through Opolo-Gbaran road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
New Jerusalem	Has no primary and secondary school. Children and wards go for their primary and secondary education at Ekpeye	Has power supply but epileptic in supply	Access to community is off East-West Road by Zarama market, through the tarred road.	Has access to potable water supply as at the time of this study. The water borehole is being provided by Seismic company operating in the area. There are other boreholes but not functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Nyambiri	Has primary school but no secondary school. Children and wards go for their primary and secondary education at Ekpeye	Has power supply powered by generator, a constituency project	Access to community is off East-West Road by Zarama market, through the tarred road.	Has access to potable water supply as at the time of this study. The water borehole is being provided by Seismic company operating in the area. There are other boreholes but not functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Epe-Zarama	Has both primary school and secondary school.	Has power supply powered but epileptic in supply	Access to community is off East-West Road by Zarama market, through the tarred road.	Has access to potable water supply as at the time of this study. The water borehole is being provided by Seismic company operating in the area. There are other boreholes but not functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Igbogene	Has both primary school and secondary school.	Has power supply powered but epileptic in supply	Access to community is through Mbiam-Yenogoa road	Has no access to public borehole. Depends on individual borehole as the existing public boreholes are no longer functional.	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Obungha	Has both primary school and secondary school.	Has constant power supply powered the SPDC	Access to community is through Mbiama-Yenogoa road	Has access to public borehole but not functional as at the time of our field visit.	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.



Plate 4.12: Available educational facilities in stakeholder's communities

(b) Electricity Supply and household energy

One of the communities in the Uzu Field Development project communities (Obungha) is connected with constant power supply courtesy of SPDC. Meanwhile, the other communities also have access to electricity but its supply is reportedly epileptic. In the absence of this basic amenity, community members who can afford it purchase private generators for personal use and for business to power electrical appliances, e.g. fridges and refrigerators for cooling of drinks. The local hurricane lanterns remain the old-time means for light of homes in the studied communities. Firewood (fuel-wood) energy is also used for cooking of foods and processing of fish (smoking). The percentage of households with electricity in Nigeria according to the most recent national demographic and health survey (NDHS 2008) is 50%. There were more households with electricity in urban areas (85 percent) than in rural areas (31 percent) (NPC and ICF Macro, 2009).

(c) Transportation and Communication

Access to almost all the stakeholder communities is by road and it is not difficult because since the roads are tarred from Opolo Junction in Yenogoa to Gbaran where the communities are located. Land transport means to the community varies, ranging from motor vehicle, tricycle (Keke), motor cycle (Okada). Transportation fare from Opolo Junction in Yenogoa to the communities is between N100-N150. Transport to Gbaran communities are easy as you can see many tricycle and taxi plying the road and you could get there between 10-15 minutes depending on your speed.

Access to public communication facilities like the telephone services in the Uzu Field Development communities are available, however, depending on your location. Network provider like MTN and Glo are very much available while other networks are there, though not strong as it fluctuates. Communication in the stakeholder's communities is effective; hence you can communicate easily while in the area.

(d) Water Supply

Increasing access to improved drinking water is one of the Millennium Development Goals that Nigeria and other nations worldwide have adopted. The source of drinking water is an indicator of whether it is suitable for drinking. Lack of ready access to water may limit the quantity of suitable

drinking water that is available to a household, even if the water is obtained from an improved source. Water that must be fetched from a source that is not immediately accessible to the household may be contaminated during transport or storage. Another factor in considering the accessibility of water sources is that the burden of fetching water often falls disproportionately on female members of the household. Finally, home water treatment can be effective in improving the quality of household drinking water.

Data from the Federal Office of Statistics, (now the National Bureau of Statistics), reveals that water in the majority of Niger Delta states comes from unsafe supply facilities, including rivers, lakes or ponds, and unprotected wells and boreholes. The Bureau classifies available sources of potable water for household consumption as: pipe borne, untreated pipe, borehole, protected well, unprotected well, river/lake/pond, vendor trucks and other categories.

The availability of social infrastructures in the proposed Uzu Field Development communities, including potable drinking water are on ground but not functional. The sources of water for the population include shallow hand-dug wells, the natural rainwater and some of the creeks which have freshwater, for cooking and bathing as well as washing. The stakeholder's communities have water facilities; Okolobiri with Kumbo-Ama have about 10 water boreholes but none is functional as at the time of our field visit. The same applies to other communities, where some have 2-3 borehole but not functional. However, it is only at Agbia community that has a functional borehole provided by MDG. Sinking of borehole is not an issue in the project area but reactivating the existing ones. Lack of energy to pump the water and poor maintenance culture are the principal reasons for the non-functioning of the facilities. A common sight across the surveyed communities is the presence of containers (tanks, drums, basins and any useful vessel) that are placed outside the dwellings to harvest rainwater. Many households, depending on affordability use sachet (packet) water for drinking; a bag of sachet water is sold for N150 to N200 in the area.



Plate 4.13: (1) Functional Water facilities at Agbia community; (2) Typical non-functional borehole at Ayama community and host of them in other communities.

(e) Housing Types and Ownership

The available houses in the Uzu Field Development stakeholder's communities were found to be built with reliable materials such as concrete/block houses with zinc roof. There exist also few houses built with unreliable materials like reeds, thatch and wood/planks. A significant proportion of the housing stocks (69.9%) are constructed of concrete/block with zinc roof. Houses made of mud wall with zinc roof 10.7%,

wood/plank as walls with zinc roof also constituted some 6.9%, mud walls with thatch roof 6.9%etc. Meanwhile, insignificant proportions (5.6%) are made of others (Fig 4.42).

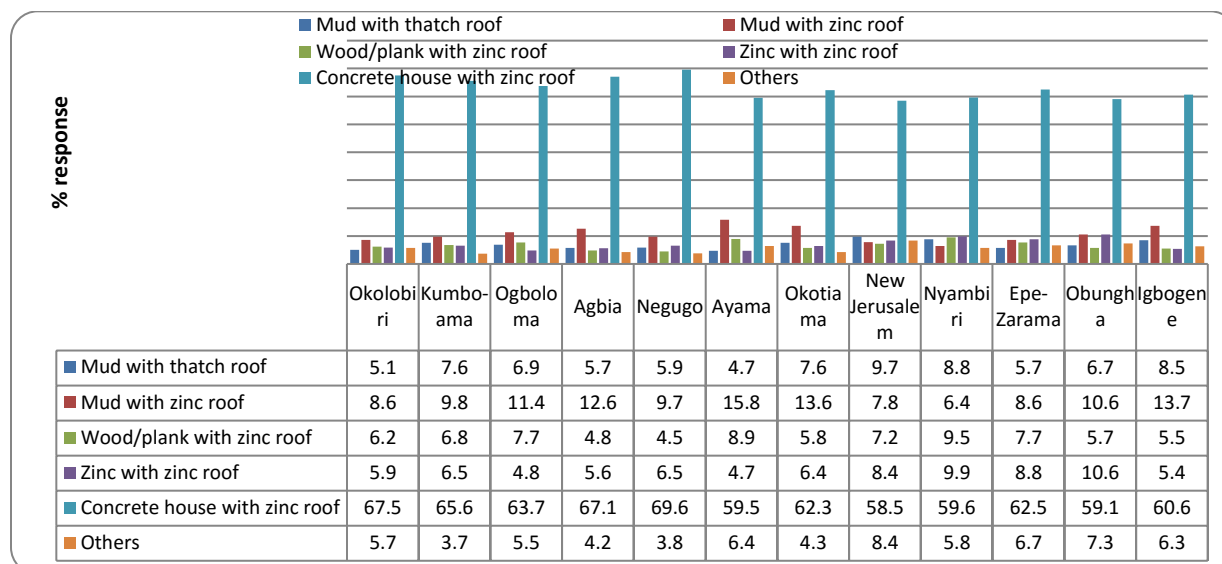


Fig. 4.42: Housing type/quality in the communities

(f) Community Halls, Recreational Facilities and Security

The Uzu Field Development Stakeholder’s communities are very organized as they are both social and hospitable people. There are however, dedicated meeting places in the communities where communal gatherings and meetings are held. The communities have town hall and a situation where meetings are not held at the town hall, it could be held at the Paramount Chief place in the community. Communal activities such as football, dancing, etc. are organized for recreation during festive periods. Common recreational activities among youngsters include football. The Gbaran and Zarama communities and its environs are relatively safe because of presence of police station and organized vigilante group.

4.16.16 Perceptions, Concerns and Social Needs/Expectations of the Population

Following discussion during the Focus Group Discussion forums, questionnaires were distributed to gather more information. Standardized SPDC EIA questionnaires were used to gather sufficient information. Individuals who were literate were guided in the filling of the questionnaires while illiterate individuals were read the questions to get as much information as possible. In addition to questionnaires shared additional interviews were conducted within the communities based on random sampling. Data from questionnaires and interviews showed that the communities were concerned about the potential negative impacts of the project irrespective of the perceived positive impacts. They showed awareness of SPDC intentions to put in place mitigations for the negative impacts. According to the community members, this will help to enhance whatever positive impacts the projects brings to the host communities. Negative impacts listed by community members includes air/water pollution, influx of people seeking for job opportunities, land take

while believe it will reduce their farm land, increase in cost of living, adulteration of culture and increase in motor/boat mishaps.

Perceived benefits of the projects include scholarship award to children and wards, provision of social amenities and renovation of the existing ones, and employment opportunities for the qualified and ready to work youths. However, they expressed fear/concerns about the likelihood of spills and flaring of gases into the atmosphere when operation starts which they believe will both degrade the water resources and ambient air quality in the surrounding environs. Again, the people said that the environmental resources which sustain their living could be threatened and the integrity of the environment compromised.

The stakeholder's communities when asked of their relationship with SPDC, on the average, they acknowledged having good cordial relationship with SPDC. They however, urge SPDC to carry them along as from hence and give them always what is due to them. Meanwhile, community consultation, FGD and responses from the administered questionnaires indicate that the resident populations are not in any way against the proposed Uzu Field Development and its operations amongst the stakeholder's communities. The fulfillment of promises and terms as may be contained in MoU when entered into is regarded as very vital in improving the company's relations with the affected communities. Provision of infrastructural facilities and maintenance of the existing ones, employment of indigene, completion and equipment of some health center and transparency in dealing with the communities, town hall and skills acquisition ranks very high among the expectations of the community members.

4.17 Health Profile

The health condition of the host communities of the Uzu Field Development Projects is similar to those of comparable communities in Bayelsa State, and the freshwater swamp ecological zone of the Niger delta region.

4.17.1 Socio-economic characteristics:

The socio-economic condition of most of the host communities of the Uzu oil/gas field development project is similar to those of the other communities in Bayelsa State, and the freshwater swamp ecological zone of the Niger delta region. Several members of these communities reside in Yenagoa main town and Port Harcourt, while those that live and ply their occupational activities in the communities are mainly farmers, fisher-folks, traders and transporters. Most members of these communities are farmers of cassava, yam, plantain and banana, with most of the farming carried out during the dry season, and at the bank of the river, because of the seasonal flood that is a perennial problem in the communities. Fishing is carried out in ponds, river and lakes in the communities, often as a common source of supplemental income to nearly all members of the communities.

The host communities of the Uzu field development project that are close to the SPDC Gbaran facilities such as the Obunagha community have become boom towns in recent years, because of the presence of the SPDC Gbaran facilities, and the employment opportunities and social amenities

that have been attracted into the communities. The population of these communities has significantly increased in recent years, such that persons from the major ethnic groups in the country could be found residing and doing business in the communities. The reasons for this influx according to the discussants in the Focus Group Discussion carried out in the communities include the regular electricity supplied by SPDC, the availability of jobs, and the proximity of the communities to Yenagoa main town.

The respondents of the questionnaire administered in the communities, for this health component of this Environmental Impact Assessment study were young, with an average age of 30.65 +/- 7.7 years. Most of the respondents 322 (81.31%) had at least secondary school education, and were mostly self-employed, famers, traders or had a job in the SPDC facilities, or its service companies.

4.17.2 Access to safe drinking water

The sources of drinking water of members of communities

Access to potable water is one of the Sustainable Development Goals. Most members of the host communities of the Uzu Field Development projects are able to meet the daily per capita water requirement of 20 – 40 liters, but mainly from a variety of sources such boreholes, sachet/bottle water, rainwater and river. The sources of drinking water in the communities are shown in Fig. 4.43. Most members of the communities get their drinking water from private borehole, sachet water, river and rain.

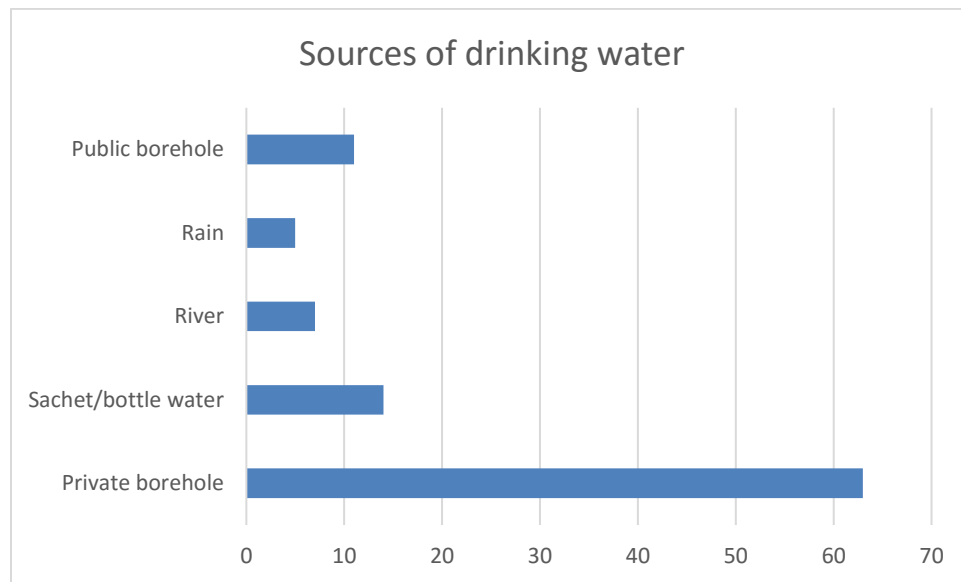


Fig. 4.43: The sources of drinking water of members of the communities

Private water boreholes were noted during the field study to provide most of the drinking water of members of the communities. This is in spite of the numerous public water facilities that were noted in all the communities, but were found to be non-functional at the time of the field study (Plate 4.14), due to reasons ranging from broken pipes, faulty pumps, and abandonment of the

project. Respondents at Ayama and Okotiana communities complained of the water being reticulated from the Gbaran water scheme at Obunagha community not getting to them; those at Nedugo and Agbia were unable to use the water facility in their communities, because of their very high iron content; while a respondent at Okolobiri complained of the choice parcels of land that are lost to the non-functional public water facilities. Members of the communities however preferred the public water facilities, because they are believed to produce water of better quality, unlike the private water boreholes. According to a discussant in Okolobiri community, the water from private boreholes taste as if too much alum was added to the water



Plate 4.14: From Left to Right - Non-functional water facility at Agbia, Okotiana, Nyambiri and Zarama-Epie communities

Sachet/bottled water is the main source of drinking water for several residents of the communities. According to the interviews carried out in the communities, this is mainly because of the taste of the ground water, and the obvious contamination of water from rain and the river. Rain water used to be an important source of drinking water in the communities (Plate 4.15), because according to those interviewed, tastes better than groundwater and water fetched from the river. Rain water is however currently used as a source of drinking by only about 5% of members of the communities. This was attributed to the contamination of the rainwater with soot, and its altered taste.



Plate 4.15: Rainwater collection system in Nedugo community

Water fetched from the river is rarely used for drinking, but commonly used for bathing (Plate 4,16) and other sanitation purposes, especially in the Zarama communities. This is because the

river in the Gbaran communities are more heavily silted, covered with aquatic plants, and obviously contaminated.



Plate 4.16: Bathing at the Taylor creek at Nyambiri community

The access to safe drinking water was noted to be about 80% in the communities, during the field study, which is better than the 58.8% average for south-south Nigeria and the national average of 55.8% (*NPC and Macro, 2008*). This improvement in access to safe drinking water is thanks to the efforts of the General Memorandum of Understanding SPDC signed with the communities.

Quality of drinking water in the communities

The WHO recognize the possible health effects of the various constituents of drinking water, and therefore set guideline values for each of them. Surface and ground water samples were taken by the relevant bio-physical experts, during the field studies. The results of these samples are presented in Table 4.27. The data presented in Table 4.27 showed the presence of total coliforms and fecal coliforms, much higher than the WHO guideline value of less than 10 and 0 MPN/ml respectively. This is however consistent with the findings in comparable communities, and have been attributed to the widespread use of the over-hung (jetty-type) toilet in the communities (Ordinioha 2011). The use of water contaminated with coliforms is capable of causing diarrhea, but can be made potable by the addition of chlorine tablets, especially those that also contain coagulants and flocculants, like the “water guard” marketed by the Society for Family Health. (Clasen et al 2005). The presence of trace metals such as iron and zinc in the samples of ground water is not necessarily a health hazard, but can be a valuable source of these essential micro-nutrients to members of the communities (Ordinioha and Sawyer, 2012). But at high concentrations, heavy metals can be toxic.

Although the quality of ground water in the communities is good, it however does not guarantee that the water at the point of use would also be as good. This is because most households in the communities do not have piped water supply, and have to collect and store water at home. Good

quality water collected from the vending tap and other water collection points can easily become grossly contaminated, in course of their transportation and storage at home (Clasen et al 2005). Chemical contamination of water in the communities is very likely, because discarded drums of drilling chemicals were noted during the field study, to be common water storage containers. The health implications of this must be recognized and tackled, as the health effects, especially from chronic exposures can easily be wrongly attributed to the proponent.

4.17.3 Access to sanitation facility

Access to sanitation facility is one of the Sustainable Development Goals. Sanitation facility was defined during the community survey as a private excreta disposal facility that is either a toilet or a latrine, but not an overhung toilet, or a flush toilet without septic tanks that channels its effluents directly into a water body. A household access was defined as when a household has a private sanitation facility, or shares a facility with not more than five other households in the building or compound (Billig et al, 1999).

The types of toilet facility used in the communities are presented in Fig 4.44. Access to toilet facilities in the communities was put at about 60% during the field study, especially when access to the jetty-type toilet that is commonly used in the Gbaran communities, and used in common by many households is included. Access to improved toilet facilities in the communities however falls as low as 25%, when the use of the jetty-type toilet is disaggregated from the data. The use of jetty-type toilet has been shown not to confer much health benefits, because it grossly contaminates the receiving surface water with faeces, and therefore exposes members of the communities to severally excreta-related diseases. Several members of the Zarama communities engage in open defecation, especially in the nearest bush, following the heavy fine imposed by members of the communities on defecating into the river.

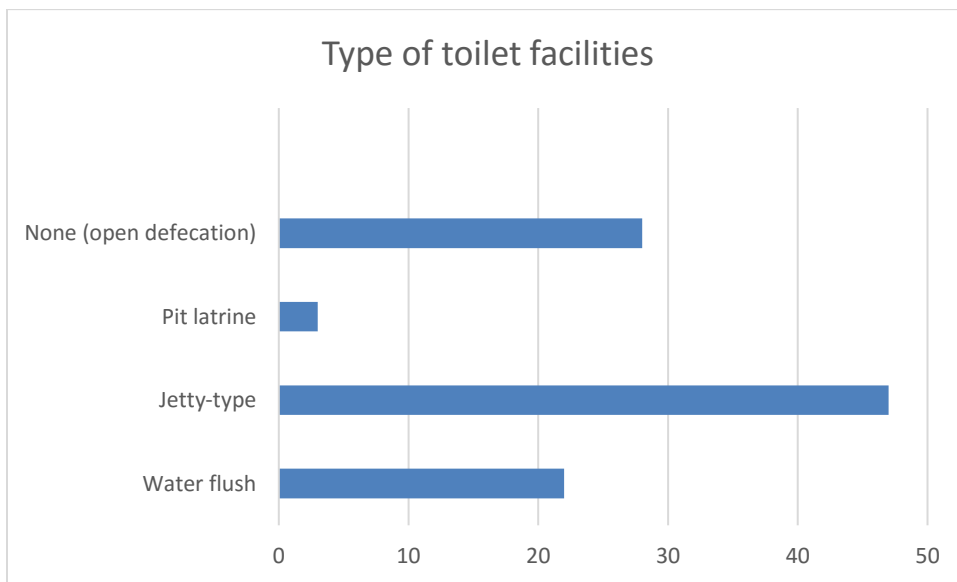


Fig. 4.44: Types of toilet facilities used in the communities

Access to sanitation facility in the communities is comparable to the Bayelsa State average of 16.9% (NDHS, 2013); but shows the enormous work that needs to be done to achieve the international benchmark of 80% access. Access to sanitation facility can however be improved in the communities through the use of sewerage system with sewage treatment facility, because of the high groundwater level in the communities that limit the use of pit latrine in the communities (Ordinioha, 2010)

4.17.4 Housing condition

The houses in the communities are built on the levees of the river, as is common in the communities of the freshwater swamp ecological zone of the Niger delta region. The housing characteristics of 20 houses located at the center of each of the host communities of the Uzu Field Development Project were noted during the field study. Most of the houses have roofs that are constructed with corrugated roofing sheets; have very high Damp Proof Course, because of the perennial seasonal flooding in the communities; and have floors that are constructed with cement (87%), mud (8%), and planks (5%). In this, the housing condition in the communities is better than the national averages for rural communities in Nigeria of 0.4% for planks/wood, 40.1% for cement and 48.6% for earth/mud (*NPC and Macro, 2013*).



Plate 4.17: The mosquito-breeding plantain tree can be observed planted in the residential quarters of the host communities of the Uzu field

4.17.5 Vector/pest control:

The following vectors were identified in the communities during the field study:

- Anopheles mosquito – the vector for malaria
- Culex mosquito – the vector for filariasis
- Aedes aegypti mosquitoes – the vector for yellow fever
- Tsetse fly (*Glossina* sp.) – the vector for sleeping sickness
- Chrsops – the vector of loa loa (eye swelling)
- Sand flies (*Phlebotomus* spp.) – the vector for Leishmaniasis

- Housefly – carrier of enteric infections such as dysentery, typhoid and diarrhea; and eye infections such as trachoma and epidemic conjunctivitis

Of all these vectors, the nuisance and diseases caused by mosquitoes are most seriously felt in the communities, as reflected in the focus group discussions held with representatives of the communities. According to a discussant in the focus group discussion from Okolobiri community: *“mosquito dey plenty for our community, especially during the rainy season when water dey everywhere”*.

4.17.6 Indoor and outdoor Air quality:

Firewood is the commonest source of fuel for domestic use in the communities. It is also the main fuel used in drying fish, the predominant method of fish preservation in the communities. The proportion of households during the Focus Group Discussion that predominantly use firewood for their cooking was high. There were also residents who use cooking gas and/or kerosene for their cooking.

The level of use of firewood in the communities is similar to the findings in other Niger delta communities where an average of 73% of the households in the communities were noted to use firewood as their primary energy source (UNDP, 2006). The use of firewood and other bio-mass fuel as domestic fuel is a major cause of indoor air pollution, with wide-ranging health implications (WHO, 2003).

The results of the air quality measurement carried out during the field studies are presented in Table 4.3. The results show that the levels of particulate matter recorded in the communities ranged from 10.8 to 92.44 $\mu\text{g}/\text{m}^3$, which are significantly below the Federal Ministry of Environment acceptable limit. This is even with the extensive use of firewood in the communities. The air quality in the communities are therefore good, considering that PM_{10} (Particulate Matter with diameter less than 10 microgram) do not just cause nose and throat irritation, but are also capable of lodging deeper into the respiratory tract, to trigger off asthmatic attack, and worsen pre-existing cardio-respiratory ailments. According to the 2013 NDHS, 1.7% of under-five children in the Niger delta region (south-south Nigeria) had symptoms of Acute Respiratory Infections, compared to 0.8% in the south-west zone and 2.1% in the south-east zone. The national average was 2.0%. The WHO estimates a 0.74% increase in the daily total number of deaths, and 0.8% increase in the daily total number of hospital respiratory admissions for every $10\mu\text{g}/\text{m}^3$ increase in SPM (WHO, 2000).

4.17.7 Ambient noise levels

The noise measurements carried out at various parts of the communities ranged from 41.0 – 62.1 dB in various locations. These noise levels are within the regulatory limit of the Nigerian Ministry of Environment, and importantly not up to the 55-dB level known to cause annoyance, the harbinger for most of the noise-induced health problems that include aggression, sexual impotence and sleep disorder (Berglund et al, 1999). The likelihood of the projects becoming a noise hazard is low, considering that they are basically gas/oil wells and pipelines that are not known to be

noisy. This is good especially as conservative estimate of the amount of disability caused by environmental noise in European countries alone, measured as Disability Adjusted Life Years (DALYs) was put at 61 000 years for ischaemic heart disease, 45 000 years for cognitive impairment of children, 903 000 years for sleep disturbance, 22 000 years for tinnitus and 587 000 years for annoyance (WHO, European Commission, 2011).

4.17.8 Waste management

The wastes generated in the communities are mainly garbage and other domestic wastes. These wastes are often dumped close to residential accommodation, or at the bank of the river, where they sometimes served for land reclamation and/or shoreline protection. Almost all the respondents (93.95%) were noted to have managed their solid waste in this manner. This problem is compounded by the near total absence of municipal solid wastes disposal services in communities, with the services only found in Igbogene community. This solid waste disposal method is probably responsible for the massive silting of the creek that runs through the communities, and the resultant overgrowth of aquatic weeds, especially in the more urbanized Gbaran communities.



Plate 4.18: Fishing in the heavily silted river in Igbogene community

Although the wastes generated in the communities are mainly garbage, leaches from them can be a major source of contamination of the water bodies in the communities, especially with the increasing use and open dumping of energy saving bulbs that have been shown to contain significant quantity of mercury (Ordinioha, 2012). Leachates from energy saving bulbs and similar waste with high content of heavy metals have been shown to cause the bio-accumulation of the heavy metals in aquatic animals, including fish, and therefore capable of causing human diseases when consumed (Ordinioha, 2012).

4.17.9 Presence of risk factors (Use of alcohol and cigarette):

Alcohol is commonly used in the communities, like most other communities in south-south Nigeria. Alcoholic beverages, including imported gin and the locally distilled gin called *kai-kai* or

ogogoro, are freely available and at all times in the communities. Alcoholic beverages are used during social functions and even in ancestral worship in the communities, just like most other communities in the Niger delta region (Brisibe and Ordinioha, 2011). They are freely given and received during marriage ceremonies, and are mandatory component of the gifts given by a groom to family of the bride. Alcohol is also a ubiquitous solvent for several traditional medicine, ranging from pain relief to aphrodisiac.

However, cases of alcohol dependence were said to be low, in spite of the high proportion of members of the communities that regularly take alcohol. Binge drinking is however said to be very high in the communities, especially during festive periods and burial ceremonies, when indigenes converge, from all works of life. The levels of alcohol consumption and alcohol abuse in the communities were said to be not higher than the levels in comparable communities in the freshwater ecological zone of the Niger delta. A study carried out in a community in the Niger delta region showed that more than 90% of the respondents in the community regularly took alcohol, most of them preferring the locally produced drinks; more than a third of respondents were classified as engaged in harmful drinking, while 12.73% had alcohol dependence problem (Brisibe and Ordinioha, 2011).

Smoking is common in the communities, especially amongst young men. About a fifth of adult males in the communities are said to smoke cigarette, but an average smoker takes at most three sticks of cigarette a day. Women in the communities rarely smoke cigarette

4.17.10 Sexual behaviour:

The sexual behaviour of members of the communities, as highlighted in the focus group discussion held with members of the communities can encourage the transmission of sexually transmitted infections, including HIV/AIDS. Polygamy is common in the communities; most adult males and single girls have multiple sexual partners, and fidelity in marriage is applied mainly to women, as men are culturally permitted to engage in extra-marital affairs. According to a respondent in New Jerusalem – Epie community: *“our men be ashawo, the ones wey dey faithful to their wife no reach five”*. The communities, especially Obunagha also have a history of attracting single girls, when an oil/gas project is being constructed, so much that a shanty settlement was established close to the SPDC Gbaran gas plant.

The sexual behavior of the communities is therefore not different from that of the other communities of the south-south region of Nigeria. According to the 2012 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2013).

- The age at first sexual intercourse in the Niger delta region is 17 years, which is the lowest in the southern Nigeria.
- 41.4% of women in the region had sex with a non-marital partner in the 12 months before the study, which is much higher than the national average of 25.0%, and significantly

higher than the 20.9% recorded in 2004. Similarly, 25.0% of men in the region had sex with a non-marital partner in the 12 months before the study, compared to the national average of 12.2%,

- 12.8% of women aged 15 – 29 years in the region had sex in exchange for gift or favour, compared to 1.4% in the North-west zone, and 8.4% in the South east zone. The national average is 5.3%
- 6.4% of women in the region had sex with multiple partner in the 12 months before the study, compared to 1.6% in the North-West zone and 7.1% in the South west zone. The national average was 5.7%

4.17.11 Knowledge and prevalence of HIV/AIDS and Sexually Transmitted Infections

Oil/gas projects in the Niger delta have been found to increase HIV transmission rate, especially with the presence of Commercial Sex Workers close to the project site (Nwauche and Akani 2006). The construction and operation of the Uzu Field Development projects therefore presents a genuine risk of increase in the prevalence of Sexually Transmitted Infections (STI) and HIV/AIDS in the host communities of the project.

All the discussants in the focus group discussions held in the communities acknowledged that they have heard of HIV/AIDS and STIs; some of them knew someone suspected to have the diseases, or to have died of HIV/AIDS; and some discussants knew the routes of transmission of HIV/AIDS. The knowledge of HIV/AIDS of members of the host communities of the Uzu Field Development projects are therefore similar to those recorded for the south-south zone in the 2012 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2013). In this survey, nearly all the respondents (95.9%) in the south-south region have heard of HIV/AIDS; 21.7% of the respondents knew somebody with the disease, or died as a result of the disease; 76.5% of respondents knew at least two ways of preventing HIV, while only 1.2% of the respondents rated their chances of contracting the disease as high, even as misconceptions about the transmission of HIV are highest in the region, compared to other regions of Nigeria. About a quarter (25.4%) of the respondents in the region believed that HIV can be transmitted through the sharing of toilet, compared to the national average of 22.2%; about a fifth (18.7%) of the respondents believed that the disease can be transmitted through the sharing of a cup, compared to the national average of 18.0%; more than a fifth (22.1%) of the respondents believed that the disease can be transmitted through mosquito bite, compared to the national average of 19.5%; while 19.9% of the respondents believed that the disease can be transmitted through witchcraft, compared to the national average of 11.8%. (FMOH, 2013). There is therefore a need to carry out health education campaign in the communities, to improve their knowledge, especially with the expected influx of workers into the communities during the construction phase of the project.

The 2012 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2013) also shows that Bayelsa State and the south-south region have one of the highest infection rates of Sexually Transmitted Infections and HIV/AIDS, as indicated by the following:

- 8.0% of sexually active persons in the South-South region experienced symptoms of STIs in the 12 months that preceded the survey, compared to the South-East average of 6.3%, the South-West average of 3.4% and the national average of 6.6%.
- 26.9% of men and 30.8% of women in the South-South region had taken the HIV test, compared to 36.3% and 44.1% in the South-East region, the 27.1% and 35.8% in the South-West region, and the national averages of 23.5% and 29.2%.
- The prevalence of HIV amongst sexually active persons of the South-South region of 5.5% is the highest in the country, and significantly higher than the 1.8% of the South-East region, the 2.8% of the South-West region, and the national average of 3.4%
- However, the prevalence of HIV amongst sexually active persons in Bayelsa State is significantly lower than the South-South average. The prevalence amongst sexually active men in the State is 0.7%, while that of sexually active women is 2.7%.
- The prevalence of HIV amongst girls who have sex for money is highest in the South-South region at 7.1%, which is significantly higher than the prevalence of 3.0% in the South-East region, 0.0% in the South-West region, and the national average of 4.9%.
- 6.1% of HIV positive men, and 5.8% of HIV positive women in the South-South region had sex with a non-marital partner in the 12 months that preceded the survey, compared to 1.3% and 3.2% of the South-East region, the 2.9% and 2.3% of the South-West region, and the national average of 3.6%.
- 4.5% of HIV positive persons in the South-South region men, used condom with a non-marital partner, compared to 2.4% of the South-East region, the 1.7% of the South-West region, and the national average of 3.5%.

.4.17.12 Household Food Security and the nutritional status of under-five children

Most members of the communities regularly eat the local staples of cassava, yam and plantain. These are starchy staples that are however usually complemented with fish and shell foods, which are the other major agricultural produce of the people. Despite this, a respondent in New Jerusalem – Epie community warned: *“Na only cassava we get plenty for this community. We no get money. If you give a child only garri and fufu, that child go short.”*

Household food security in the communities was put at about 85% in the communities, but several respondents pointed to a worsening food security situation, due to loss of soil fertility; and the

damming of the water channels, especially in the Gbaran communities, by pipeline construction activities that affected the fish stock in their earthen fish ponds. The nutritional status of under-five children of the communities was assessed during the field survey, through the anthropometric measurement of under-five children in the communities. The result of the anthropometric measurements is presented in the Table 4.34 and Fig. 4.45.

Table 4.34: The Anthropometric measurement of under-five children in the communities

Community	No. of children measured	Weight for age (< -2 SD)
Surveyed communities	246	22 (8.94%)
South-South Nigeria	2, 619	12.8%
Bayelsa State	217	10.0%
National average	26, 190	28.7%
Rural areas	16, 465	32.2%
Urban area	9, 725	22.9%

* The values for South-South Nigeria and the urban areas are according to National Demographic and Health Survey, 2013.

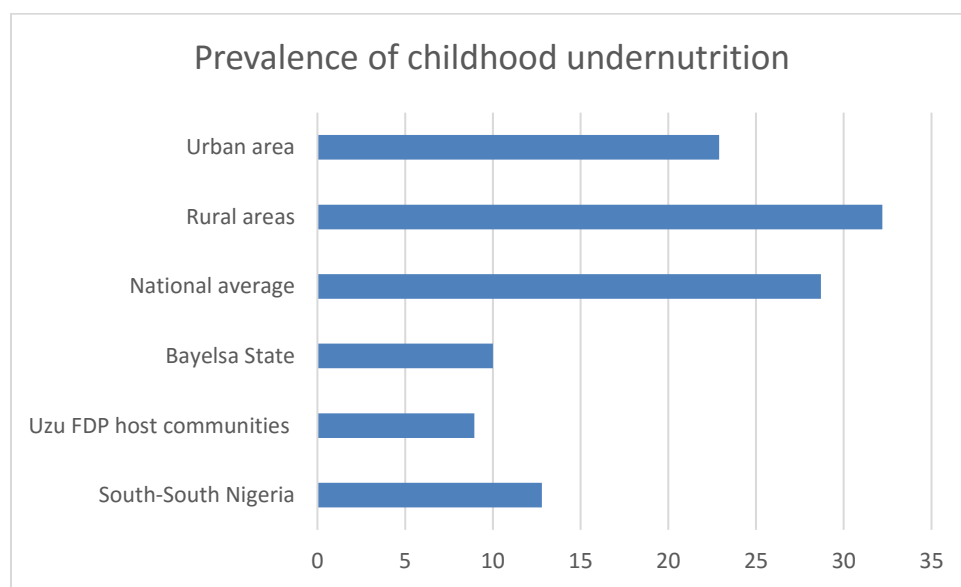


Fig. 4.45: A comparison of the prevalence of childhood malnutrition

The level of childhood under-nutrition in the host communities of the Uzu Field Development projects is lower than the prevalence in the whole of Baylesia State, and significantly lower than the average for communities in the south-south zone, and the national averages. The prevalence of malnutrition is however not only a reflection of the diet and socio-economic status of the people, but also points to the environmental conditions in the communities (Ruel and Menon 2003).

4.17.13 Morbidity pattern

The morbidity rates in the host communities of the Uzu Field Development projects, according to respondents from the communities are not different from those of comparable oil bearing

communities of the Niger Delta Region. The reported health problems are similar to those noted in the records of the health facilities that serve the communities; and consistent with the diseases reported in similar Nigerian communities (NDHS, 2013). By combining these different sources of data, the top five causes of ill health in the host communities of the Uzu Field Development projects are as follows:

- Malaria,
- Water-related diseases,
- Respiratory diseases
- Traffic accidents;
- Non-communicable diseases

Malaria

Malaria is holoendemic in the host communities of the Uzu Field Development projects, just like the other communities in south-south Nigeria, with transmission occurring throughout the year, with seasonal peaks corresponding to the wet season. Most of the malaria transmissions are carried out by *Anopheles gambiae* and *Anopheles funestus* that are most active between 10pm – 1am, and therefore very susceptible to the use of ITN (Adjuik et al, 1998).

The records of the health facilities in the communities show that malaria is easily the most common cause of morbidity, accounting for over half of the cases seen in the health facilities. This is also similar to the situation in other parts of southern Nigeria. The Bayelsa State government has been proactive in malaria control, with the distribution of insecticide-treated bed nets, and free rapid malaria tests in health centers, as part of the Roll Back Malaria Initiative of the government. This is reflected in the ownership and use of ITN amongst respondents in Bayelsa State, as reported in the 2013 National Demography and Health survey (NDHS, 2013). According to the survey, 46.7% of respondents in Bayelsa State owned at least one ITN, compared to the 42.7% average for the south-south region, and to the national average of 49.5%; while more than a quarter (29.1%) of those that owned an ITN in the State slept under the net the night before the survey, compared to the 16.7% average for the south-south region, and the national average of 14.3% (NDHS, 2013).

Water-related diseases

The following water-related diseases were noted to be common in the communities (Ordinioha, 2010):

- Typhoid fever,
- Diarrhoeal diseases and food poisoning; and
- Skin diseases

While typhoid, diarrhoeal diseases and food poisoning are often due to the drinking of water contaminated with faeces, skin diseases can be due to water shortage or irritations that can be caused by chemical irritants (Ordinioha, 2010). They are the second most common cause of ill health in the communities, behind malaria, accounting for more than 25% of all the cases seen in

the health facilities. The conditions that favour the proliferation of these diseases include faecal and crude oil contamination of water, and the use of jetty-type toilets. These conditions are already present in the communities, and are likely to be exacerbated with the expected influx of people into the communities, during the construction phase of the project. Efforts are therefore needed to prevent an increase of the water-related diseases in the communities. Efforts are specifically needed to improve access to portable water, which is currently a problem in the communities, and is likely to increase during the project. It should also be made mandatory that workers in the project be housed in houses with the appropriate toilet facilities.

Upper respiratory tract infections and diseases

Upper respiratory tract infections and diseases are related to air pollution (*Ordinioha, 2010*). The prevalence recorded in the health facilities that serve the communities was not different from those in comparable communities in the Niger delta region. The respiratory ailments in most Niger delta communities have been linked to indoor air pollution, from the use of firewood, and outdoor air pollution principally caused by gas flaring, and in recent years from illegal refining of crude oil. In the host communities of the Uzu Field Development projects, the pollution caused by the use of firewood is significant and widespread, considering the widespread use of firewood by members of the communities, for cooking and for preservation their fish catches.

The air quality assessment carried out as part of this EIA study however showed that the pollutants are within the Federal Ministry of Environment acceptable limit. Indoor air quality can however be further improved in the communities, if support is given to technologies that result in the substitution of the use of firewood with cleaner fuel.

Traffic accidents

The communities are transverse by a major road, with a fairly high vehicular traffic. The results of the traffic analysis carried out on this road, and in the various communities during the field study showed an average of 19 motor vehicles, including heavy duty vehicles and 49 motorcycles every five minutes. This heavy traffic is responsible for road traffic accidents, which is the fourth commonest cause of morbidity in the communities.

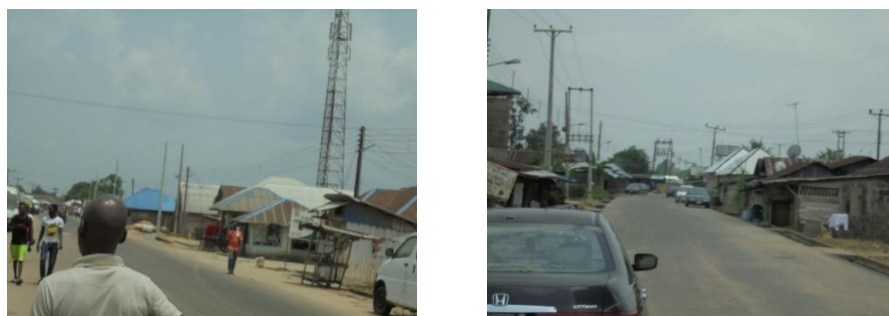


Plate 4.19: Traffic along the major road in some of the communities

The incidence of road traffic accidents is likely to increase during the construction of the Uzu Field Development Projects due to the expected increase in vehicular traffic, and the population explosion that is expected in the communities. This can be prevented with better education of not only the drivers, but also members of the communities, especially the children of the communities.

Prevalence of non-communicable diseases:

The more prevalent non-communicable diseases in the communities, according to members of the communities are hypertension, diabetes and arthritis. This is consistent with the records of the health facilities that serve the communities, and similar to the findings in comparable communities in the Niger delta region. There has been a rising prevalence of these non-communicable diseases in communities of the Niger delta region in recent years. For instance, the prevalence of hypertension has increased from 27.9% in 2010 in a rural Ogoni community (Wokoma and Alasia, 2011), to 68.9% amongst the traditional chiefs of an oil bearing community in Rivers State (Ordinioha and Brisibe, 2013).

There is an indication of a rising prevalence of hypertension in the communities as a random measurement of blood pressure carried out on 78 adult members of the communities during the field showed a prevalence of 24 (30.77%), as defined using the WHO/ISH criteria of systolic blood pressure greater than or equal to 140 mmHg and/or diastolic blood pressure greater than or equal to 90 mmHg. The rising prevalence of hypertension and other non-communicable diseases has been blamed on several factors including the increasing adoption of western lifestyle (Omran, 1971).

However, the incidence of cancer was said to be very low in the communities, and none of the discussants at the Focus Group Discussions held in the communities knew any member of the communities that had or died of cancer. This is even as they believed that oil exploration and exploitation activities could cause cancer.

4.17.14 Mortality pattern

The mortality rates of the communities were said to be comparable to those of the comparable neighbouring communities. Discussants at the Focus Group Discussions held in the communities acknowledged that women still die in pregnancy, and during labour in their communities, but not as many as in the past. An average of one woman was said to die in the communities for every 300 deliveries, which gives a maternal mortality ratio of 333 per 100,000 live births. This is almost half of the national average 576 maternal deaths per 100,000 live births. This decrease in maternal mortality was attributed to the retraining of Traditional Birth Attendants and Masseurs in the communities, and the speed with which emergencies are recognized and taken to Yenagoa or Port Harcourt, for appropriate treatment. The causes of the maternal deaths recorded in the communities in the last five years, according to verbal autopsy were: prolonged labour, post-partum haemorrhage, abortion; and eclampsia. These causes are also consistent with the findings in most other communities in Nigeria (NDHS, 2013).

Under-five mortality was said to be high in the past, but was acknowledged during the field study to have reduced considerably in recent years, from immunization and better medical care. An average of 200 under-five deaths were said to occur in the communities in a year, giving an under-five mortality rate of about 100 under-five deaths per 1,000 live births. This is similar to the average for south-south Nigeria of 109 per 1,000 live births, and better than the national average of 122 per 1000 ((FMOH, 2013). The common causes of under-five mortality include: malaria and its complications, especially anaemia and febrile convulsion, gastro-enteritis (diarrhoea and vomiting), and acute lower respiratory tract infection. These causes are also common in most other communities in south-south Nigeria, but they point to poor environmental conditions, poor health seeking behaviour, and poor standard of health care delivery in the communities (NDHS, 2013).

Adult members of the host communities of the Uzu Field Development projects, according to the health workers in the health facilities that serve the communities die mostly from the following communicable diseases: malaria; water-related diseases such as typhoid and diarrheal diseases; and respiratory diseases such as pneumonia and bronchitis. Non-communicable diseases such as diabetes and hypertension were also said to be growing causes of death, especially amongst the elderly and middle-aged persons in the communities. Inter-personal violence was also said to be an important cause of death, especially amongst the youths of the area in recent years.

4.17.15 The health system:

Primary Health Centers:

The communities are served by health centers (Plate 4.20), located such that most members of the communities are able to access primary health care within the prescribed 30-minutes travel time. The health centers and their state, as at the time of the field study are outline in Table 4.35.

Most of the health centers are equipped with human and material resources that meet the national standard (Asuzu and Ogundeji 2007). They offer mainly maternal and child health services like childhood immunization, ante-natal care, and maternity services; and also have the capacity to treat minor injuries and endemic diseases.

But, even with the physical facilities and manpower, services at the health center were noted to be below expectation. Service utilization was poor across the health centers. All the facilities did not provide round the clock service, and saw a daily average of about two sick patients. Although this is higher than the 1.44 average for primary health care centers in the south-south region, according to the 2006 records of the National Primary Health Care Development Agency, it translates to just 60 sick patients a month.



Plate 4.20: Some of the health facilities in the communities from left to right - Obunagha health center, Nedugo health center, Agbia health center (yet to be put into use) and King Malla Sasime Medical Center, Igbogene

Table 4.35: List of primary health care facilities in the host communities

S/N	COMMUNITIES	PRIMARY HEALTH CENTRE	STATUS
1	Okolobiri	Yes NDTH - Okolobiri	Catchment community of the teaching hospital at Okolobiri
2	Kumboama	Yes NDTH - Okolobiri	Catchment community of the teaching hospital at Okolobiri
3	Obunagha	Yes Obunagha health center	Functional, but poorly utilized Built by the community, with funds provided by SPDC, but currently managed by the government. Has only a Community Health Extension Workers.
4	Ogboloma	Yes Ogboloma health center	Barely functional
5	Nedugo	Yes, Nedugo health center	Functional, and highly utilized Built through community effort, and managed by the government Properly equipped with equipment donated by MDG projects. Staffed only with Community Health Extension Workers
6	Agbia	Currently one of the catchment communities of Nedugo health center Has a complete health center built by MDGs project, but yet to be commissioned	Agbia health center was built under the Conditional Grant Scheme of the Office of Special Assistant to the President on the MDGs, but yet to be staffed and put to use
7	Ayama	None. One of the catchment communities of NDTH - Okolobiri	
8	Okotiama	None. One of the catchment communities of NDTH - Okolobiri	
9	New Jerusalem	None. One of the catchment communities of the Epie – Zarama health center	
10	Nyambiri – Zarama	None. One of the catchment communities of the Epie – Zarama health center	
11	Epie – Zarama;	Yes, Epie – Zarama health center	Functional, but poorly utilized.

S/N	COMMUNITIES	PRIMARY HEALTH CENTRE	STATUS
12	Igbogene	King Malla Sasime Medical Center, provides primary and secondary health care services to the community	The hospital has the full complement of staff and equipment. Utilization was however said to be very poor, for various reasons

Traditional Medicine

The use of traditional medicine is common in the host communities of the Uzu Field Development projects, like most communities in rural Niger delta. The use of herbal drugs is very common, and patronage of traditional medicine practitioners such as Traditional Birth Attendants, massagers (masseurs) and bonesetters is widespread and sometimes preferred to western medicine, even among the western educated members of the communities.

Herbal drugs are used in the communities for various ailments, ranging from fever, aches and pains to aphrodisiac. They are prepared from different herbs, leaves, barks and roots sourced from the forests of the communities, or brought in from other communities, sometimes from sources outside the Niger delta region. The herbal preparations used in the communities are often concoctions of alcohol, prepared and packaged by the herbalist in various containers, and sold in neighbourhood shops, throughout the communities. The herbal preparations are commonly prepared from the following (Nwauzoma and Dappa, 2013) plate species (Table 4.36):

Table 4.36: Common Medicinal Plants and their Uses in the communities

Common/local names	Botanical Names	Medicinal Uses
Pawpaw leaves	<i>Carica papaya</i>	Treatment of malaria
Alligator pepper plant	<i>Aframomum melegueta</i>	Galactagogue, purgative, sore throat, malaria
Lemon orange	<i>Citrus aurantium</i>	Abdominal upset, and as a base for other herbs in treatment of malaria
Cashew fruit, leaf and bark	<i>Anarcadium occidentale</i>	Treatment of diarrhoea and menstrual problems
Mango leaves and bark	<i>Mangifera indica</i>	Treatment of malaria
Banana plant	<i>Musa spp</i>	Treatment of fever
Guava tree leaves and bark	<i>Psidium guajava</i>	Treatment of malaria, diarrhoea and menstrual disorders
Siam weed (awolowo)	<i>Chromolaena odorata</i>	Dysentery, malaria, skin disease

Common/local names	Botanical Names	Medicinal Uses
Coconut	<i>Cocos nucifera</i>	The water is used as poison antidote
African walnut	<i>Tetracarpidium conophorum</i>	Aphrodisiac

Traditional Birth Attendants and massagers are very prominent in the communities (Plate 4.21). Traditional birth attendants are persons who assist mothers during childbirth, using the traditional birthing practices of the community, while massagers realign supposedly mal-aligned internal organs believed to be responsible for a great variety of illness, including paediatric and pregnancy-related illnesses. These traditional medicine practitioners have been noted to use significantly less herbal products in their practice, when compared to the other traditional medicine practitioners. They are therefore less likely to be affected by deforestation.



Plate 4.21: Signboard of a TBA in Okotiana community, and that of a Bonesetter and massager in Negugo community

Tertiary health care

For tertiary health care, members of the communities can easily access the Niger Delta University Teaching Hospital, Okolobiri, Federal Medical Center Yenagoa, and the University of Port Harcourt Teaching Hospital, Port Harcourt. These tertiary health care facilities have more than two thousand in-patient beds between them, and provide services in almost all specialties of medicine, including emergency care, orthopedics, medical and surgical care, and at a cost that is affordable to a large proportion of the citizenry.

4.17.16 Medical Emergency Evacuation System

There is no formal medical emergency evacuation system in all the host communities. Members of the communities make their own private arrangement in convening their sick for appropriate treatment.

CHAPTER FIVE

ASSOCIATED AND POTENTIAL IMPACTS

5.1 Introduction

There are several approaches and techniques developed for evaluating existing, associated, and potential impacts of any project on the environment. The Overlays techniques (McHarg, 1968); Leopold matrix (Leopold *et al.*, 1971); Battelle Environmental Evaluation System (Dee *et al.*, 1973), Peterson Matrix (Peterson *et al.*, 1974), Rau and Wooten (1980) and ISO 14001 are among the most widely used methods. The ISO 14001 method was used for evaluating the potential and associated impacts of Uzu field.

5.2 Assessment of Potential Impacts using ISO 14001 and RAM Method

The ISO 14001 method is simple to apply and provides a high level of detail and also relies on limited data. This method was therefore selected for the evaluation of potential impacts for the proposed project.

In line with general guidelines for an Environmental Impact Assessment (EIA) process, the following were the basic steps adopted for identification and evaluation of impacts (Fig. 5.1):

- Impact identification
- Impact description
- Impact qualification
- Impact Risk and Severity rating

5.2.1 Impact Identification

The aim of impact identification is to account for the entire potential and associated bio-physical, 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 existing, associated, potential and cumulative impacts of the project are listed in Tables 5.1.

5.2.2 Impact Description and Qualification

The identified impacts of the project were described based on the following criteria:

- Positive or negative
- Direct or indirect

Negative impacts are those that adversely affect the biophysical environments while positive impacts are those which enhance the quality of the environment. Direct impacts refer to those impacts that are caused by the project activity and occur at the same time and place. Indirect impacts are impacts caused by a project activity, but would occur in the future or outside the project area and are reasonably foreseeable. Impacts are qualified either as:

- Short term < 3 months (S) or Long term > 3 months (L), or
- Reversible (R) or Irreversible (I).

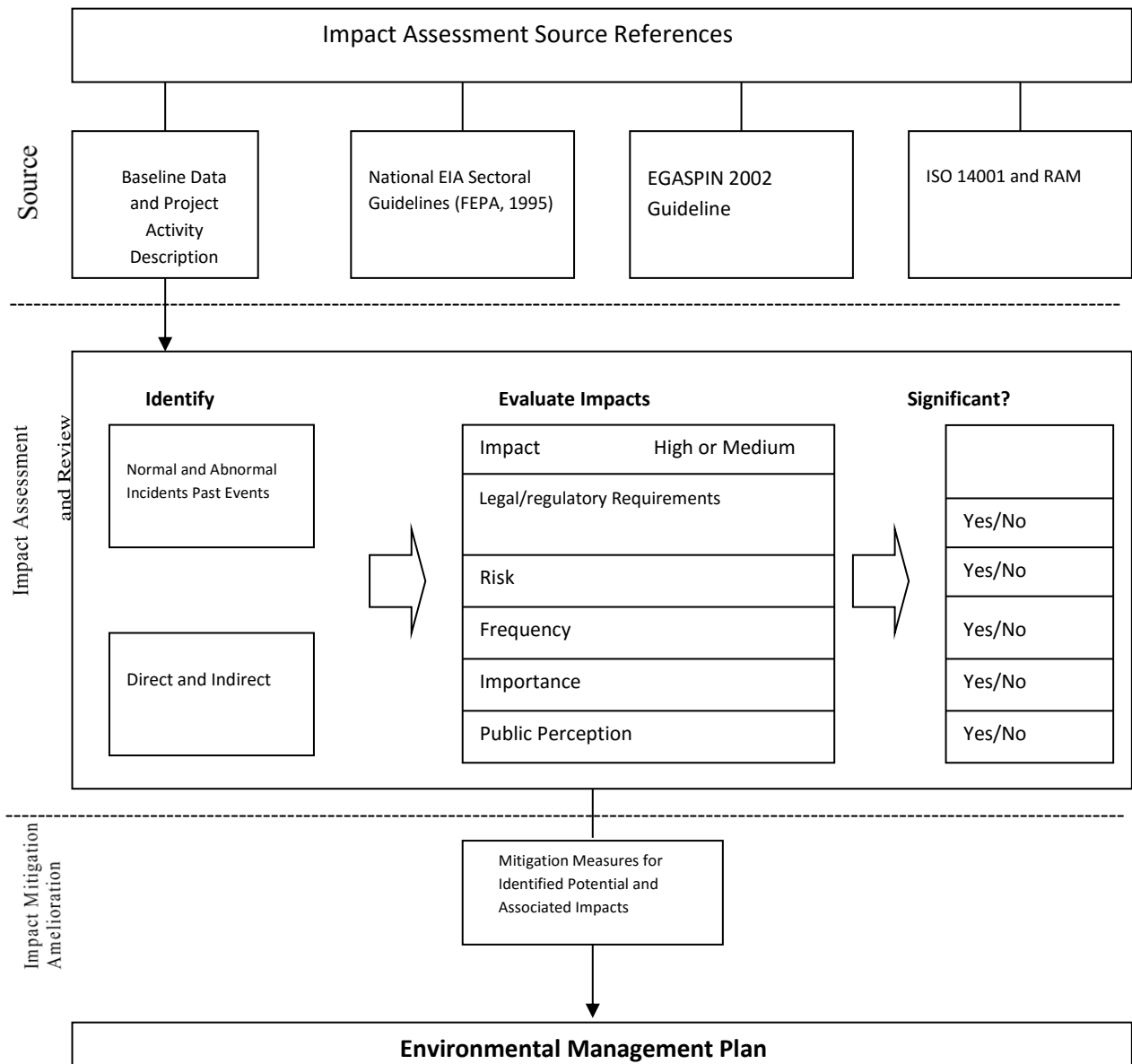


Fig. 5.1: Impact Assessment Methodology

For this study, short term means a period of time less than three months while any period greater than three months is considered long term. Reversible means the environment can revert to its previous conditions while irreversible means the impacts remain permanent even after the activity causing the impact is terminated.

Table 5.1: Associated and Potential Impacts of Proposed Uzu field development Project

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
PRE-CONSTRUCTION	Land acquisition, Survey, consultation,	<ul style="list-style-type: none"> • Measurements (sounding, geotechnical/geomechanical, pipeline route) • Transportation 	<ul style="list-style-type: none"> • Risk of accident • Risk of Piracy & kidnapping
MOBILIZATION AND RIG MOVE	Mobilization of Equipment and Personnel to Site	<ul style="list-style-type: none"> • Transportation of personnel, materials, equipment and Rig to site by road and water; • Employment of local labor and award of contracts; 	<ul style="list-style-type: none"> • Impairment of air quality from emissions of air pollutants including greenhouse gases • Increase in noise and vibration/levels • Increase In violent crime and Kidnappings • Third party agitations • Increase in income to local hired labor hands
DRILLING OPERATIONS	Drilling (Rig positioning, Casing, Logging, Cementation, Production (well Testing), Production(operations)	<ul style="list-style-type: none"> • Boring into the earth crust to get to the Oil & Gas Reservoir • Employment of local labour and award of contracts to members of the communities • Accidents and injuries • Surface water contamination and impairment of air quality • Waste generation and disposal • Increase in noise and vibration levels • Increase in periods of brightness • Contamination of the environment by chemicals/drilling wastes • Contamination of the environment by domestic wastes from offices and Field Logistics Base 	<ul style="list-style-type: none"> • Impairment of air quality by emissions of air pollutants including greenhouse gases • Noise and vibration nuisance • Influx of People into the project area • Contamination of surface water • Injuries and death from blowouts • Continuous glare from rig operation • Opportunities for business and employment

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
		<ul style="list-style-type: none"> • Threats to health of workers or aquatic wildlife injuries, etc 	<ul style="list-style-type: none"> • Water pollution from chemicals, drill cuttings and mud • Third party agitation • Accidents and injuries • Contamination of the surface water and sediment by wastes
CONSTRUCTION	Construction of pipeline, flowline, bulk lines, manifold	<ul style="list-style-type: none"> • Excavation • Employment of local labour and award of contracts to members of the communities • Accidents and injuries • Surface water contamination and impairment of air quality • Waste generation and disposal • Increase in noise and vibration levels • Contamination of the environment (air, soil and land) by wastes • Contamination of the environment (air, soil and land) by domestic wastes from offices and construction camps • Threats to health of workers, aquatic life and wildlife etc 	<ul style="list-style-type: none"> • Impairment of air quality by emissions of air pollutants including greenhouse gases • Noise and vibration nuisance • Contamination of water bodies • Continuous glare during construction • Opportunities for business and employment • Third party agitation • Accidents and injuries • Contamination of the surface water and sediment by wastes • Increase in population due to influx of persons • Overcrowding of persons in the houses • Pressure on health facilities.
FACILITY UPGRADE	Installation of 200 MMscfd TEG	<ul style="list-style-type: none"> • Excavation 	<ul style="list-style-type: none"> • Impairment of air quality by

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
	plant	<ul style="list-style-type: none"> • Transportation of personnel, materials, equipment • Employment of local labour and award of contracts to members of the communities • Accidents and injuries • Surface water contamination and impairment of air quality • Waste generation and disposal • Increase in noise and vibration levels • Increase in periods of brightness • Contamination of the environment by wastes • Contamination of the environment by domestic wastes • Threats to health of workers or aquatic wildlife injuries, etc 	<ul style="list-style-type: none"> • emissions of air pollutants including greenhouse gases • Noise and vibration nuisance • Contamination of water bodies • Continuous glare at site • Opportunities for business and employment • Third party agitation • Accidents and injuries • Physical and mental health issues such as stress on those living near the facilities.
DEMOBILIZATION	Mobilization of Equipment and Construction workers out of the project site	<ul style="list-style-type: none"> • Transportation of personnel, materials, equipment and Rig from site by water and air • Downscaling of local labour and community contracts • Emigration of workers and followers (dependants, bounty seekers) from the host Communities • Increase potential for water traffic volume and accidents from movement of heavy equipment from worksites • Clearing and Disposal of wastes 	<ul style="list-style-type: none"> • Impairment of air quality by emissions of air pollutants including greenhouse gases • Water traffic incidents • Improper disposal of materials removed from site • Increase in noise and vibration level • Loss of employment/income
PRODUCTION, OPERATIONS AND MAINTENANCE	Operation of well, pipeline, flow lines, bulk lines, manifold and upgraded CPF	<ul style="list-style-type: none"> • Oil and Gas leaks • Noise and vibration levels • Reduction in air quality • Degradation of surface water and sediment by spills and leaks • Danger of explosion and fire 	<ul style="list-style-type: none"> • Environmental pollution arising from improper disposal of lubricants and oily debris • Equipment failure and damage leading to

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
		<ul style="list-style-type: none"> • Opportunity for contracting and employment • Oil and gas production and sales • Skills training and acquisition 	<ul style="list-style-type: none"> • injuries/fatality • Revenue generation to government and company • Increase in noise levels • Oil and Gas leaks
DECOMMISSIONING & ABANDONMENT	Demolition of structures and removal of well casings Demobilization of Equipment, Materials and Wastes out of the project site	<ul style="list-style-type: none"> • Transportation of personnel, materials, equipment and wastes from site by water • Disengagement of local labour and community contractors • Increase potential for road traffic volume and accidents from movement of heavy equipment from project sites • Contamination of surface water from excavation of well head and pipelines • Clearing and Disposal of solid wastes • Oil and Gas leaks • Noise and vibration levels • Reduction in air quality • Degradation of soils and surface water by spills and leaks • Danger of explosion and fire 	<ul style="list-style-type: none"> • Employment and income generating opportunity • Increase in noise and vibration/levels • Interference with water transport • Kidnappings • Impairment of air quality from fumes, dust, including greenhouse gases • Third party agitations • Increase potential for water traffic accidents/injury • Potential for inhalation of welding fumes • Potential for conflicts arising from labor issues • Contamination of surface water • Contamination of aquatic fauna community • Destruction of fauna population as a result of surface water and sediment pollution • Surface water and sediment degradation from spills and

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
			leaks • Injury/fatalities in workforce

5.3: Impact Risk Assessment

The Risk that an impact poses is determined using the Risk Assessment (RAM) shown in Fig. 5.2. The Environmental Consequences in the Fig. are defined in Table 5.2. The Impact Risk is rated as:

- 1= Low risk
- 3 = Medium/intermediate risk
- 5 = High risk

Consequences					Increasing Likelihood				
					A	B	C	D	E
Severity	People	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the Organization or more than once per year in the industry	Has happened at the location or more than once per year in the Organization	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health	Slight damage	Slight effect	Slight impact		Low			
2	Minor Injury or health	Minor damage	Minor effect	Minor impact		Risk			
3	Major Injury or health effect	Moderate damage	Moderate effect	Moderate impact			Medium		
4	PTD or up to 3 fatalities	Major damage	Major effect	Major impact			Risk	High	
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact				Risk	

Fig. 5.2: Risk Assessment Matrix

5.4: Determination of Impact Rating and Significance

The ISO 14001 methodology, for determining potential impact rating and significance, is adopted in this study. The criteria employed in evaluating the potential impacts are:

- Legal/regulatory requirements (L);
- Risk factor (R);
- Frequency of occurrence of impact (F);
- Importance of impact on an affected environmental component (I); and
- Public perception/interest (P).

Each of the criteria is weighted on a scale of 0, 1, 3 and 5 depending on the perceived significance of the impact under consideration. This is a modification of the arbitrary scale proposed by Vesilind *et al.* (1994). The weightings are described below and are adapted from The International Organization for Standardization ISO 14001 – Environmental Management System Approach.]

Table 5.2: Definition of Consequence in the Risk Matrix (RAM)

Severity	Potential Impact	Definition
0	Zero effect	No environmental damage. No change in the environment. No financial consequences.
1	Slight effect	Local environmental damage within the fence and within systems. Negligible financial consequences.
2	Minor effect	Contamination, damage sufficiently large to affect the environment. Single exceedance of statutory or prescribed criteria, single complaint. No permanent effect on the environment
3	Localized effect	Limited loss of discharges of known toxicity. Repeated exceedance of statutory or prescribed limit. Affecting neighborhood
4	Major effect	Severe environmental damage. The company is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedance of statutory or prescribed limits
5	Massive effect	Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservancy, a major economic loss for the company. Constant high exceedance of statutory or prescribed limits.

Source: SIEP (1996).

- **Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit**

required?

- 0 = There is no legal/regulatory requirement
- 3 = There is legal/regulatory requirement
- 5 = There is a legal/regulatory requirement and permit required

• **Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix (RAM)?**

- 1 = Low risk
- 3 = Intermediate risk
- 5 = High risk

• **Frequency of Impact (F) – What is the frequency rating of impact?**

- 1 = Low frequency (rare)
- 3 = Intermediate frequency (likely)
- 5 = High frequency (very likely)

- The frequency of occurrence of each impact was determined from historic records and consensus of experts' opinion.

• **Public interest/perception (P) – What is the public perception and interest in the proposed project and impacts based on consultation with stakeholders?**

- 1 = Low interest/perception
- 3 = Intermediate interest/perception
- 5 = High interest/perception

The perception of the general public on each potential impact and were determined through consultation and consensus of opinions of environmental professionals.

• **Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions? Will the impact be localized or spread to cover greater areas of the environmental component?**

- 1 = Low
- 3 = Medium
- 5 = High

The importance of affected environmental component was determined through consultation and consensus of opinions.

This approach combines the following factors in assessing the overall rating of the potential impacts of the proposed project on the environment:

- The sensitivity/vulnerability of the ecosystem components;
- The productivity evaluation/rating of the ecosystem components;
- Knowledge of the possible interactions between the proposed project and the environment;
- Envisaged sustainability of the project environment;
- The economic value of the proposed project activities; and
- Projected duration of the impact of each project activity on various environmental components.

The overall impact significance rating is determined as shown in Table 5.3. The potential and associated impacts of the project are presented in Table 5.4. All impacts with the Medium and High Ranking are considered significant and will require mitigation measures. Impacts with Low ranking will be addressed by application of the SPDC HSE Policy. Impacts rated as positive do not require mitigation and are considered Beneficial. Significant and beneficial impacts are discussed in the proceeding paragraphs.

Table 5.3: Impact Value and Rating

Impact value	Cut off values	Impact Rating	Impact Significance
L+R+F+I+P	<8	Low	Not Significant
	≥8 but <15	Medium	Significant
	≥15	High	
F + I	≥6		
P	= 5		
Positive		Positive	Beneficial

Table 5.4: Ranking of Potential and Associated Impacts of Proposed Uzu Field Development Project

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating	
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
Pre-construction (survey)	Land acquisition, Survey, Consultations	Risk of accident		√	√		√	√	√	√	0	3	3	3	3	12	6	H
		Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
Mobilization and Rig movement	Mobilization of Equipment, Rig and Personnel to Site	Impairment of air quality		√	√		√		√		5	1	1	1	1	9	2	M
		Increase in noise and vibration		√	√		√		√		5	1	1	1	1	9	2	M
		Interference with fishing activities		√	√		√		√		0	1	1	3	1	6	4	L
		Interference with water transport		√	√		√		√		0	1	3	1	1	6	2	L
		Risk of accident		√	√		√	√	√	√	0	3	3	3	3	12	6	H
		Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Site preparation (piling)	Increase in noise and vibration		√	√		√	√	√		5	3	3	3	1	15	4	H
		Interference		√	√		√		√		0	1	3	3	1	8	4	M

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating	
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
		with fishing activities																
		Risk of accident		√	√		√	√	√	√	0	3	3	3	3	12	6	H
		Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
		Fish-kills		√	√			√		√	0	3	3	3	1	10	6	H
Construction	Pipeline construction (Piping/ flowlines, bulk lines, manifolds, well hook-up)	Increase in income generating activities	√		√		√	√	√									P
		Reduction of flora and fauna population		√	√		√		√		0	1	1	3	1	6	4	H
		Risk of accident		√	√		√	√	√	√	0	3	3	3	3	12	6	H
		Disturbance to fauna and subsequent migration due to increase in noise and vibration/levels		√	√		√		√		0	1	1	3	1	6	4	M
		Loss of		√	√		√		√		0	1	1	3	1	6	4	H

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating		
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I	
		important species and other forms of disturbance from land clearing activities and associated loss of ecosystem services																	
		Creation of new accesses to areas that were formally inaccessible, leading to increased threat of poaching and over-exploitation of the natural resources		√	√		√		√			0	1	1	3	1	6	4	H
		Risk of Piracy & kidnapping		√	√		√	√	√	√		0	5	3	5	5	18	8	H
		Impairment of		√	√		√		√			5	3	3	1	1	13	4	M

Project Phase	Project Activity	Impacts	Impact Description				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 quality																	
		Increase in noise and vibration levels		√	√		√		√			3	3	1	3	1	11	4	M
		Contamination of land, groundwater, surface water and sediment		√	√		√	√	√			3	3	1	3	5	15	4	H
Drilling	Drilling (Rig positioning, Casing, Logging, Cementation, Production (well Testing), Production(operations))	Exposure to radiation materials		√	√			√		√		3	3	1	3	5	15	4	H
		inhalation of welding fumes		√	√		√		√			3	3	1	3	3	13	4	M
		Soft tissues damage from welding sparks		√	√		√		√			3	3	1	3	3	13	4	M
		Conjunctivitis from welding flash		√	√		√		√			3	3	1	3	3	13	4	M
		Increase in pressure on available health facility due increase in population		√	√		√	√	√			3	3	2	3	3	14	6	H

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating			
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I		
		Potential for conflicts arising from labour issues		√	√		√		√			3	5	3	3	3	17	4	H	
		Stress on existing security structures		√	√		√	√	√	√		0	5	3	5	5	18	8	H	
		Contamination of water from inhibited hydrotest water		√	√		√		√			3	1	1	1	1	7	2	L	
		Accidents and injuries		√	√		√	√	√	√		0	5	3	5	5	18	8	H	
Demobilization	Demobilization of Equipment, Materials and Wastes out of the project site	Impairment of air quality		√	√		√		√			3	1	1	3	5	13	4	M	
		Water traffic incidents		√	√		√	√	√	√			0	3	3	3	3	12	6	H
		Improper disposal of materials removed from site		√	√		√	√	√				3	3	1	3	3	13	4	M
		Increase in noise and vibration level		√	√		√		√				3	3	1	3	1	11	4	M

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating		
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I	
		Loss of employment/ income		√	√		√	√	√	√	0	5	3	3	5	16	6	H	
		Risk of accident		√	√		√	√	√	√	0	3	3	3	3	12	6	H	
		Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H	
Operation and Maintenance	Installation of 200 MMscfd TEG plant Mobilization of Equipment and Construction workers out of the project site Operation of well, pipeline, flow lines, bulk lines, manifold and upgraded CPF	Improper disposal of materials		√	√		√	√	√	√	3	3	3	3	3	15	6	H	
		Equipment failure and damage leading to injuries/fatality		√	√		√	√	√	√	3	1	1	1	3	9	2	M	
		Revenue generation to government and company	√		√			√	√			-	-	-	-	-	-	-	P
		Increase in noise levels		√	√			√	√		3	1	1	1	1	7	2	L	
		gas flaring	√	√	√			√	√		3	3	3	5	3	17	8	H	
		produced water	√	√	√			√	√		3	3	5	1	3	15	4	H	
		Risk of accident		√	√		√	√	√	√	3	3	3	3	3	15	6	H	
		Risk of Piracy		√	√		√	√	√	√	0	5	3	5	5	18	8	H	

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating		
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I	
		& kidnapping																	
Decommissioning and Abandonment	Demolition of structures and removal of well casings and waste from location	Employment and income generating opportunity	√		√		√		√										P
		Increase in noise and vibration		√	√		√		√			3	3	1	3	1	11	4	M
		Interference with water transport		√	√		√		√			0	1	1	1	3	6	2	L
		Impairment of air quality		√	√		√		√			3	1	1	1	1	8	2	M
		Risk of accident		√	√		√	√	√	√		0	3	3	3	3	12	6	H
		Risk of Piracy & kidnapping		√	√		√	√	√	√		0	5	3	5	5	18	8	H
		Increase potential for water traffic accidents/ injury		√	√		√	√	√	√		3	1	1	3	1	9	4	M
		Potential for conflicts arising from labour issues		√	√		√		√			0	1	3	5	5	16	8	H

Project Phase	Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating		
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I	
		Contamination of surface water and sediment		√	√		√		√			3	1	1	1	1	7	2	L
		Destruction of aquatic fauna population		√	√		√		√			0	1	1	1	1	4	2	L
		Injury/fatalities in workforce		√	√		√	√	√	√		3	3	1	3	3	13	4	H

5.5: Potential Impacts

Table 5.4 present the potential impacts of the proposed Uzu field development project. Only the medium and high impacts are described in this subsection. The impacts rated low were not described and could be effectively addressed by routine SPDC procedures and would therefore not require mitigation.

5.5.1 Pre-construction (pipeline route survey)

Risk of accident

There is potential risk of accident particularly during the pipeline and flowline survey. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during hydrosurveys. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

5.5.2 Mobilization (equipment & personnel), and Rig Move

Impairment of air quality

Transportation of equipment, materials and personnel via road, air and water to site could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

Increase in noise and vibration

Noise and vibrations could increase during mobilization to site. Current noise levels at site were is by far lower than the regulatory limits of 90 dB. However, this impact was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

Risk of accident

There is potential risk of accident particularly during mobilization to site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during mobilization to site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

5.5.3 Site preparation (piling)

Increase in noise and vibration

Noise and vibrations could increase during site preparation particularly piling. Current noise levels at site were 45.56 ± 1.18 dB, which is by far lower than the regulatory limits of 90 dB. But during piling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

Interference with fishing activities

Piling could affect fishing activities especially at the continental shelf. The impact was described as negative, direct, short-term, reversible and was rated medium.

Impact on Biodiversity

There is potential of the vegetation clearing, habitat fragmentation, wildlife displacement, introduction of alien species and impact on ecosystem services as a result of site preparation activities.

Risk of accident

There is potential risk of accident during site preparation. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during site preparation. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

5.5.4 Fabrication, facility upgrade, positioning and Installation of Wellhead Platform

Increase in noise and vibration

Noise and vibrations could increase during fabrication, positioning and installation of well platforms. Current noise levels at site were 44.20-62.10dB (wet season) and 41.00-59.40 dB (dry season), which is by far lower than the regulatory limits of 90 dB. But during construction, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

Impact on Biodiversity

There is potential of the vegetation clearing, habitat fragmentation, wildlife displacement, introduction of alien species and impact on ecosystem services as a result project activities.

Interference with fishing activities

Installation of the well head could affect fishing activities especially at the continental shelf. The

impact was described as negative, direct, short-term, reversible and was rated medium.

Risk of accident

There is potential risk of accident particularly during site construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during site construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

Impacts of Wastes

Various streams of wastes could be generated during site construction including liquid (oily wastewater, sewage and effluents from barges and houseboats), air emissions (fumes from welding activities and generators) and solid wastes (wood wastes, iron offcuts, plastics, cement and concrete wastes). Waste generation during construction activities could mount pressure on existing waste management infrastructure in Gbaran CPF. On the other hand, poor waste management could impact the environment negatively. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the construction period, reversible and was rated as high impact.

Impairment of air quality

Site construction could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

5.5.5 Drilling

Impairment of air quality

Drilling could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

Increase in noise and vibration

Noise and vibrations could increase during drilling. Current noise levels at site were 45.56±1.18 dB, which is by far lower than the regulatory limits of 90 dB. But during drilling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

Impact on Biodiversity

There is potential of the vegetation clearing, habitat fragmentation, wildlife displacement, introduction of alien species and impact on ecosystem services as a result of drilling activities.

Injuries and death from blowouts

Blowouts could occur during drilling. Today, only a few blowouts have occurred in Nigeria while drilling, but none in SPDC. Notwithstanding, injuries and death from blowouts was described as negative, direct and it could either be short- or long-term, reversible or irreversible depending on the scale and severity, hence this impact was rated high.

Opportunities for business and employment

Drilling activities in Uzu fields could create opportunities for business, contracting and employment. Though, this is a positive impact, it can be enhanced by using local and indigenous contractors and personnel, otherwise, it could be lead to agitation.

Increased oil and gas production

Existing wells in the Uzu field are depleting with high water production. Drilling of additional 5 wells in the Uzu field could boost oil and gas production in Nigeria and increase capacity utilization of the Gbaran CPF. This impacted was ranked positive.

Increased revenue

Increased oil production could result in increased revenue for SPDC and the Nigerian Government. This impacted was ranked positive as well.

Surface water and sediment pollution from chemicals, drill cuttings, and mud

Surface water and sediment pollution from chemicals, drill cuttings, and mud could occur as a result of drilling activities. Several chemicals are used during drilling and completion such as drilling mud (consisting of several additives such as barite, bentonite, potassium chloride, calcium carbonates, base oil or pseudo-oil etc), cement etc. Large volumes of wastes could be generated from the use of these chemicals. In addition, other types of wastes could be generated including effluent, sewage, food wastes and other solid wastes particularly packaging materials such as plastics. This impact was therefore described as negative, direct, short-term, reversible and was rated major.

Accidents and injuries

Accidents and injuries could arise from drilling operations. This impact was described as negative, direct, short-term, reversible and was rated major.

5.5.6 Pipeline construction (Piping/ flowlines, well hook-up)

Increase in income generating activities

Income generating activities (business/contracting) could increase during pipeline construction. This impact was ranked positive.

Risk of accident

Accidents and injuries could arise from pipeline construction such as explosion, fire and drowning. This impact was described as negative, direct, short-term, reversible and was rated major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during pipeline construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

Impairment of air quality

Pipeline construction could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

Increase in noise and vibration

Noise and vibrations could increase during pipeline construction. Current noise levels at site were by far lower than the regulatory limits of 90 dB. But during drilling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term, reversible and was rated as medium.

Impact on Biodiversity

There is potential of the vegetation clearing, habitat fragmentation, wildlife displacement, introduction of alien species and impact on ecosystem services as a result project activities.

Contamination of surface water bodies

Surface water and sediment pollution could arise from pipeline construction activities. In addition, wastes could be generated including effluent, sewage, food wastes and other solid wastes particularly packaging materials such as plastics. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

Exposure to radiation

Personnel could be exposed to radiation during pipeline construction activities especially during arc welding. Radiations are known to cause cancer. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

Inhalation of welding fumes

Fumes are released during welding, which could be inhaled by welders. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

Soft tissues damage from welding sparks

Welding sparks could cause tissue damage. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

Conjunctivitis from welding flash

Conjunctivitis could result from welding flash. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

Potential for conflicts arising from labour issues

Conflicts could arise from labour related issues during pipeline construction. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

Stress on existing security structures

Stress on existing security structures could arise during pipeline construction activities. Kidnapping and hostage taking is common in the Niger Delta. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

5.5.7 Demobilization

Impairment of air quality

Emissions into the environment can occur during demobilization of equipment and personnel. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

Road traffic incidents

Road traffic incidents can occur during demobilization of equipment and personnel. This impact was described as negative, direct and it could either be short- or long-term, reversible or irreversible depending on the scale and severity, hence this impact was rated high.

Improper disposal of materials removed from site

Wastes could be generated from materials removed from site during demobilization. If not well managed, these wastes could cause environmental pollution. This impact was assessed and described as negative, direct, short-term, reversible and was rated as medium

Increase in noise and vibration

Noise and vibrations could increase during demobilization. Current noise levels at site were by far lower than the regulatory limits of 90 dB. But during construction, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term and was rated as high impact.

Loss of employment/ income

Employment and income could be loss due to demobilization. Conflict could arise from the poor management of demobilization. This impact was assessed and described as negative, direct, short-

term and was rated as high impact.

Risk of accident

There is potential risk of accident during demobilization from site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during demobilization from site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

5.5.8 Commissioning, Operations and Maintenance

Improper disposal of materials

Several waste streams could be generated during commissioning, routine operations and maintenance. If not well managed, these wastes could cause environmental pollution. This impact was assessed and described as negative, direct, short-term, reversible and was rated high.

Equipment failure and damage leading to injuries/fatality

Equipment failure could result to damage leading to injuries and fatality. This impact was assessed and described as negative, direct, short-term, reversible and was rated medium.

Revenue generation to government and company

Operations of the production facilities could result in increased production and revenue generation for the government and SPDC. The impact was ranked positive.

Risk of accident

There is potential risk of accident particularly during operations. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during operations. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

5.5.9 Decommissioning and Abandonment

Employment and income generating opportunity

Decommissioning can create opportunity for business and employment. This impact was ranked positive.

Increase in noise and vibration

Noise and vibrations could increase during decommissioning of equipment. Current noise levels

at site were by far lower than the regulatory limits of 90 dB. But during decommissioning, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term and was rated as high impact.

Impairment of air quality

Emissions into the environment can occur during decommissioning of equipment. Despite being a brown field, all the priority air quality parameters tested (SO_x, NO_x, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium.

Risk of accident

There is potential risk of accident particularly drowning during decommissioning. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

Risk of Piracy & kidnapping

Piracy and kidnapping could occur during decommissioning. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

Increase potential for road traffic accidents/ injury

Road traffic accidents could occur as a result of increased transportation during decommissioning, which could result in injury or death. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity of the accident and was rated medium.

Potential for conflicts arising from labour issues

Conflicts could arise from labour related issues during decommissioning. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The actions and measures that SPDC intend to take to reduce (or eliminate) negative impacts and promote positive impacts of the proposed Project are presented in this chapter. In this mitigation measures, emphases are placed on those negative impacts rated as significant (medium and high impacts). The measures are aimed at reducing these impacts to As Low As Reasonably Practicable (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. None significant impacts are expected to be mitigated through effective implementation of Health, Safety and Environment (HSE) plans that will be put in place during the different phases of the project.

The mitigation measures proposed are in consonance with the following:

- Department of Petroleum Resources guidelines and standards,
- Environmental laws at national, regional and international levels,
- FMEEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management,
- Best Available Technology for Sustainable Development;
- Social wellbeing and
- Concerns of stakeholders.

The following criteria were used to define mitigation measures for the identified impacts:

Prevention - Exclude significant potential impacts and risks by design and management Measures.

Reduction - Minimize the effects or consequences of those significant associated and potential impacts that cannot be prevented, to a level as low as reasonably practicable 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: Mitigation Measures

A summary of the mitigation measures for the potential impacts is presented in Table 6.1. These measures are recommended to ameliorate all the significant impacts of existing facilities and significant associated and potential impacts for the proposed Project.

Table 6.1: Mitigation Measures for Significant Associated and Potential Impacts of the Proposed Project

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Pre-construction	Site visit, pipeline route survey, consultation	Risk of accident	H	<p>SPDC shall ensure:</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p> <p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Mobilization	Mobilization (equipment & personnel), and Rig Move	Impairment of air quality	M	<p>SPDC shall:</p> <p>use only pre-mobbed and regularly maintained watercrafts, vessels, generators and other machines.</p> <p>Use only low sulphur containing fuel and low NOx burners in large generators and turbines.</p>	L
		Disturbance to fauna and subsequent migration due to increase in noise and vibration/levels	M	<p>SPDC shall</p> <p>use only pre-mobbed and regularly maintained equipment and water crafts</p> <p>Reduce movement time to ALARP. As much equipment as is safe to be transported should be transported at a time.</p>	L
		Risk of accident	H	SPDC shall ensure	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Risk of Piracy & kidnapping	H	SPDC shall	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p> <p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Site preparation	Increase in noise and vibration	H	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used</p> <p>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				Workers with existing hearing impairment shall not be deployed to site.	
		Interference with fishing activities	M	Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fisheries operations.	L
		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p> <p>SPDC shall support initiatives and programmes by Government to improve security</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	
		Loss of important species and other forms of disturbance from land clearing activities and associated loss of ecosystem services	H	<p>SPDC shall reduce land take to as low as possible.</p> <p>Minimize land/vegetation clearing to only portions required</p> <p>Revegetate unused portions of land with indigenous species</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Creation of new accesses to areas that were formally inaccessible, leading to increased threat of poaching and over-exploitation of the natural resources	H	Reduce landtake to as low as possible	M
		Migration of fauna due to noise and vibration	H	SPDC shall use equipment with low noise and vibration	M
Construction	Fabrication, Installation and positioning of Wellhead, facility upgrade	Increase in noise and vibration	H	Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits High sound energy equipment shall be enclosed in noise	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Workers with existing hearing impairment shall not be deployed to site.</p>	
		Interference with fishing activities	M	Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fisheries operations	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p> <p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Impacts of Wastes	H	<p>Site specific solid waste management plan in line with SPDC waste management guidelines shall be put in place. These include:</p> <p>Waste shall be segregated at source using colour-coded bins.</p> <p>Scrap metal/pipe off-cuts shall be transported to Shell Kidney Island (KI) scrap yard, Port Harcourt, for onward delivery to SPDC approved metal recycling vendor(s).</p> <p>Generated glass and paper materials shall also be transported to SPDC Industrial Area (IA) waste recycling depot for onward delivery to any SPDC approved glass recycling vendor(s).</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>The camp site shall be equipped/fitted with a biological sewage treatment plant.</p> <p>Spent batteries shall be taken to any SPDC approved battery re-cycling company.</p> <p>Medical waste shall be collected and taken to the medical incinerator at Shell IA</p>	
		Impairment of air quality	M	<p>Emissions from machinery shall be reduced by the use of standard equipment that meet existing emissions requirements (low NOx burners) and fume catalysers provided on all suitable equipment.</p> <p>Ambient air quality shall be monitored in line with FMENV/DPR requirement (NOx, COx, SOx, SPM etc)</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				There shall be regular maintenance of combustion systems (generators etc)	
Drilling	Drilling and casing of wells	Impairment of air quality	M	<p>Ensure that drilling equipment is of high standard and in good condition prior to mobilisation</p> <p>Ensure that all emission releasing equipment shall be maintained regularly</p> <p>Ambient air quality shall be monitored in line with FMENV/DPR requirement (NO_x, CO_x, SO_x, SPM etc)</p>	L
		Disturbance to activities of nocturnal animals (eg reproduction) due to increase in	M	As much as is practicable, night activities should be avoided or duration reduced to the barest minimum	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		hours of brightness and other forms of disturbance			
		Noise and vibration nuisance	M	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used</p> <p>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Workers with existing hearing impairment shall not be deployed to site.</p>	
		Injuries and death from blowouts	H	<p>SPDC shall ensure that only skilled personnel and certified equipment are used</p> <p>use appropriate blowout preventer</p> <p>use appropriate mud density</p> <p>ensure high quality chemicals and materials are used</p> <p>ensure emergency response procedures are in place</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Job hazard assessment shall be conducted</p> <p>Daily pep talks shall be conducted on identified hazards</p>	
		Destruction of Vegetation from blowout	H	<p>Remediate affected area</p> <p>Revegetate with indigenous species</p>	M
		Surface water and sediment pollution from chemicals, drill cuttings, and mud	H	<p>SPDC shall</p> <p>Recover oil based drilling mud for re-processing and re-use.</p> <p>Wells shall be drilled with Water Based Mud in top hole.</p> <p>Develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice.</p> <p>All industrial wastes such as plastics, metals, rubber and wood</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>shall be segregated on site and collected in designated containers.</p> <p>Drilling mud and cuttings shall be treated to DPR specifications</p>	
		Accidents and injuries	H	<p>Creating awareness amongst local communities on the potential of increased traffic on road & waterways and the need for extra precautions;</p> <p>SPDC journey management policy for road/water/ air transport shall be adhered to (all journey must be approved, no night journeys, speed limits on water etc);</p> <p>Defensive driving course (DDC) for all SPDC vehicle boat drivers (including contractors and casual drivers);</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>All vehicle/water/ air borne crafts shall be pre-mobilized and certificate of worthiness issued;</p> <p>All personnel for water/ air borne operations shall have certificate of swimming proficiency;</p> <p>Adequate first aid shall be maintained in all vehicle & watercrafts and at site;</p> <p>Use of life-vest while on transit for water borne operations;</p> <p>Compensation for proven project-induced injuries accidents and fatalities on third parties;</p> <p>Use only trained personnel for specified jobs;</p> <p>Carry out job hazard analysis;</p> <p>Daily pep-talk before each day's job;</p>	

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				Medevac shall be provided at site	
		Contamination of the environment by wastes	H	<p>SPDC shall ensure regular collection and monitoring of wastes from cradle to grave in accordance with SPDC's waste management plan.</p> <p>all oily wastes shall be properly segregated and contained before disposal.</p> <p>Sanitary wastes shall be treated in a sewage treatment plant.</p> <p>Non-hazardous wastes shall be subjected to SPDC's waste management process.</p> <p>Hazardous wastes shall be segregated and sent to approved waste disposal sites.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Rags (clothing, worn coveralls, shirt, trousers), shall be segregated and sent to approved incinerator.</p> <p>Miscellaneous domestic waste, old tooth brushes/disposable razors etc/old footwear, hand gloves etc and garbage, will be segregated and subjected to SPDC's waste management procedure.</p> <p>General paper waste shall be segregated and sent to approved SPDC's waste management guidelines.</p> <p>Plastic containers shall be sent to recycling depot subjected to SPDC's waste management guidelines.</p> <p>IBC tanks for chemicals shall be re-used for fresh chemical</p>	

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>supplies to the rig while spent chemical drums shall be sent to town for incinerator.</p> <p>Kitchen waste (garbage) shall be segregated and subjected to SPDC's waste management guidelines.</p> <p>SPDC shall enforce adequate waste management on site.</p> <p>SPDC shall ensure that disposal of drilling wastes is in line with regulatory standards (See section on mitigation of wastes).</p>	

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Construction	Pipeline construction (Piping/ flowlines, well hook-up)	Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p> <p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Impairment of air quality	M	<p>Emissions from machinery shall be reduced by the use of standard equipment that meet existing emissions requirements (low NOx burners) and fume catalysers provided on all suitable equipment.</p> <p>Ambient air quality shall be monitored in line with FMENV/DPR requirement (NOx, COx, SOx, SPM etc)</p> <p>There shall be regular maintenance of combustion systems (generators etc)</p>	L
		Increase in noise and vibration levels	M	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used</p> <p>Acoustic mufflers shall be provided for heavy engines with</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>noise level above acceptable limits</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Workers with existing hearing impairment shall not be deployed to site</p>	
		Contamination of surface water bodies	H	SPDC shall	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>treat all effluents to regulatory limits before discharging into the environment.</p> <p>Dispose all wastes in line with regulatory requirements</p> <p>SPDC shall activate existing oil spill contingency plans in the event of oil spill.</p>	
		Exposure to radiation materials	H	<p>Health awareness training will be conducted prior to commencement of activities.</p> <p>Staff shall undergo routine medical check-ups for radiation exposure.</p> <p>Radiation monitors shall be provided to monitor radiation levels at site.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>The use of radiography aprons to protect the body from radiation shall be enforced.</p> <p>Warning signs shall be provided during radiation emitting activities to prevent the public from trespassing into such areas.</p> <p>The radiation emitting activity shall be carried out in accordance with standard construction specifications.</p>	
		inhalation of welding fumes	M	<p>Awareness sessions on health risks and safety precautions of welding operations to be carried out for workers.</p> <p>SPDC shall enforce the use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
		Soft tissues damage from welding sparks	M	<p>Awareness sessions on health risks and safety precautions of welding operations to be carried out for workers.</p> <p>SPDC shall enforce the use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding.</p> <p>A functional site clinic shall be provided by the contractor and approved by SPDC</p>	L
		Conjunctivitis from welding flash	M	<p>Awareness sessions on health risks and safety precautions of welding operations for workers.</p> <p>Pre-employment medical certification the welders.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				Enforcement of the use of PPEs (welder's mask, earmuffs, jacket, gloves, boots and coveralls), by welders during welding. Provision of site clinic for workers	
		Potential for conflicts arising from labour issues	H	Indigenes shall be prevailed upon to concede some employment spaces to migrants. SPDC & her contractors shall respond to complaints by locals on the activities of her workers	L
		Stress on existing security structures	H	SPDC shall support initiatives and programmes by Government to improve security, SPDC shall continue to engage stakeholders in order to minimize resentment.	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	
		Disturbance to nocturnal animals due to increase in hours of brightness and other forms of disturbance at night	M	<p>As much as is practicable, night activities should be avoided or duration should be reduced to ALARP</p> <p>Maintain lighting at only areas required at night</p>	L
Demobilization	Demobilization of personnel, equipment	Impairment of air quality	M	<p>SPDC shall:</p> <p>use only pre-mobbed crafts</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	and waste from field location			<p>regularly maintenance of water crafts, vessels, generators and other machines.</p> <p>use low sulphur containing fuel and low NOx burners</p>	
		Road & Water traffic incidents	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Improper disposal of materials removed from site	M	<p>SPDC shall ensure:</p> <p>all removed materials shall be properly disposed of and monitored from cradle to grave in line with the waste management plan</p> <p>Scrap metals shall be collected, segregated and subjected to SPDC's waste management guidelines.</p> <p>Plastic wastes shall be sent to approved Recycling Waste Depot (RWD).</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Radioactive wastes/materials shall be managed according to Nigerian Nuclear Regulatory Authority (NNRA) approved procedure.</p> <p>SPDC waste management policy shall be enforced.</p>	
		Increase in noise and vibration level	M	<p>SPDC shall use only pre-mobbed and regularly maintained equipment and water crafts</p>	L
		Loss of employment/ income	H	<p>SPDC Shall:</p> <p>Strengthen existing cooperatives and encourage the formation of new ones that will engage in commercial activities to sustain the local economy</p> <p>Workers shall be made aware that employment is only temporal</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>and shall cease at the end of the contract</p> <p>Support micro credit schemes that promote trade and self sustenance</p> <p>Require contractors to prepare and implement workers disengagement plans</p> <p>Encourage and support skill acquisition programmes of Government, NGOs and CBOs</p>	
		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	
Operation	Commissioning and Maintenance	Improper disposal of materials removed from site	H	<p>SPDC shall:</p> <p>ensure all oily wastes are properly segregated and contained before disposal.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>ensure all oily wastes are properly disposed of and monitored from cradle to grave.</p> <p>ensure regular clean-up of equipment at site.</p> <p>provide containment for chemicals and liquid discharges.</p> <p>ensure her waste management policy shall be enforced</p> <p>ensure that a controlled fuelling, maintenance and servicing protocol for machinery at worksite is established and followed to minimize leaks and spills</p> <p>ensure Spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of.</p>	

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>ensure Used chemical drums and containers are sent to an approved RWD.</p> <p>Small chemicals spills, crude oil and aqueous effluents shall be cleaned up promptly.</p>	
		Equipment failure and damage leading to injuries/fatality	M	<p>SPDC shall ensure that</p> <p>Only skilled personnel and certified equipment are used.</p> <p>Certified first Aiders shall be available at every site.</p> <p>First aid boxes and emergency response procedures are in place</p> <p>hazard assessment has been conducted.</p> <p>emergency response procedures are in place.</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				HSE standards are strictly adhered to. Permit to work and proper briefing is given before any work action.	
		gas flaring	H	SPDC shall: not routinely flare associated gas associated gas shall be sent to NLNG via the EGGS	L
		produced water	H	Produced water shall be treated to regulatory standards before discharge via the Bonny Terminal	L
		Risk of accident	H	SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	
Decommissioning	Demolition, removal of pipeline, well and well casing and	Increase in noise and vibration	M	SPDC shall use only pre-mobbed and regularly maintained equipment and water crafts	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	removal of associated waste			Activities should be carried out simultaneously to reduce duration of noise and vibration	
		Impairment of air quality	M	SPDC shall: use only pre-mobbed crafts regularly maintenance of water crafts, vessels, generators and other machines. use low sulphur containing fuel and low NOx burners	L
		Risk of accident	H	SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET. Only pre-mobbed vehicle & water crafts are used.	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	
		Risk of Piracy & kidnapping	H	<p>SPDC shall make adequate security arrangements at the project site</p> <p>ensure that security orientation and awareness is conducted for workforce</p>	M

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>SPDC shall support initiatives and programmes by Government to improve security</p> <p>A security management plan shall be produced for the project before mobilization</p> <p>Workers to be made aware to be security conscious</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition</p> <p>Employment opportunities for the indigenes</p>	
		Increase potential for water traffic accidents/ injury	M	<p>SPDC shall ensure compliance with her journey management policy for marine transport</p> <p>Only pre-mobbed water crafts are used</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>daily pep talk is carried out for marine transportation</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational water crafts</p> <p>Emergency response plan shall be in place</p>	
		Potential for conflicts arising from labour issues	H	<p>Indigenes shall be prevailed upon to concede some employment spaces to migrants.</p> <p>SPDC & her contractors shall respond to complaints by locals on the activities of her workers</p>	L
		Injury/fatalities in workforce	H	<p>SPDC shall ensure</p> <p>daily pep talk is carried out for marine transportation</p>	L

Project Phases	Project Activities	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
				<p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational water crafts</p> <p>Emergency response plan shall be in place</p>	

CHAPTER SEVEN

ENVIRONMENTAL MANAGEMENT PLAN

7.1: General

Environmental management is concerned with a planned and integrated program aimed at ensuring that unforeseen and unidentified impacts of a proposed project are contained and brought to acceptable minimum levels. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from mobilization to abandonment. In keeping with Shell policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design, up to the present stage of EIA and will continue throughout the project life cycle. This EIA report is part of the environmental management program, and is intended to provide an environmental input into the planning and execution of the project. The project's HSE-MS addresses the overall approach adopted for management of HSE risks through the project development phases by the project management team. The project HSE-MS document provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practices, etc., and demonstrates how the Hazards and Effects Management Process (HEMP) will be applied on the project such that HSE risks are kept As Low As Reasonably Practicable (ALARP).

Good environmental management, which is part of SPDC HSE-MS goals, has the following long term objectives:

- Ensure compliance with Legislations and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified in this environmental impact assessment are implemented, a comprehensive EMP was developed (Table 7.1). The EMP takes cognizance of the technical implementation of the EIA findings in the design phase of project development, such that a plan of action for managing residual environmental impacts can then be evolved.

7.2: Compliance Environmental Monitoring

Compliance environmental monitoring is required during all the phases of the proposed project. Accordingly, a compliance monitoring plan is included in this EMP. The parameters to be monitored will help to provide information on the quality of the environment as the project progresses, The Monitoring Plan is presented in Table 7.2., and it specified the component of the environment to be monitored, the parameter required, location of monitoring, frequency and the method to be deployed for data collection.

Table 7.1: Environmental Management Plan

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
Pre-construction (survey)		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p>	L	<p>Journey management records</p> <p>Premob certificates of vessels</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Use of PPEs by the team.				
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements for the project.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Support initiatives and programmes by Government to improve security.</p> <p>A security management plan shall be produced for the project before mobilization.</p> <p>Workers to be made aware to be security conscious.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition. Employment opportunities for the indigenes.				
Mobilization (equipment & personnel), and Rig Move		Impairment of air quality	M	SPDC shall: Use only pre-mobbed and regularly maintained watercrafts, vessels, generators and other machines. Use only low sulphur containing fuel and low NOx burners in large generators and turbines.	L	Premob certificates Maintenance records Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)	Monthly	SPDC Project Manger, HSE project focal point, Federal and State Government
		Increase in noise and vibration	M	SPDC shall:	L	Premob certificates	Monthly	SPDC Project Manger,

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Use only pre-mobbed and regularly maintained equipment and water crafts.</p> <p>Use PPEs such as ear muff.s</p> <p>Equipment with low noise rating (85 - 90 dB (A)).</p>		Maintenance records		HSE project focal point, Federal and State Government
		Risk of accident	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>				
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements at the project site.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Latch on to the existing security management plan for the project.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Conduct regular security awareness with workers.</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition.</p> <p>Employment opportunities for the indigenes.</p>				
Site preparation		Increase in noise and vibration	H	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used.</p> <p>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits.</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy.</p>	L	<p>Premob certificates</p> <p>Maintenance records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Implement hearing conservation programme for all workers.</p>				
		Interference with fishing activities	M	Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fisheries operations.	L	Records of engagement sessions,	Monthly	SPDC Project Manger, HSE project focal point,

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Deploy the sustainable development strategy to the project.				Federal and State Government
		Risk of accident	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine transport.</p> <p>Only pre-mobbed water crafts are used.</p> <p>Daily pep talk is carried out for marine transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Ensure provision of first aid boxes in operational water crafts.</p> <p>Emergency response plan shall be in place.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements at the project site.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Latch on to the existing security management plan for the project.</p> <p>Conduct regular security awareness with workers.</p> <p>Engagement of the youths from the area on worthwhile</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				ventures e.g. skills acquisition. Employment opportunities for the indigenes.				
Fabrication, Installation and positioning of Wellhead, facility upgrade		Increase in noise and vibration	H	Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used. Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits. High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational	L	Premob certificates Maintenance records	Monthly	SPDC Project Manger, HSE project focal point, Federal and State Government

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Implement hearing conservation programme for all workers.</p>				
		Interference with fishing activities	M	Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fisheries operations	L	Records of engagement sessions,	Quarterly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Risk of accident	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements at the project site.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Latch on to the existing security management plan for the project.</p> <p>Conduct regular security awareness with workers.</p> <p>Engagement of the youths from the area on skills acquisition ventures.</p> <p>Employment opportunities for the indigenes.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Impacts of Wastes	H	<p>Site specific solid waste management plan in line with Gbaran CPF waste management guidelines shall be put in place. These include:</p> <p>Waste shall be segregated at source using colour-coded bins.</p> <p>Scrap metal/pipe off-cuts shall be transported to Shell Kidney Island (KI) scrap yard, Port Harcourt, for onward delivery to SPDC approved metal recycling vendor(s).</p> <p>Generated glass and paper materials shall also be transported to SPDC Industrial Area (IA) waste recycling depot for onward delivery to any SPDC</p>	L	<p>SPDC Waste management plan</p> <p>Waste consignment note,</p> <p>Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water),</p> <p>Site inspection Reports</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>approved glass recycling vendor(s).</p> <p>The camp site shall be equipped/fitted with a biological sewage treatment plant.</p> <p>Spent batteries shall be taken to any SPDC approved battery re-cycling company.</p> <p>Medical waste shall be collected and taken to the medical incinerator at Shell IA, Port Harcourt.</p>				
		Impairment of air quality	M	Emissions from machinery shall be reduced by using standard equipment that meet existing emissions requirements (low NOx burners) and fume	L	<p>Premob certificates</p> <p>Maintenance records</p> <p>Compliance Monitoring Reports (soil,</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>catalysers provided on all suitable equipment.</p> <p>Ambient air quality shall be monitored in line with FMEnv/DPR requirement (NO_x, CO_x, SO_x, SPM).</p> <p>There shall be regular maintenance of combustion systems.</p>		air, groundwater, sediment, surface water)		Federal and State Government
Drilling		Impairment of air quality	M	<p>Ensure that drilling equipment is of high standard and in good condition prior to mobilization.</p> <p>Ensure that all emission releasing equipment are maintained regularly.</p> <p>Ambient air quality shall be monitored in line with FMEnv/DPR requirement (NO_x, CO_x, SO_x, SPM).</p>	L	<p>Premob certificates</p> <p>Maintenance records</p> <p>Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)</p>	<p>Continuous</p> <p>Monthly</p>	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Noise and vibration nuisance	M	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used</p> <p>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy</p>	L	<p>Premob certificates</p> <p>Maintenance records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>sound to reduce noise levels.</p> <p>Implement hearing conservation programme for all workers.</p>				
		Injuries and death from blowouts	H	<p>SPDC shall ensure that:</p> <p>Only skilled personnel and certified equipment are used.</p> <p>Use appropriate blowout preventer.</p> <p>Use appropriate mud density.</p> <p>Ensure high quality chemicals and materials are used.</p> <p>Ensure emergency response procedures are in place.</p>	L	<p>Certification of workforce</p> <p>MSDS and Technical specification</p> <p>Emergency response plan</p> <p>HAZID register.</p> <p>Pep-talk records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Job hazard assessment shall be conducted.</p> <p>Daily pep talks shall be conducted on identified hazards.</p>		Site inspection Reports		
		Surface water and sediment pollution from chemicals, drill cuttings, and mud	H	<p>SPDC shall:</p> <p>Recover oil based drilling mud for re-processing and re-use.</p> <p>Wells shall be drilled with Water Based Mud in top hole.</p> <p>Develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice.</p> <p>All industrial wastes such as plastics, metals, rubber and wood shall be segregated on</p>	L	<p>Drill cutting treatment records</p> <p>Drilling mud recovery record</p> <p>Compliance Monitoring Reports (soil, air, groundwater,</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>site and collected in designated containers.</p> <p>Drilling mud and cuttings shall be treated to DPR specifications</p>		<p>sediment, surface water)</p> <p>Waste consignment note</p>		
		Accidents and injuries	H	<p>Creating awareness amongst local communities on the potential of increased traffic on waterways and the need for extra precautions.</p> <p>SPDC journey management policy for water/ air transport shall be adhered to.</p> <p>Defensive driving course (DDC) for all SPDC boat drivers (including</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>contractors and casual boat drivers).</p> <p>All water/ air borne crafts shall be pre-mobilized and certificate of worthiness issued.</p> <p>All personnel for water/ air borne operations shall have certificate of swimming proficiency.</p> <p>Adequate first aid shall be maintained in all watercrafts and at site.</p> <p>Use of life-vest while on transit for water borne operations.</p> <p>Compensation for proven project-induced injuries accidents and fatalities on third parties.</p>				

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Use only trained personnel for specified jobs.</p> <p>Carry out job hazard analysis;</p> <p>Daily pep-talk before each day's job.</p> <p>Medevac shall be provided at site.</p>				
		Contamination of the environment by wastes	H	<p>SPDC shall ensure:</p> <p>Regular collection and monitoring of wastes from cradle to grave in accordance with SPDC's waste management plan.</p> <p>All oily wastes shall be properly segregated and contained before disposal.</p>	L	<p>SPDC Waste management plan</p> <p>Waste consignment note</p> <p>Compliance Monitoring Reports (soil, air, groundwater,</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Sanitary wastes shall be treated in a sewage treatment plant.</p> <p>Non-hazardous wastes shall be managed in line with SPDC's waste management process.</p> <p>Hazardous wastes shall be segregated and sent to approved waste disposal sites.</p> <p>Rags (clothing, worn coveralls, shirt, trousers), shall be segregated and sent to approved incinerator.</p> <p>Miscellaneous domestic waste, old tooth brushes/disposable razors etc/old footwear, hand gloves etc and garbage, will be segregated and managed</p>		sediment, surface water) Site inspection Reports		

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>in line with SPDC's waste management procedure.</p> <p>General paper waste shall be segregated and managed in line with SPDC's waste management guidelines.</p> <p>Plastic containers shall be sent to recycling depot and managed in line with SPDC's waste management guidelines.</p> <p>IBC tanks for chemicals shall be re-used for fresh chemical supplies to the rig while spent chemical drums shall be sent to town for incinerator.</p> <p>Kitchen waste (garbage) shall be segregated and managed in line with</p>				

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>SPDC's waste management guidelines.</p> <p>SPDC shall enforce adequate waste management on site.</p> <p>SPDC shall ensure that disposal of drilling wastes is in line with regulatory standards (See section on mitigation of wastes).</p>				

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
Pipeline construction (Piping/ flowlines, well hook-up)		Risk of accident	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements for the project.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Support initiatives and programmes by Government to improve security.</p> <p>A security management plan shall be produced for the project before mobilization.</p> <p>Workers to be made aware to be security conscious.</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition.</p> <p>Employment opportunities for the indigenes.</p>		<p>situation/ updates</p> <p>Site Inspection records</p>		
		Impairment of air quality	M	<p>SPDC shall:</p> <p>Use only pre-mobbed and regularly maintained watercrafts, vessels, generators and other machines.</p>	L	<p>Premob certificates</p> <p>Maintenance records</p> <p>Compliance Monitoring</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Use only low sulphur containing fuel and low NOx burners in large generators and turbines.		Reports (soil, air, groundwater, sediment, surface water)		Federal and State Government
		Increase in noise and vibration levels	M	<p>Generators with noise levels within acceptable limits of (85 - 90 dB (A)) shall be used.</p> <p>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits.</p> <p>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</p> <p>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational</p>	L	<p>Premob certificates</p> <p>Maintenance records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>sites where high noise is produced.</p> <p>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</p> <p>Implement hearing conservation programme for all workers.</p>				
		Contamination of surface water bodies	H	<p>SPDC shall</p> <p>Treat all effluents to regulatory limits before discharging into the environment.</p> <p>Dispose all wastes in line with regulatory requirements.</p>	L	<p>Effluent monitoring records</p> <p>Waste Consignment note</p> <p>Compliance Monitoring Reports (soil, air,</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				SPDC shall activate existing oil spill contingency plans in the event of oil spill.		groundwater, sediment, surface water)		
		Exposure to radiation materials	H	<p>Health awareness training will be conducted prior to commencement of activities.</p> <p>Staff shall undergo routine medical check-ups for radiation exposure.</p> <p>Radiation monitors shall be provided to monitor radiation levels at site.</p> <p>The use of radiography aprons to protect the body from radiation shall be enforced.</p> <p>Warning signs shall be provided during radiation emitting activities to prevent</p>	L	<p>Minutes of toolbox meetings/safety briefings.</p> <p>Site inspection reports.</p> <p>Radiation levels record at work site</p> <p>Records of medical checks.</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>the public from trespassing into such areas.</p> <p>The radiation emitting activity shall be carried out in accordance with standard construction specifications.</p>				
		inhalation of welding fumes	M	<p>Awareness sessions on health risks and safety precautions of welding operations to be carried out for workers.</p> <p>SPDC shall enforce the use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding.</p>	L	<p>Records of PPEs issuance and usage</p> <p>Records of awareness sessions</p> <p>Site clinic records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Soft tissues damage from welding sparks	M	<p>Awareness sessions on health risks and safety precautions of welding operations to be carried out for workers.</p> <p>SPDC shall enforce the use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding.</p> <p>A functional site clinic shall be provided by the contractor.</p>	L	<p>Records of PPEs issuance and usage</p> <p>Records of awareness sessions</p> <p>Site clinic records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>
		Conjunctivitis from welding flash	M	<p>Awareness sessions on health risks and safety precautions of welding operations for workers.</p> <p>Pre-employment medical certification the welders.</p> <p>Enforcement of the use of applicable PPEs.</p>	L	<p>Records of PPEs issuance and usage</p> <p>Records of awareness sessions</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Provision of site clinic for workers.		Site clinic records		
		Potential for conflicts arising from labour issues	H	SPDC & her contractors shall respond to complaints by locals on the activities of her workers	L	Records of employment Records of issues settled	Monthly	SPDC Project Manger, HSE project focal point, Federal and State Government
		Stress on existing security structures	H	SPDC shall support initiatives and programmes by Government to improve security. SPDC shall continue to engage stakeholders in order to minimize resentment.	M	Security Management procedure Journey management procedure Record of security	Weekly	SPDC Project Manger, HSE project focal point, Federal and State Government

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Latch on to the existing security management plan for the project.</p> <p>Conduct regular security awareness and periodic drill with workers.</p> <p>Engagement of the youths from the area on skills acquisition ventures.</p>		<p>situation/ updates</p> <p>Site Inspection records</p>		
Demobilization		Impairment of air quality	M	<p>SPDC shall:</p> <p>Use only pre-mobbed and regularly maintained watercrafts, vessels, generators and other machines.</p> <p>Use only low sulphur containing fuel and low NOx burners in large generators and turbines.</p>	L	<p>Premob certificates</p> <p>Maintenance records</p> <p>Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Road & Water traffic incidents	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Improper disposal of materials removed from site	M	<p>SPDC shall ensure:</p> <p>All removed materials shall be properly disposed of and monitored from cradle to grave in line with the waste management plan.</p> <p>Scrap metals shall be collected, segregated and subjected to SPDC's waste management guidelines.</p> <p>Plastic wastes shall be sent to approved Recycling Waste Depot (RWD).</p> <p>Radioactive wastes/materials shall be managed according to Nigerian Nuclear</p>	L	<p>SPDC Waste management plan</p> <p>Waste consignment note</p> <p>Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)</p> <p>Site inspection Reports</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Regulatory Authority (NNRA) approved procedure. SPDC waste management policy shall be enforced.				
		Increase in noise and vibration level	M	SPDC shall Use only pre-mobbed and regularly maintained equipment and water crafts.	L	Premob certificates Maintenance records	Weekly	SPDC Project Manger, HSE project focal point, Federal and State Government
		Loss of employment/ income	H	SPDC Shall: Strengthen existing cooperatives and encourage the formation of new ones that will engage in commercial activities to sustain the local economy.	L	Evidences of workers disengagement plans,	Monthly	SPDC Project Manger, HSE project focal point,

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Support micro credit schemes that promote trade and self sustenance.</p> <p>Require contractors to prepare and implement workers disengagement plans.</p> <p>Encourage and support skill acquisition programmes of Government, NGOs and CBOs.</p>		<p>Records of skill acquisition,</p> <p>Evidence of support for micro-credits</p>		Federal and State Government
		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	<p>As required</p> <p>At purchase of materials</p> <p>Monthly</p>	SPDC Project Manger,

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>			Monthly/For each activity	<p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements for the project.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Support initiatives and programmes by Government to improve security.</p> <p>A security management plan shall be produced for the project before mobilization.</p> <p>Workers to be made aware to be security conscious.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition.</p> <p>Employment opportunities for the indigenes.</p>				
Commissioning Operations and Maintenance		Improper disposal of materials removed from site	H	<p>SPDC shall:</p> <p>Ensure all oily wastes are properly segregated and contained before disposal.</p> <p>Ensure all oily wastes are properly disposed of and monitored from cradle to grave.</p> <p>Ensure regular clean-up of equipment at site.</p> <p>Ensure her waste management policy shall be enforced</p>	L	<p>Waste consignment note</p> <p>Site Inspection reports</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Ensure that a controlled fuelling, maintenance and servicing protocol for machinery at worksite is established to minimize leaks and spills.</p> <p>Ensure spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of.</p> <p>Ensure used chemical drums and containers are sent to an approved Recyclable Waste Dump (RWD).</p> <p>Small chemicals spills, crude oil and aqueous effluents shall be cleaned up promptly.</p>				
		Equipment failure and damage	M	SPDC shall ensure that:	L	Premob certificates	Monthly	SPDC Project Manger,

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		leading to injuries/fatality		<p>Only skilled personnel and certified equipment are used.</p> <p>Certified first Aiders shall be available at every site.</p> <p>First aid boxes and emergency response procedures are in place.</p> <p>Hazard assessment has been conducted.</p> <p>Emergency response procedures are in place.</p> <p>HSE standards are strictly adhered to.</p> <p>Permit to work and proper briefing is giving before any work action.</p>		<p>Maintenance records.</p> <p>Certification of work force</p> <p>First Aid box inventory</p> <p>HAZID register</p> <p>Records Tool box meeting</p> <p>HSE inspection records.</p>		<p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
						Emergency response procedure.		
		Gas flaring	H	<p>SPDC shall:</p> <p>Not routinely flare associate gas.</p> <p>Associated gas shall be sent to NLNG via the OGGS.</p>	L	<p>Records of gas produced,</p> <p>Records of gas flared,</p> <p>Records of gas sent to NLNG</p>	Quarterly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>
		Produced water	H	<p>SPDC shall:</p> <p>Treat produced water to regulatory standards before discharge.</p>	L	Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
								Federal and State Government
		Risk of accident	H	<p>SPDC shall ensure Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>				
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements for the project.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p> <p>Support initiatives and programmes by Government to improve security.</p> <p>A security management plan shall be produced for the project before mobilization.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security situation/ updates</p> <p>Site Inspection records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Workers to be made aware to be security conscious.</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition.</p> <p>Employment opportunities for the indigenes.</p>				
Decommissioning and Abandonment		Increase in noise and vibration	M	<p>SPDC shall:</p> <p>Use only pre-mobbed and regularly maintained equipment and water crafts.</p>	L	<p>Premob certificates</p> <p>Maintenance records</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>
		Impairment of air quality	M	<p>SPDC shall:</p> <p>Use only pre-mobbed and regularly maintained watercrafts, vessels,</p>	L	<p>Premob certificates</p>		<p>SPDC Project Manger,</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>generators and other machines.</p> <p>Use only low sulphur containing fuel and low NOx burners in large generators and turbines.</p>		<p>Maintenance records</p> <p>Compliance Monitoring Reports (soil, air, groundwater, sediment, surface water)</p>	Monthly	<p>HSE project focal point,</p> <p>Federal and State Government</p>
		Risk of accident	H	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p> <p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p>	L	<p>Journey management records</p> <p>Premob certificates</p> <p>Pep-talk records</p> <p>Accident records</p>	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>				
		Risk of Piracy & kidnapping	H	<p>SPDC shall</p> <p>Make adequate security arrangements for the project.</p> <p>Ensure that security orientation and awareness is conducted for workforce.</p>	M	<p>Security Management procedure</p> <p>Journey management procedure</p> <p>Record of security</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Support initiatives and programmes by Government to improve security.</p> <p>A security management plan shall be produced for the project before mobilization.</p> <p>Workers to be made aware to be security conscious.</p> <p>Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition.</p> <p>Employment opportunities for the indigenes.</p>		<p>situation/ updates</p> <p>Site Inspection records</p>		
		Increase potential for road & water traffic accidents/ injury	M	<p>SPDC shall ensure</p> <p>Compliance with SPDC journey management policy for marine & road transport including TBOSIET.</p>	L	<p>Journey management records</p> <p>Premob certificates</p>	Weekly	

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				<p>Only pre-mobbed vehicle & water crafts are used.</p> <p>Daily pep talk is carried out for marine & road transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provide first aid boxes in operational vehicle & water crafts.</p> <p>Emergency response plan shall be in place.</p> <p>Use of PPEs by the team.</p>		<p>Pep-talk records</p> <p>Accident records</p>		<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Potential for conflicts arising from labour issues	H	<p>SPDC shall:</p> <p>Implement GMOU provision for end of contract.</p> <p>Respond to complaints.</p>	L	Records of employment	Monthly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>
		Injury/fatalities in workforce	H	<p>SPDC shall ensure:</p> <p>Daily pep talk is carried out for marine transportation.</p> <p>Safety signage shall be deployed at strategic locations.</p> <p>Provision of first aid boxes in operational watercrafts</p> <p>Emergency response plan is in place.</p>	L	<p>Certification of workforce</p> <p>Emergency response plan</p> <p>MSDS and Technical specification</p> <p>HAZID register.</p>	Weekly	<p>SPDC Project Manger,</p> <p>HSE project focal point,</p> <p>Federal and State Government</p>

Project Activities		Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
						Pep-talk records		

Table 7.2: Environmental Monitoring Plan for the Uzu Project – Sources of Impact Monitoring

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
Sanitary wastewater	DPR EGASPIN II E 3.5.6.1(h) – Table II-6 Limitation on treated sanitary wastewater and DPR EGASPIN II E Table II-8	Maximum daily discharge rate Residual Cl<1.5 mg/l BOD ₅ < 45 mg/l Fecal coliform 400 MPN/100ml DO 4.0-5.0 mg/l	Daily rate Residual chlorine BOD ₅ Fecal coliform MPN/100ml DO	Discharge point from chlorinating unit (i.e. after treatment)	Weekly	Analysis of grab sample
Hydrocarbon release	DPR EGASPIN VIII B & C	Notification within 24 hours using Form A	Oil Spill Contingency Response Readiness (procedures and	Rig drilling points	Monthly	Analysis of grab sample and water sample

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
		Report investigation finding within 1 week using Form B Report response/ clean up within 4 weeks using Form C	plans at the rig site). Oil spill investigation and reporting			
Use of Stuck radioactive tool	DPR EGASPIN II E 3.7.2 & 3.7.3.2	Monitor radiation levels during operations	Radiation in circulating fluid mud system, environment, equipment and personnel	Rig	Hourly	Radiation monitor
		Weekly and End-of-Well reports of radiation levels Report stuck RA tool within 24 hours	Reporting	Documentation	Weekly, on completion of wells and when there is a stuck tool	Assurance of documentation

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
Discharge of drilling waste (drilling fluids, cuttings, sand)	DPR EGASPIN II E 3.5.4.2 (Discharge of toxic substances during drilling)	<ul style="list-style-type: none"> ▪ Daily minimum and monthly average 96hrLC50 of 30,000 ppm for <i>Palaemonetes africanus</i> in 9:1 seawater to drilling fluid suspended particulate phase ▪ Maximum discharge rate of 1,000 bbls/hr EXCEPT drilling fluid discharges that are shunted to the bottom 	96 Hr LC ₅₀ for drilling fluid and drill cuttings Discharge rate	Rig	Once a month and at end of well	Laboratory analysis

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
	DPR EGASPIN II E 3.5.6.1 and DPR EGASPIN II E Table II-8 MARPOL 93/98	No discharge into inland or nearshore waters No visible oil sheen for WBM No more than 5% oil on cuttings for SBM No more than 1% oil on cuttings for LTOBM No more than 10 g of oil on Kg (dry weight) of solid pH Metals Petroleum Hydrocarbons	Oil on cuttings pH Metals Petroleum Hydrocarbons Total hydrocarbons PAH	Every 305 m From the lowest section of well (NOT in pay zone)	Every 305 m	Sampling of treated drill cuttings and analyses of samples to be carried out by a DPR-accredited laboratories.
	DPR EGASPIN II E Table II-8	Monitoring	Free oil	Surrounding waters	Weekly during discharge	Visual check
Other liquid waste (waste oils, paint, chemicals, BOP, well	DPR EGASPIN VIII C	Categorise and quantify waste	Categorisation of waste and management from cradle to grave	Waste discharge points	Continuous	Record quantity in each category of waste

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
treatment and work over fluids)	DPR EGASPIN II E Table II-8	Monitor specified parameters	Volume of BOP fluid	Discharge point	Hourly during discharge	Measure/Estimate
			Volume of well treatment and	Discharge point	Daily during discharge	Measure OR estimate
Other liquid waste (waste oils, paint, chemicals, BOP, well treatment and work over fluids) cont'd	DPR EGASPIN II E Table II-8 cont'd	Monitor specified parameters cont'd	Volume, pH, Chloride and THC for work over fluids and wastes	Discharge point	Daily during discharge	Insitu measurements AND/OR Laboratory analysis
			Hg & Cd	Mud	Ice per new stock of barite/new well	Laboratory analysis
Combustion	DPR EGASPIN III E 4.4.2 Gaseous point sources emission monitoring	1-hour mean ($\mu\text{g}/\text{m}^3$) CO ⁽³⁾ =30 SO ₂ = 350 NO ₂ ⁽³⁾ = 400 Total SPM = 150-230	Volume of fuel/gas consumed Emissions rate CO, CO ₂ , SO _x , NO _x , THC, VOC, SPM from emissions	Emission point	Weekly	Normal operations flow meter is read daily.
	DPR EGASPIN III E 4.4.5 Table III-3 National Ambient Air Quality Standards	Daily average mean ($\mu\text{g}/\text{m}^3$) CO ⁽³⁾ =10 SO ₂ = 100-150 NO ₂ ⁽³⁾ = 150 Total SPM = 60-90	Particulates, ozone, H ₂ S, heavy and trace metals in ambient air	Emission point	Weekly (DPR)	Calculate using emission factors for fuel consumed

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
Gas flaring	DPR EGASPIN III E 3.8.8.1	Gas flaring is prohibited except an appropriate waiver /permit is granted by DPR	Flare volume	Prior to HP and LP flare tips (automatic online system)	Daily during flaring (recorded from CCR)	All vented gas into the HP and LP Flare Systems are measured and totaled prior to entering flare tip.
		Smoke Relative density < 2 Ringlemann No. (1hr period)	Smoke	Flare tip	Daily during flaring	Smoke- Ringlemann No.
		Allowable heat radiation (ground level) 6.31 kw/m ² during max. flaring (60m from flare base - ground level)	Temperature	Each of the mooring structures and highest point of Compression Pallet	Daily during flaring (recorded from CCR)	Temperature probe or temperature transmitters OR both
Gas flaring contn'd	DPR EGASPIN III E 3.8.8.1 cont'd	Noise levels at 60 m from base of flare stack shall be within threshold of pain (80 – 100 dB(A)). Lower and upper limits of 78 and 83 dB(A) and max limit of no more than 85 dB(A)	Noise	Points 60 m from base of flare stack	Weekly	Noise meter

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
**Oily water, sand and oily sludge discharges	DPR EGASPIN III E 3.6.2 b Disposal of produced formation water/oily water offshore /deepwater AND DPR EGASPIN III E 3.8.2 Required quality of produce/oily waters from offshore production operation	No more than 40mg/l monthly average for oil in produced water to be discharged offshore OR ELSE disposal must be via re-injection	O&G content of produced water to be discharged offshore	Discharge line for treated produced water	Continuous	Water sampling & Analysis (record daily max., and monthly average in mg/l)
**Oily water, sand and oily sludge discharges cont'd	DPR EGASPIN III E 4.1.1)	Complete chemical assay/analysis of the constituents of produced formation water; and 96-hr LC50 toxicity testing, for produced water as may be specified			As may be specified by DPR	Laboratory analysis using appropriate species

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
	DPR EGASPIN III E 4.1.2 Table 111-2 Other monitoring requirements and SPDC Waste Management Procedure	Monitor	Volume/discharge rate for produced water	Produced water discharge outfall downstream of last treatment equipment	Daily – during discharge	Read off from flow meter (record max. daily rate) for produced water
			Free oil from produced water	Surrounding sea surface	Daily – during discharge	Visual observation for sheen on water (record as no. days sheen observed)
			Volume/discharge rate for oily water Physico-chemical parameters (pH, Temperature, THC, Cl ⁻ , Turbidity, TDS, TSS, COD, BOD ₅ , Pb ²⁺ , Fe (total), Cu ²⁺ , Cr ⁶⁺ , Zn ²⁺) for oily water	Discharge point for effluent	Weekly	Estimation for discharge rate Analysis of grab samples for physico-chemical parameters
			Quantity/weight of produced sand and oily sludge	Sand bag, drum, or cuttings box	During drilling	Estimate
			Quantity/weight of solids containing LSA/NORM	Sand bag, drum, or cuttings box	During drilling	Estimate

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
			Background radiation levels and average of highest and lowest radiation	Sand bag, drum, or cuttings box	During drilling	Radiation monitor
DPR EGASPIN III E 3.6.4.2 Disposal of sands containing LSA/NORM	Alert DPR within 24hrs when LSA/NORM present at levels 50micro rems/hr > background reading or 30 pci/gm	LSA/NORM background radiation (record average of highest and lowest readings)	Production tubing, vessels, pumps/valves, scales, produced sand	Continuous	Radiation Monitor (record as specific activity in Bq/gm and Pci/L, and dose limit mSv/a)	

SOURCE OF IMPACT	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
**Oily water, sand and oily sludge discharges cont'd	DPR EGASPIN III E 3.8.6.1 Limitation on the quality of offshore recipient water bodies for permitted discharge	The notional mixture shall meet the following requirement relative to undisturbed sea water: Oil content $\leq \pm 1$ pH $\leq \pm 1$ HCO ₃ ⁻ + Cl ⁻ + SO ₂ ⁻ $\leq 20\%$ NO ₃ + NH ₄ ≤ 25 mg/l Temperature $\leq \pm 5^{\circ}\text{C}$ DO $\leq 4\text{mg/l}$ assuming conc. in undisturbed water is 7 mg/l	Oil in water pH HCO ₃ ⁻ Chloride (Cl ⁻) SO ₄ ²⁻ NO ₃ ⁻ NH ₄ ⁺ Temperature Dissolved oxygen (for notional mixture)	Sampling of seawater (mid-depth and 500m from discharge point)	Monthly	Sample collection and analysis in an external approved lab. Calculated as notional mixture (3.8.6.1)

Table 7.3: Environmental Monitoring Plan for the Uzu Project – Receptor of Impacts Monitoring

Receptor	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
**Recipient surface water	DPR EGASPIN III E 3.8.6.1 Limitation on the quality of offshore recipient water bodies for permitted discharge		Physico-chemical parameters (pH, Temperature, THC, Cl ⁻ , Turbidity, TDS, TSS, COD, BOD ₅ , Pb ²⁺ , Fe (total), Cu ²⁺ , Cr ⁶⁺ , Zn ²⁺) Oil in water HCO ₃ ⁻ Chloride (Cl ⁻) SO ₄ ²⁻ NO ₃ ⁻ NH ₄ ⁺ Temperature Dissolved oxygen TPH, PAH, BTEX, Heterotrophic	500m and 1000m upstream down stream	Monthly	Sample collection and analysis in an external approved lab.

Receptor	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
**Recipient surface water contd.	DPR EGASPIN III E 3.8.6.1 Limitation on the quality of offshore recipient water bodies for permitted discharge		Heavy metals and other metals (Ni, Zn, Cu, Fe, Mn, Cd, As, Ba, Pb, , Co, Cr, V Total Heterotrophic Bacteria, Total fungi, Hydrocarbon utilizing Bacteria, Hydrocarbon utilizing Fungi, Total Coliforms, Faecal coliforms,	500m and 1000m upstream down stream	Monthly	Sample collection and analysis in an external approved lab.
**Recipient sediment	DPR EGASPIN III E 3.8.6.1 Limitation on the quality of recipient water bodies for permitted discharge		Physico-chemical parameters (pH, Temperature, THC, Cl ⁻ , Pb ²⁺ , Fe (total), Cu ²⁺ , Cr ⁶⁺ , Zn ²⁺) Oil in water SO ₄ ²⁻ NO ₃ ⁻ NH ₄ ⁺ TPH, PAH, BTEX, Heterotrophic	500m and 1000m upstream down stream	Monthly	Sample collection and analysis in an external approved lab.

Receptor	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
**Recipient sediment contd.	DPR EGASPIN III E 3.8.6.1 Limitation on the quality of offshore recipient water bodies for permitted discharge		Heavy metals and other metals (Ni, Zn, Cu, Fe, Mn, Cd, As, Ba, Pb, Co, Ag, Cr, K, V) Total Heterotrophic Bacteria, Total fungi, Hydrocarbon utilizing Bacteria, Hydrocarbon utilizing Fungi, Total coliforms, Faecal coliforms, Sulphate Reducing Bacteria	500m and 1000m upstream down stream	Monthly	Sample collection and analysis in an external approved lab.
Air	DPR EGASPIN III E 4.4.2 Gaseous point sources emission monitoring	1-hour mean ($\mu\text{g}/\text{m}^3$) $\text{CO}^{(3)} = 30$ $\text{SO}_2 = 350$ $\text{NO}_2^{(3)} = 400$ Total SPM = 150- 230	Volume of fuel/gas consumed Emissions rate CO , CO_2 , SO_x , NO_x , THC, VOC, SPM from emissions	Emission point	Continuous readings – record daily	Normal operations flow meter is read daily.

Receptor	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency	Data collection method
Air Quality	DPR EGASPIN III E 4.4.5 Table III-3 National Ambient Air Quality Standards	Daily average mean ($\mu\text{g}/\text{m}^3$) $\text{CO}^{(3)} = 10$ $\text{SO}_2 = 100-150$ $\text{NO}_2^{(3)} = 150$ Total SPM = 60-90	Particulates, ozone, H_2S , heavy and trace metals in ambient air	Emission point	Weekly (DPR) Monthly (TBC)	Calculate using emission factors for fuel consumed

****The oil and associated fluids produced from this drilling will be piped to Bonny Terminal via Gbaran IOGP, hence the produced water will be monitored and disposed appropriately in Bonny Terminal**

CHAPTER EIGHT

CONCLUSION

The EIA of Uzu field was carried out in accordance with relevant local, national and international regulations based on DPR and FMEnv approved terms of reference. The methodology applied for the study involved desktop studies, two season field data gathering and community consultations. To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various biophysical, social and health components. The magnitude of the anticipated impacts of the project activities on the environmental components: air, water, soils, sediment, vegetation, fauna, fisheries, land use, waste management, social, economic and health issues were assessed, ranked and rated. The EIA of the project shows that it would have a significant beneficial impact on both local and national economy. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented.

Mitigation measures were proffered to reduce the magnitude of identified adverse impacts, to a level as low as reasonably practicable (ALARP), while the positive impacts were enhanced. These mitigation measures are incorporated in the Environmental Management Plan developed specifically for this project, and Environmental Monitoring Plan for the negative impacts, applicable to the entire soil microbiology of the project. With the implementation of the EMP/Monitoring Plan, GMoU, respect for socio-cultural values, applicable legal and administrative frameworks and SPDC corporate policies and strict adherence to HSE provisions and other corporate best practices and design codes, this Uzu project could be implemented sustainably.

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APPENDICES

Appendix 1: DPR Approved Terms of Reference

MINISTRY OF PETROLEUM RESOURCES

DEPARTMENT OF PETROLEUM RESOURCES

7 KOFO ABAYOMI STREET, VICTORIA ISLAND, LAGOS.

P.M.B. No:.....12650.....

Telephone:.....01-2790000,,4611777.

Website: www.dprnigeria.com



Ref. No:.....DPR/HSE.02/001.101/2015/045

Date:.....5th November, 2015.....

The Managing Director
Shell Petroleum Development Company
Freeman House
21/22 Marina
Lagos

Dear Sir,

TERMS OF REFERENCE /SCOPE OF WORK FOR THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF UZU DEVELOPMENT PROJECT

We write to acknowledge receipt of your letter of 21st October 2015 referenced UIO/G/NG/SPDC-HSSE-10-2015-013L and the joint scoping workshop held from 11th – 14th August, 2015 on the above subject matter.

2. We have reviewed the submitted Terms of Reference/Scope of Work for the Environmental Impact Assessment (EIA) of Uzu Development project and are pleased to convey to you our **acceptance** and **approval** as follows:

- (i) A randomized and targeted sampling rationale shall be adopted to cover existing wells, flowstation, gas plant and compressor stations, pipelines, existing point sources and other facilities.
- (ii) Sampling stations shall be established at distances of 200m, 400m and 800m in the four cardinal directions of the proposed wells locations. The boreholes shall be positioned in triangular form to aid determination of direction of flow of the ground water. Similarly, random and targeted sampling shall be employed for air quality/noise and soil and shall cover the proposed wells locations, major river and its associated creeks and creeklets, ecological features (wetlands) and communities/settlements within the project area.
- (iii) The field data gathering for the study shall be for **two seasons** and the collected samples would be analysed for the following parameters:

S/N	Sample	Sample Type	Analysis	Parameters
1	Soil 25 + 2 control	Surface (0 –15cm)	Physico-chemical	pH, TPH, PAH, THC, BTEX, Phenols, Percent carbon, Available PO ₄ ³⁻ , Total-N, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , Na, K, Ca and Mg, cation exchange capacity, (CEC), conductivity, oil & grease, heavy metals (Fe, Cd, Cr, Pb, Cu, Hg, Ar, Ni, V and Zn, Ba, As)
		Subsurface (15-30cm)	Soil characterisation/ classification,	Texture, grain size analysis, porosity, permeability, bulk density, erosion potential

S/N	Sample	Sample Type	Analysis	Parameters
	Soil samples shall cover the proposed Wells locations, ecological features (wetlands) and communities/settlements within the project area		Microbiology	Total heterotrophic bacteria and fungi, Total hydrocarbon utilising bacteria and fungi
2.	Sediment 9 + 2 control Sediment shall be sampled downstream and upstream direction on the major River and its associated channels (creeks and creeklets) within the defined study boundary	Composite Grab samples	Physico-chemical	pH, THC, Percent carbon, Available PO ₄ -P, Total-N, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , Na ⁺ , K ⁺ , Ca ²⁺ and Mg ²⁺ , Redox potential, oil & grease, heavy metals (Fe, Cd, Cr, Pb, Cu, Ni, V and Zn).
			Microbiology	Total heterotrophic bacteria and fungi, Total hydrocarbon utilising bacteria and fungi
			Sediment characterisation	Colour and texture
			Benthos	Benthic macro-invertebrate studies – identification to the nearest taxonomic level as well as their species distribution, abundance, diversity and density
3.	Surface water 9 + 2 control shall be sampled downstream and upstream direction on the major River and its associated channels (creeks and creeklets) within the defined study boundary	Composite	Physico-chemical	Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, Redox potential, BOD ₅ , COD, Oil & Grease, Anions/Cations, NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻ , PO ₄ ³⁻ , SO ₄ ²⁻ , SiO ₂ , Na ⁺ , K ⁺ , Ca ²⁺ , Mn ²⁺ , Mg ²⁺ . Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg).
			Microbiology	Total heterotrophic bacteria and fungi, Total hydrocarbon utilising bacteria and fungi
			Phytoplankton	Identification to the nearest taxonomic level, Species diversity (composition, distribution and density) and productivity.
			Zooplankton	Identification to the nearest taxonomic level, species diversity (composition, distribution and density)
			Fisheries	Species types and distribution, catch assessment survey (CAS), breeding sites, migration routes, pathology, fisheries activities.
			Aquatic macrophyte	Identification and spatial distribution, biomass per unit area covered, including submerged vegetation, floating and emergent/bank types, <i>aufwuchs</i> * density
			Hydrodynamics	River water depth and width, flow direction and flow rate. River bed current, and tidal information, bathymetric data etc.
4.	Ground-water 3 + 2 control Boreholes shall be drilled within the 2km radius of the	Composite	Physico-chemical	Temperature, pH, salinity, EC, DO, Turbidity, THC, Redox potential, oil & grease, anions and cations, heavy metals (Fe, Cd, Cr, Pb, Cu, Ni, V and Zn)
			Hydrodynamics	Water table depth, flow direction and rate.
			Microbiology	Total heterotrophic bacteria and fungi, Total hydrocarbon utilising bacteria and fungi
			Hydrogeology	Stratigraphy of the initial underground layers.

S/N	Sample	Sample Type	Analysis	Parameters
	field. Two control stations shall be drilled outside the spatial boundary (2km radius) of the field.		Log analysis	Physico-chemical and heavy metal characterisation.
5.	Vegetation	**Transect area	<i>In situ</i> study Herbarium studies Plants and crops pathological studies	Vegetation types, floral composition Sampled /field unidentifiable plant species Identification of health conditions, insect pests, fungi, bacteria and viral disease of crops around the field and associated villages, farmlands or plantations, plant tissue analysis
6.	Wildlife	Transect/ Visual observation	Mammals, reptiles, birds, amphibians and invertebrates	Diversity, distribution, density, conservation status, formal/traditional conservation practices, wildlife exploitation methods.
7.	Air Quality 26 + 2 control Air quality/noise shall cover the proposed Wells locations, River and its associated creeks and creeklets, ecological features (wetlands) and communities/s ettlements within the project area		Physico-chemical	SO _x , NO _x , VOC/HC, Particulates, CO, CO ₂ , NH ₃ , soot
8.	Socio-economic	Demography, Social Structure & Organisation, Livelihood, Social Infrastructure, Cultural Properties, Natural Resources and Land Use, Perception of the project, the role of women and children, Physically Challenged, Vehicular Traffic Analysis, Sex Trade		

3. Furthermore, we request that the draft Environmental Impact Assessment (EIA) study report be forwarded to the DPR in both hard and electronic copies. The electronic copy of the study report should be submitted on a compact disc (CD).

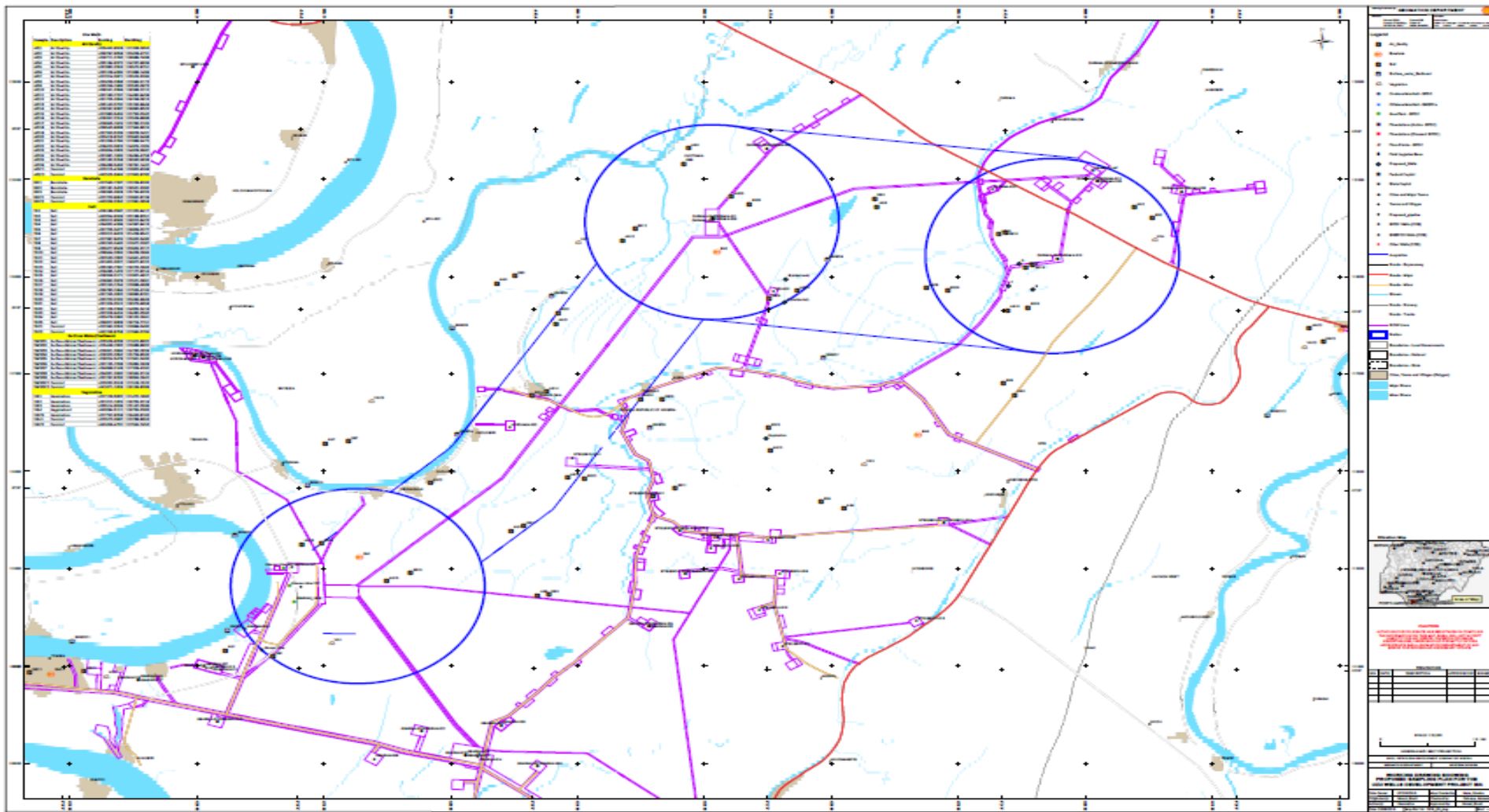
4. Finally, you are required to liaise with our Port Harcourt Zonal office to ensure adequate representation of the DPR during the field data gathering exercise and laboratory analysis.

Yours faithfully,



Dr. Musa M. Zagi SPE, mei
for: Director of Petroleum Resources.

Appendix 2 Map Showing Sample Stations



Appendix 3a: Local Meteorological, Air Quality, Noise Levels and NORM Data of the Study Area in the Wet Season

Units/ Parameters	Meteorology					Noise Level	Air Quality								NORM
	Ambient Air Temp	Wind Velocity	Wind Direction	Atm. Pressure	Rel. Humidity		TSP	NO _x	SO _x	CO	H ₂ S	VOC/HC	NH ₃	CO ₂	
	°C	m/s	N/A	mmHg	%		dB(A)	µg/m ³	ppm	ppm	ppm	ppm	ppm	ppm	
AQ1	32.9	0.50	SW	758.6	71.3	52.3	25.40	0.02	<0.01	10.34	<0.01	1.69	<0.01	0.033	100.20
AQ2	31.6	0.60	SW	759.2	72.6	62.1	21.33	0.02	0.06	14.31	<0.01	18.66	<0.01	0.029	100.40
AQ3	32.0	0.90	SW/SS	758	71	49.7	19.20	0.05	0.01	8.55	<0.01	5.15	<0.01	0.023	100.60
AQ4	35.6	0.40	SW	759.2	68.2	46.2	36.20	<0.01	<0.01	4.44	<0.01	4.44	<0.01	0.026	100.20
AQ5	33.6	0.60	SW/SE	759.0	69.2	47.4	32.00	<0.01	<0.01	6.27	<0.01	9.11	<0.01	0.033	100.20
AQ6	31.2	0.20	SW	757.2	65.2	48.2	19.20	<0.01	0.02	8.88	0.19	18.96	<0.01	0.029	100.00
AQ7	38.2	0.30	SW/NE	755.2	68.4	47.0	28.20	<0.01	0.05	0.14	<0.01	1.04	<0.01	0.032	101.40
AQ8	34.4	1.60	SW/SS	758.3	65.2	47.6	15.30	0.07	0.03	3.26	<0.01	2.29	<0.01	0.028	100.30
AQ9	33.4	0.90	SW/NE	756.2	70.2	44.2	10.80	<0.01	0.02	0.14	<0.01	3.34	<0.01	0.027	100.40
AQ10	37.0	0.80	SW	757.6	65.2	49.7	16.20	0.02	<0.01	2.65	<0.01	2.41	<0.01	0.029	100.20
AQ11	38.0	0.60	SW	749	69	44.2	24.10	<0.01	<0.01	3.31	<0.01	2.26	<0.01	0.021	104.30
AQ 12	32.0	1.00	SW	761.5	82.5	55.3	18.20	<0.01	<0.01	1.22	<0.01	1.39	<0.01	0.023	101.00
AQ 13	33.2	0.25	SW	759.9	81.3	44.9	23.00	<0.01	<0.01	3.61	0.14	4.79	<0.01	0.024	99.20
AQ 14	34.0	1.00	SW	758.7	73.7	54.3	19.20	<0.01	<0.01	1.52	<0.01	0.56	<0.01	0.029	100.30
AQ 15	32.6	1.00	SW/NE	756.0	74	56.0	11.40	<0.01	<0.01	2.36	<0.01	1.44	<0.01	0.03	100.20
AQ 16	31.5	0.96	SW	757.3	80.3	49.2	15.60	<0.01	<0.01	1.42	<0.01	2.24	<0.01	0.031	99.20
AQ 17	30.2	1.20	SW	746.3	74.2	51.6	28.20	<0.01	<0.01	0.37	<0.01	1.28	<0.01	0.029	101.40

Source: TNL (2017): Uzu Field Development EIA

Appendix 3b: Local Meteorology, Air Quality, Noise Levels and NORM Data of the Study Area in the Wet Season.(Cont'd.)

Units/ Parameters	Meteorology					Noise Level dB(A)	Air Quality								NORM μ R/hr
	Ambient Air Temp	Wind Velocity	Wind Direction	Atm. Pressure	Rel. Humidity		TSP	NO _x	SO _x	CO	H ₂ S	VOC/HC	NH ₃	CO ₂	
	°C	m/s	N/A	mmHg	%		ug/m3	ppm	ppm	ppm	ppm	ppm	ppm	%	
AQ18	36.1	1.00	SW	757.5	70.4	60.4	31.62	<0.01	<0.01	0.53	<0.01	0.92	<0.01	0.03	100.30
AQ19	32.4	1.20	SW	757.5	70.4	60.4	24.20	<0.01	<0.01	0.44	<0.01	12.3	<0.01	0.029	101.20
AQ20	32.0	0.80	SW	759.5	81.9	51.6	30.60	<0.01	<0.01	0.49	<0.01	6.71	<0.01	0.031	100.00
AQ21	29.8	0.90	SW	758.2	80.2	54.1	26.30	<0.01	<0.01	0.44	<0.01	9.99	<0.01	0.032	99.80
AQ22	34.9	0.80	SW/SE	753.2	75.2	60.4	15.60	<0.01	<0.01	0.55	<0.01	9.32	<0.01	0.039	101.20
AQ23	35.2	1.10	SW	752.8	65.4	60.3	18.40	<0.01	<0.01	1.49	<0.01	8.62	<0.01	0.038	100.40
AQ24	35.8	0.70	SW/SE	759.3	79.2	56.4	24.10	<0.01	<0.01	0.39	<0.01	5.42	<0.01	0.032	99.70
AQ25	32.4	0.64	SW	761.2	80.3	52.3	20.60	<0.01	<0.01	0.33	<0.01	4.96	<0.01	0.029	98.20
AQ26	36.00	0.40	SW/NE	762.3	71.0	58.6	24.10	<0.01	<0.01	0.48	<0.01	3.22	<0.01	0.038	101.20
Statistics															
Min	29.80	0.20	SW	746.30	65.20	44.20	10.80	<0.01	<0.01	0.14	<0.01	0.56	<0.01	0.021	98.20
Max	38.20	1.60	NE	762.30	82.50	62.10	36.20	0.07	0.06	14.31	0.19	18.96	<0.01	0.039	104.30
Average	33.69	0.78	SW/NE	757.26	72.90	51.26	22.27	0.04	0.03	3.00	0.17	5.48	<0.01	0.030	100.44
AQC1	32.40	1.10	SW	759.3	76.2	58.6	26.90	<0.01	<0.01	0.32	<0.01	4.69	<0.01	0.034	99.80
AQC2	33.60	0.85	SW/NE	785.2	79.3	59.3	42.60	<0.01	<0.01	0.36	<0.01	5.52	<0.01	0.034	101.20
Average (Control)	33.00	0.98	SW	772.25	77.75	58.95	34.75	<0.01	<0.01	0.34	<0.01	5.11	<0.01	0.03	100.50
DPR/FMEnv Limit	30	N/A	N/A	N/A	N/A	80 – 100	250.00	0.04 – 0.06	0.10	10.00 - 20.00	N/A	0.011	No Limit	No Limit	No Limit

Source: TNL (2017) Uzu Field Development EIA

Appendix 3c: Local Meteorology, Air Quality, Noise Levels and NORM Data of the Study Area in the Dry Season.

Units/ Parameters	Meteorology						TSP µg/m ³	Air Quality							NORM µR/hr
	Ambient Air Temp	Wind Velocity	Wind Direction	Atm. Pressure	Rel. Humidity	Noise Level		NO _x	SO _x	CO	H ₂ S	VOC/HC	NH ₃	CO ₂	
	°C	m/s	N/A	mmHg	%	dB(A)		ppm	ppm	ppm	ppm	ppm	ppm	%	
AQ1	38.6	1.90	NE	753.70	51.2	49.8	42.60	<0.001	0.01	1.74	<0.01	9.99	<0.01	0.030	99.80
AQ2	36.8	0.20	SW / NE	755.0	58.2	59.4	46.92	0.020	0.09	19.26	<0.01	2.98	<0.01	0.034	100.20
AQ3	35.7	0.20	SW	756.0	57.5	41.9	58.20	0.015	0.01	10.64	<0.01	5.06	<0.01	0.028	100.20
AQ4	34.3	0.19	SW	757.6	67.0	43.9	49.00	<0.001	0.02	0.94	<0.01	32.49	<0.01	0.031	100.40
AQ5	38.9	0.40	SW	756.0	82.6	48.9	49.20	0.041	0.02	8.64	<0.01	42.68	<0.01	0.029	100.50
AQ6	36.0	0.40	NE	754.9	60.9	48.5	52.60	0.030	0.01	2.99	<0.01	11.60	<0.01	0.032	100.00
AQ7	35.8	0.20	SW / NE	756.0	68.5	41.9	64.21	0.051	0.01	8.64	<0.01	2.69	<0.01	0.031	100.50
AQ8	37.9	0.30	NE / SW	755.6	59.6	48.9	82.60	0.040	0.18	14.20	<0.01	39.41	2.42	0.031	101.30
AQ9	37.2	0.90	SW	755.2	56.9	47.1	28.20	0.041	0.02	12.60	<0.01	9.64	<0.01	0.029	101.20
AQ10	33.9	0.20	SW	752.4	71.2	44.20	39.80	0.040	<0.01	4.44	0.29	7.11	<0.01	0.028	101.50
AQ11	35.0	0.70	SW	754.0	59.3	41.0	22.69	<0.001	<0.01	1.11	0.09	3.62	<0.01	0.030	100.30
AQ 12	36.1	0.60	SW	751.4	54.2	48.2	46.17	0.059	<0.01	2.89	<0.01	1.82	<0.01	0.029	99.80
AQ 13	34.1	0.10	SW/ NE	758.3	69.3	43.0	62.40	0.020	0.06	2.79	<0.01	4.17	<0.01	0.029	100.20
AQ 14	34.8	1.50	SW	750.20	63.9	51.8	49.20	<0.001	0.02	0.09	0.06	2.16	<0.01	0.020	100.40
AQ 15	37.0	0.30	SW	755.4	52.0	55.6	20.36	0.062	0.01	8.61	<0.01	25.41	<0.01	0.032	101.00
AQ 16	38.9	0.40	SW/ NE	751.2	54.4	56.8	64.81	0.032	0.02	9.79	<0.01	8.88	<0.01	0.029	100.60
AQ 17	38.8	0.40	SW	756.0	56.0	48.4	56.71	0.051	0.02	0.19	<0.01	1.69	0.19	0.029	100.80

Source: TNL, 2017, Uzu Field Development Project EIA

Appendix 3d: Local Meteorological, Air Quality, Noise Levels and NORM Data of the Study Area in the Dry Season (Cont'd.)

Units/ Parameters	Meteorology					Noise Level	Air Quality								NORM
	Ambient Air Temp	Wind Velocity	Wind Direction	Atm. Pressure	Rel. Humidity		TSP	NO _x	SO _x	CO	H ₂ S	VOC/HC	NH ₃	CO ₂	
	°C	m/s	N/A	mmHg	%		µg/m ³	ppm	ppm	ppm	ppm	ppm	ppm	%	
AQ18	35.1	0.40	SW	756.2	66.4	54.2	54.92	0.03	<0.01	1.33	<0.01	3.06	<0.01	0.027	100.20
AQ19	38.2	0.20	NE	757.7	58.1	48.3	69.14	<0.001	<0.01	4.92	<0.01	12.88	<0.01	0.033	100.00
AQ20	37.6	0.70	SW/NE	753.2	54.2	44.1	62.36	0.030	<0.01	2.40	<0.01	10.88	<0.01	0.030	99.80
AQ21	35.7	0.90	SW	759.0	63.2	52.7	92.44	0.061	0.03	10.81	<0.01	2.59	<0.01	0.030	101.20
AQ22	35.0	2.30	SW	757.2	63.60	41.7	81.60	0.014	0.01	0.02	0.16	0.77	0.21	0.032	100.80
AQ23	35.7	0.20	SW	755.0	57.7	41.9	79.23	0.015	0.01	10.64	<0.01	5.06	<0.01	0.028	100.40
AQ24	36.1	0.10	NE	754.0	59.2	50.8	74.17	<0.001	0.01	2.79	<0.01	2.11	<0.01	0.029	100.20
AQ25	37.5	0.20	SW/NE	754.5	59.9	48.9	62.31	0.032	<0.01	7.48	<0.01	8.24	<0.01	0.029	100.00
AQ26	33.5	0.40	NE/SW	751.2	71.2	44.2	72.72	0.004	<0.01	4.44	0.29	7.11	<0.01	0.028	100.40
Statistics															
Min	33.5	0.10	SW	750.2	52.00	41.00	20.36	<0.01	<0.01	0.02	<0.01	0.77	<0.01	0.020	99.80
Max	38.9	2.30	NE	759.0	82.60	59.40	92.44	0.06	0.18	19.26	0.29	42.68	<0.01	0.034	101.50
Average	36.3	0.55	SW/NE	754.9	61.39	47.93	57.10	0.03	0.03	5.94	0.18	10.16	<0.01	0.030	100.45
AQC1	37.0	0.20	NE/SW	755.3	56.50	55.40	45.6	0.062	<0.01	2.18	<0.01	2.40	<0.01	0.030	99.20
AQC2	33.8	0.40	SW	756.7	58.60	68.20	99.25	0.001	0.04	8.19	<0.01	13.22	<0.01	0.028	100.00
Average (Control)	35.4	0.30	SW	756.00	57.55	61.80	72.43	0.031	0.02	5.19	<0.01	7.81	<0.01	0.03	99.60
DPR/FMEnv Limit	30	N/A	N/A	N/A	N/A	80 – 100	250.00	0.04 – 0.06	0.1	10.00 - 20.00	N/A	0.011	No Limit	No Limit	No Limit

Source: TNL, 2017, Uzu Field Development EIA

**Appendix 4a: Physicochemical and microbiological properties of Uzu
Field surface water in the study area in the wet season**

PARAMETERS	RESULTS				
	SW1	SW2	SW3	SW4	SW5
Physicochemical					
pH	6.5	6.6	6.5	6.4	6.6
Temperature, °C	28.1	28.7	29.2	28.4	30.9
E. Conductivity, (µS/cm)	196.10	65.40	66.50	168.4	69.2
Total Dissolved Solid, (mg/l)	103.2	34.66	35.26	89.25	31.00
Turbidity, (NTU)	56.20	66.10	42.50	51.00	99.20
Colour, LCU	25	25	25	25	30
Dissolved Oxygen, mg/l	5.3	6.2	6.8	6.6	5.7
Oxidation – Reduction Potential, ±mV	+21.1	+24.7	+38.0	-98.3	-143.6
Depth, m	2.4	1.8	2.30	1.70	3.80
Flow rate, meter/min	2.30	2.00	1.80	2.50	3.00
Bicarbonate (Alkalinity), mg/l	19.52	9.76	7.76	12.20	14.64
Biochemical Oxygen Demand (BOD), mg/l	5.20	4.70	4.90	4.80	5.60
Chemical Oxygen Demand (COD), mg/l	8.65	6.66	5.82	5.63	6.40
Total Suspended Solids, mg/l	30.80	42.50	20.60	32.80	58.36
Salinity(as chloride), mg/l	7.09	7.09	7.09	7.09	3.55
Cations, mg/l					
Potassium(K ⁺)	1.80	1.97	2.09	1.79	2.62
Sodium (Na ⁺)	4.82	4.53	4.79	4.26	5.00
Calcium(Ca ²⁺)	7.26	5.81	11.38	9.06	10.10
Manganese (Mn ²⁺)	0.24	0.57	0.09	0.13	0.17
Magnesium(Mg ²⁺)	2.53	2.33	2.58	2.34	2.76
Anions, mg/l					
Ammonium (NH ₄ ⁺)	0.15	0.12	0.21	0.19	0.42
Nitrate (NO ₃ ⁻)	<0.001	<0.001	<0.001	<0.001	0.28
Nitrite (NO ₂ ⁻)	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate (PO ₄ ³⁻)	0.52	0.94	0.31	<0.01	0.45
Sulphate (SO ₄ ²⁻)	1.54	0.74	2.26	2.78	3.04
Silica (SiO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02
Sulphite (SO ₃ ²⁻)	0.02	0.02	0.03	0.04	<0.01
Organics, mg/l					
Total Hydrocarbon Content	0.24	0.18	0.14	<0.01	<0.01
Oil & Grease	0.26	0.20	0.15	<0.01	<0.01
Polynuclear Aromatic Hydrocarbon, (PAH),	<0.01	<0.01	<0.01	<0.01	<0.01
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/l					
Total Iron (Fe ²⁺ & Fe ³⁺)	1.86	1.79	2.13	1.98	2.58
Cadmium (Cd ²⁺)	0.082	0.075	0.07	0.067	0.09
Chromium (Cr ³⁺ & Cr ⁶⁺)	<0.001	<0.001	<0.001	<0.001	0.191
Nickel (Ni ²⁺)	0.20	0.21	0.14	0.38	0.28
Vanadium (V ²⁺)	<0.001	<0.001	<0.001	<0.001	<0.001

PARAMETERS	RESULTS				
	SW1	SW2	SW3	SW4	SW5
Lead (Pb ²⁺)	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc (Zn ²⁺)	0.147	0.132	0.147	0.068	0.098
Mercury (Hg ²⁺)	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu ²⁺)	0.068	0.016	0.054	0.043	0.045
Microbiology					
Total Heterotrophic Bacteria x10 ² cfu/ml	2.05	3.25	3.25	1.15	3.25
Total Fungi, x 10 ² cfu/ml	1.15	1.10	1.10	1.10	1.13
Hydrocarbon Utilizing Bacteria x10 ² cfu/ml	2.15	2.15	2.45	2.65	1.95
Hydrocarbon Utilizing Fungi x 10 ² cfu/ml	1.03	1.03	1.44	1.06	1.09
Total Coliform Count (MPN/100ml)	39	39	23	43	34
Feecal Coliform (MPN/100ml)	20	19	15	20	9

Source: Environmental Impact Assessment of Uzu FDP SPDC, 2017

Appendix 4b: Physicochemical and microbiological properties of surface water in the study area in the wet season

PARAMETERS	RESULTS					
	SW6	SW7	SW8	SW9	SWC1	SW C2
Physico-chemical						
pH	6.7	6.5	6.4	6.3	6.3	6.5
Temperature, °C	31.9	31.1	27.2	31.4	32.3	26.4
E/Conductivity, µS/cm	63.2	68.7	61.8	89.7	68.2	28.2
Total Dissolved Solid, mg/l	33.50	36.41	32.75	47.65	36.15	14.95
Turbidity, NTU	48.60	18.70	65.40	18.70	46.10	26.20
Colour, (LCU)	50.00	75.00	100.00	75.00	50.00	50.00
Dissolved Oxygen, mg/l	5.60	5.50	5.40	5.50	5.40	5.60
Oxidation –Reduction Potential, ± mV	-132	-103.4	-101.9	-101.3	-48.0	-42.8
Depth, m	2.30	1.60	0.52	0.30	8.10	4.60
Flow rate, metre/min	3.20	2.90	2.40	1.80	3.90	4.20
Bicarbonate (Alkalinity), mg/l	7.32	7.32	4.88	9.76	12.20	7.37
Biochemical Oxygen Demand (BOD), mg/l	5.50	5.00	5.30	5.55	5.30	5.50
Chemical Oxygen Demand (COD), mg/l	8.23	8.42	8.19	8.36	6.22	7.24
Total Suspended Solids, mg/l	72.00	40.28	40.00	62.40	60.00	80.00
Salinity(as chloride), mg/l	6.24	7.09	6.64	6.09	7.09	6.66
Cations, mg/l						
Potassium(K ⁺)	1.28	1.98	2.18	2.05	1.75	1.03
Sodium (Na ⁺)	4.33	3.57	4.64	5.43	4.88	4.41
Calcium(Ca ²⁺)	9.21	7.92	6.47	8.90	12.72	6.97
Manganese (Mn ²⁺)	0.06	0.78	0.37	0.72	0.02	0.03
Magnesium(Mg ²⁺)	2.43	1.81	2.43	2.26	2.73	1.44
Anions, mg/l						
Ammonium (NH ₄ ⁺)	0.24	0.77	0.69	0.24	0.46	0.17
Nitrate (NO ₃ ⁻)	<0.01	0.57	<0.01	<0.01	<0.01	0.041
Nitrite (NO ₂ ⁻)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate (PO ₄ ³⁻)	1.85	0.16	0.92	0.04	0.06	0.03
Sulphate (SO ₄ ²⁻)	1.77	2.52	2.37	1.99	2.74	0.82
Silica (SiO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Sulphite (SO ₃ ²⁻)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Organics, mg/l						
Total Hydrocarbon Content	<0.01	<0.01	0.34	<0.01	0.35	0.36
Oil & Grease	<0.01	<0.01	0.33	<0.01	0.36	0.35
Polynuclear Aromatic Hydrocarbon, (PAH)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy metals, mg/l						
Total Iron (Fe ²⁺ & Fe ³⁺)	2.48	4.09	5.04	4.23	1.64	2.75
Cadmium (Cd ²⁺)	0.10	0.09	0.04	0.12	0.03	0.02
Chromium (Cr ³⁺ & Cr ⁶⁺)	<0.01	0.08	0.23	<0.01	0.07	0.21
Nickel (Ni ²⁺)	0.23	0.31	0.39	0.38	0.31	0.49
Vanadium (V ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

PARAMETERS	RESULTS					
	SW6	SW7	SW8	SW9	SWC1	SW C2
Lead (Pb ²⁺)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (Zn ²⁺)	0.11	0.09	0.08	0.06	0.08	0.09
Mercury (Hg ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu ²⁺)	0.08	0.09	0.05	0.11	0.14	0.15
Microbiology						
Total Heterotrophic Bacteria x 10 ² cfu/ml	1.03	3.20	1.03	1.04	2.83	1.93
Total Fungi, x 10 ² cfu/ml	1.00	1.02	1.00	1.00	1.03	1.05
Hydrocarbon Utilizing Bacteria x 10 ² cfu/ml	2.65	2.43	2.68	1.90	1.90	1.90
Hydrocarbon Utilizing Fungi x 10 ² cfu/ml	1.00	1.03	1.00	1.03	1.03	1.00
Total Coliform Counts (MPN/100ml)	35	36	29	36	29	15
Feecal Coliform (MPN/100ml)	15	15	15	19	10	25

Source: Environmental Impact Assessment of Uzu FDP SPDC, 2017

Appendix 4c: Physicochemical and microbiological properties of surface water in the study area in the dry season

PARAMETERS	RESULTS				
	SW1	SW2	SW3	SW4	SW5
Physico-chemical					
pH	7.3	7.0	7.0	7.9	7.8
Temperature, °C	33.0	31.2	31.0	31.3	30.3
E.Conductivity, (µS/cm)	76.60	79.08	74.70	74.70	75.10
Total Dissolved Solid, (mg/l)	40.70	42.02	39.59	38.60	39.50
Turbidity, (NTU)	48.30	42.40	42.50	6.40	95.70
Colour, LCU	25	25	50	25	25
Dissolved Oxygen, mg/l	4.20	5.38	5.42	5.50	5.48
Oxidation – Reduction Potential, ±mV	-119.6	-108.4	-120.4	-104.3	-120.6
Depth, m	2.50	1.92	2.30	1.80	4.00
Flow rate, metre/min	1.90	1.80	2.00	2.50	1.50
Bicarbonate (Alkalinity), mg/l	43.92	40.60	31.36	46.36	46.36
Biochemical Oxygen Demand (BOD), mg/l	6.40	5.27	5.31	5.00	5.36
Chemical Oxygen Demand (COD), mg/l	8.06	7.36	7.30	6.91	7.68
Total Suspended Solids, mg/l	20.00	24.00	24.50	10.60	40.50
Salinity(as chloride), mg/l	7.09	7.09	7.09	3.55	10.64
Cations, mg/l					
Potassium(K ⁺)	2.36	2.30	2.36	2.17	2.31
Sodium (Na ⁺)	4.31	4.44	4.24	3.82	4.34
Calcium(Ca ²⁺)	7.14	6.12	8.31	7.51	5.96
Manganese (Mn ²⁺)	0.02	0.16	<0.01	0.22	<0.01
Magnesium(Mg ²⁺)	2.79	2.36	2.60	2.42	2.43
Anions, mg/l					
Ammonium (NH ₄ ⁺)	0.24	0.18	0.47	0.50	0.63
Nitrate (NO ₃ ⁻)	0.69	0.27	0.62	0.85	0.15
Nitrite (NO ₂ ⁻)	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate (PO ₄ ³⁻)	0.04	0.01	0.02	0.03	0.02
Sulphate (SO ₄ ²⁻)	0.76	0.41	1.13	1.17	0.9
Silica (SiO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02
Sulphite (SO ₃ ²⁻)	0.05	0.04	0.25	0.36	0.01
Organics, mg/l					
Total Hydrocarbon Content	0.12	0.17	0.52	<0.01	<0.01
Oil & Grease	0.15	0.25	0.55	<0.01	<0.02
Polynuclear Aromatic Hydrocarbon, (PAH).	<0.01	<0.01	<0.01	<0.01	<0.01
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/l					
Total Iron (Fe ²⁺ & Fe ³⁺)	1.842	1.032	1.084	1.056	1.285
Cadmium (Cd ²⁺)	0.069	0.065	0.075	0.066	0.076
Chromium (Cr ³⁺ & Cr ⁶⁺)	0.027	0.039	0.047	0.054	0.062
Nickel (Ni ²⁺)	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (V ²⁺)	<0.001	<0.001	<0.001	<0.001	<0.001

PARAMETERS	RESULTS				
	SW1	SW2	SW3	SW4	SW5
Lead (Pb ²⁺)	0.066	0.077	0.024	0.007	0.002
Zinc (Zn ²⁺)	0.113	0.085	0.100	0.087	0.096
Mercury (Hg ²⁺)	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu ²⁺)	0.257	0.267	0.127	0.116	0.157
Microbiology					
Total Heterotrophic Bacteria x10 ² cfu/ml	1.60	1.30	1.63	1.03	1.05
Total Fungi, x 10 ² cfu/ml	11.20	1.20	1.35	1.80	1.00
Hydrocarbon Utilizing Bacteria x10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil
Hydrocarbon Utilizing Fungi x 10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil
Total Coliform Count (MPN/100ml)	23	23	23	27	28
Feecal Coliform (MPN/100ml)	12	15	15	19	19

Source: Environmental Impact Assessment of Uzu FDP SPDC, 2017

Appendix 4d: Physicochemical and microbiological properties of surface water in the study area in the dry season

PARAMETERS	RESULTS					
	SW6	SW7	SW8	SW9	SWC1	SW C2
Physico-chemical						
pH	7.7	6.9	7.0	7.6	7.6	6.9
Temperature, °C	31.3	32.2	32.0	32.0	34.1	31.2
E/Conductivity, µS/cm	125.40	60.50	78.40	78.20	88.40	26.20
Total Dissolved Solid, mg/l	66.46	32.07	41.55	41.45	46.85	13.89
Turbidity, NTU	95.80	48.90	43.60	93.20	49.40	12.30
Colour, (LCU)	50	25	25	25	25	50
Dissolved Oxygen, mg/l	5.60	5.20	5.40	5.30	4.50	5.20
Oxidation –Reduction Potential, ± mV	-95.3	-113.3	-83.2	-104.6	-113.5	-63.7
Depth, m	2.40	1.50	0.40	0.35	5.3	4.80
Flow rate, metre/min	2.00	1.60	3.40	1.70	2.10	4.20
Bicarbonate (Alkalinity), mg/l	42.20	30.60	31.28	41.16	43.92	31.20
Biochemical Oxygen Demand (BOD), mg/l	5.40	5.10	5.30	5.20	6.00	5.10
Chemical Oxygen Demand (COD), mg/l	7.03	7.36	7.30	7.68	8.45	6.99
Total Suspended Solids, mg/l	60.40	30.20	30.00	60.00	32.00	5.00
Salinity(as chloride), mg/l	24.85	7.09	10.64	10.64	7.09	7.09
Cations, mg/l						
Potassium(K ⁺)	1.96	2.43	2.69	0.97	1.89	0.80
Sodium (Na ⁺)	7.58	4.00	4.69	1.75	3.94	2.03
Calcium(Ca ²⁺)	18.49	1.29	2.33	1.08	6.77	5.29
Manganese (Mn ²⁺)	0.07	<0.01	<0.01	0.05	<0.01	<0.01
Magnesium(Mg ²⁺)	3.87	1.14	1.27	0.64	2.34	1.25
Anions, mg/l						
Ammonium (NH ₄ ⁺)	0.33	0.16	0.51	<0.01	0.38	<0.01
Nitrate (NO ₃ ⁻)	2.34	0.11	0.46	0.11	0.31	0.73
Nitrite (NO ₂ ⁻)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate (PO ₄ ³⁻)	0.02	0.03	0.02	0.02	0.34	0.02
Sulphate (SO ₄ ²⁻)	0.34	0.04	0.30	0.04	0.15	0.11
Silica (SiO ₂)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulphite (SO ₂ ⁻³)	0.06	<0.01	0.02	0.01	0.04	0.02
Organics, mg/l						
Total Hydrocarbon Content	0.19	<0.01	0.14	0.13	0.18	0.12
Oil & Grease	0.21	<0.01	0.18	0.15	0.21	0.15
Polynuclear Aromatic Hydrocarbon, (PAH)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BTEX	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy metals, mg/l						
Total Iron (Fe ²⁺ & Fe ³⁺)	0.99	0.75	0.91	0.81	1.38	0.85
Cadmium (Cd ²⁺)	0.09	0.09	0.10	0.09	0.10	0.11
Chromium (Cr ³⁺ & Cr ⁶⁺)	<0.01	<0.01	<0.01	0.01	0.04	<0.01
Nickel (Ni ²⁺)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium (V ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

PARAMETERS	RESULTS					
	SW6	SW7	SW8	SW9	SWC1	SW C2
Lead (Pb ²⁺)	0.02	0.01	0.01	0.04	0.04	0.05
Zinc (Zn ²⁺)	0.15	0.17	0.17	0.17	0.21	0.21
Mercury (Hg ²⁺)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu ²⁺)	0.22	0.23	0.30	0.33	0.19	0.14
Microbiology						
Total Heterotrophic Bacteria x 10 ² cfu/ml	1.50	1.15	1.10	1.15	1.50	1.05
Total Fungi, x 10 ² cfu/ml	1.15	1.02	1.10	1.03	1.10	0.90
Hydrocarbon Utilizing Bacteria x 10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil
Hydrocarbon Utilizing Fungi x 10 ² cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil
Total Coliform Counts (MPN/100ml)	29	29	28	20	29	20
Feecal Coliform (MPN/100ml)	11	10	12	9	15	12

Source: Environmental Impact Assessment of Uzu FDP SPDC, 2017

Appendix 5a: Physicochemical and microbiological characteristics of sediment in the dry season

Parameter	SD1	SD2	SD3	SD4	SD5	SD6
Physico-chemical Properties						
pH	5.6	5.2	5.0	5.80	5.90	5.10
Colour	Dark	Brown	Dark Brown	Brown	Dark	Brown
Texture	Clayey	Sandy	Sandy - Clayey	Sandy	Sandy - Clayey	Sandy
Oxidation –Reduction Potential, ± mV	-51.80	-45.60	-43.50	-19.20	-31.60	-21.60
Available PO ₄ -P, mg/kg	7.72	27.08	17.12	12.59	10.13	17.61
Total Nitrogen , %	0.06	0.01	0.02	0.04	0.02	0.02
Anions, mg/kg						
Ammonium (NH ₄),	45.73	44.52	45.78	40.80	28.14	34.48
Nitrate (NO ₃)	14.01	9.39	8.93	9.70	15.86	11.55
Nitrite (NO ₂)	0.02	0.05	0.05	0.06	0.08	0.06
Cations, mg/kg						
Potassium (K)	23.29	214.28	243.19	663.90	939.17	235.42
Sodium (Na)	309.36	221.99	290.96	428.77	5679.00	252.35
Calcium (Ca)	522.10	180.80	192.10	120.23	630.80	303.50
Magnesium (Mg)	73.46	276.09	237.01	274.20	260.84	278.43
Organics						
Percent Organic Carbon, %	0.992	1.70	1.01	0.99	1.80	2.02
Total Hydrocarbon Content, mg/kg	0.96	0.44	0.65	1.28	<0.05	1.11

Parameter	SD1	SD2	SD3	SD4	SD5	SD6
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.10	<0.10	0.93	<0.10	<0.10	1.63
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	846.83	2248	1818	2081	1919	2205
Cadmium (Cd)	1.09	0.04	1.97	1.29	0.69	0.27
Chromium (Cr)	37.08	8.02	8.02	7.62	5.65	36.77
Lead (Pb)	33.31	37.75	20.81	34.10	3.93	38.42
Nickel (Ni)	15.78	15.55	30.86	28.82	25.43	29.65
Vanadium (V)	0.63	1.44	0.06	<0.05	<0.05	<0.05
Zinc (Zn)	6.38	19.25	23.38	33.70	26.39	17.28
Copper (Cu)	3.28	15.37	3.84	14.22	14.24	14.93
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	2.00	2.25	2.23	2.10	2.00	3.00
Total Fungi x 10 ³ cfu/g	1.15	1.20	1.15	1.10	1.17	2.25
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.09	1.15	1.10	1.07	1.15	1.43
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	1.00	1.00	1.00	1.01	1.00

Appendix 5b: Physico-chemical and microbiological characteristics of sediment in the dry season, (Cont'd)

Parameter	SD7	SD8	SD9	SDC1	SDC2
Physico-chemical Properties					
pH	5.1	4.9	5.2	5.3	6.4
Colour	Brownish	Grey	Brownish	Grey	Dark Brown
Texture	Sandy - Clayey	Loamy Clayey	Loamy Sandy	Clayey	Loamy Sandy
Oxidation –Reduction Potential, \pm mV	-45.90	-19.50	-27.30	-62.50	-41.20
Available PO ₄ -P, mg/kg	17.90	22.43	13.82	15.16	17.315
Total Nitrogen , %	0.02	0.01	0.02	0.04	0.02
Anions, mg/kg					
Ammonium (NH ₄),	15.38	4.47	20.45	10.60	20.91
Nitrate (NO ₃)	8.01	6.93	8.64	3.54	6.78
Nitrite (NO ₂)	0.19	0.06	0.05	0.14	0.03
Cations, mg/kg					
Potassium (K)	737.41	71.43	425.59	845.26	192.71
Sodium (Na)	214.14	231.49	176.13	244.07	246.76
Calcium (Ca)	366.90	355.50	199.40	568.50	470.10
Magnesium (Mg)	203.15	175.84	296.09	305.77	266.71
Organics					
Percent Organic Carbon, %	1.39	0.79	1.99	2.19	0.97
Total Hydrocarbon Content, mg/kg	0.99	0.65	0.92	1.36	1.53
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	1.21	0.81	1.07	1.59	1.66
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg					
Iron (Fe)	2146	1807	2432	2671	1901
Cadmium (Cd)	3.52	2.43	1.05	1.44	0.15
Chromium (Cr)	43.12	55.34	26.22	38.07	23.90
Lead (Pb)	30.6	38.0	40.4	40.1	31.6
Nickel (Ni)	30.1	47.5	25.8	26.2	11.2
Vanadium (V)	0.69	0.31	0.25	0.26	0.94
Zinc (Zn)	43.63	39.44	79.50	36.24	49.85
Copper (Cu)	14.30	1.53	17.03	20.38	10.58
Microbiology					
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.50	1.30	1.35	1.20	1.20
Total Fungi x 10 ³ cfu/g	1.20	1.20	1.17	1.15	1.10
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.07	1.09	1.10	1.03	1.07
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.02	1.00	1.03	1.01	1.00

Appendix 5c: Physicochemical and microbiological characteristics of sediment in the wet season,

Parameter	SD1	SD2	SD3	SD4	SD5	SD6
Physico-chemical Properties						
pH	5.9	5.8	5.6	5.7	5.8	5.8
Colour	Dark brown	Dark Brown	Dark Brown	Brown	Dark	Brown
Texture	Clayey	Sandy	Sandy - Clayey	Sandy	Sandy - Clayey	Sandy
Oxidation –Reduction Potential, ± mV	147.4	190.4	201.8	160.8	110.4	109.0
Available PO ₄ -P, mg/kg	3.11	7.39	7.49	12.11	3.11	7.39
Total Nitrogen , %	0.01	0.01	0.01	0.01	0.001	0.01
Anions, mg/kg						
Ammonium (NH ₄),	19.27	15.42	17.95	7.55	9.73	7.84
Nitrate (NO ₃)	<0.001	0.65	2.63	0.55	1.86	9.28
Nitrite (NO ₂)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cations, mg/l						
Potassium (K)	68.19	120.00	1149	623.95	843.93	593.25
Sodium (Na)	259.61	255.34	303.61	294.97	272.38	305.06
Calcium (Ca)	114.55	96.17	110.01	241.49	43.55	33.74
Magnesium (Mg)	160.93	201.82	248.37	247.17	243.49	242.69
Organics						
Organic Carbon, %	0.54	0.32	0.17	0.26	0.20	0.36
Total Hydrocarbon Content, mg/kg	0.24	0.21	0.49	<0.05	0.65	1.28
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.058
Oil & grease, mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	0.42
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals						
Iron (Fe)	1211	2117	2097	2120	2029	1855
Cadmium (Cd)	3.038	2.922	2.303	3.081	2.370	3.191
Chromium (Cr)	8.336	9.094	0.189	11.57	1.137	9.852
Lead (Pb)	13.112	14.729	12.729	8.614	12.442	3.805
Nickel (Ni)	33.582	25.157	22.564	18.087	16.261	27.160
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	21.035	33.192	32.384	31.406	55.319	23.834

Parameter	SD1	SD2	SD3	SD4	SD5	SD6
Copper (Cu)	5.694	8.278	8.458	9.577	5.445	1.300
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	2.00	1.52	2.30	1.54	3.11	3.70
Total Fungi x 10 ³ cfu/g	1.85	1.10	2.35	1.15	1.70	3.00
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	3.65	2.15	2.40	3.15	2.65	2.45
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.00	1.03	1.01	1.05	1.00	1.03

Appendix 5d: Physicochemical and microbiological characteristics of sediment in the wet season

Parameter	SD7	SD8	SD9	SDC1	SDC2
Physico-chemical Properties					
pH	6.3	5.8	5.9	6.2	6.4
Colour	Brownish	Grey	Brownish	Grey	Dark Brown
Texture	Sandy - clayey	Loamy Clayey	Loamy Sandy	Clayey	Loamy Sandy
Oxidation –Reduction Potential, ± mV	132.10	130.00	122.70	148.90	230.40
Available PO ₄ -P, mg/kg	7.21	1.33	3.22	0.43	2.64
Total Nitrogen , %	0.0011	0.0013	0.0012	0.009	0.004
Anions, mg/kg					
Ammonium (NH ₄),	14.44	15.15	6.05	5.35	7.83
Nitrate (NO ₃)	0.62	<0.02	<0.02	0.31	<0.02
Nitrite (NO ₂)	<0.01	<0.01	<0.01	0.02	<0.01
Cations, mg/l					
Potassium (K)	437.11	76.35	399.05	995.34	96.70
Sodium (Na)	246.69	248.11	297.11	234.06	263.27
Calcium (Ca)	35.91	21.97	36.20	74.20	112.13
Magnesium (Mg)	184.70	175.39	240.23	243.56	195.35
Organics					
Percent Organic Carbon, %	0.28	0.31	0.28	0.80	0.84
Total Hydrocarbon Content, mg/kg	0.49	0.27	0.24	<0.10	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals					

Iron (Fe)	1414	1349	1697	2040	1902
Cadmium (Cd)	2.146	2.731	3.265	3.081	3.020
Chromium (Cr)	13.48	14.21	20.65	28.61	11.94
Lead (Pb)	3.50	2.68	0.29	11.87	15.51
Nickel (Ni)	28.82	22.68	32.76	12.73	14.49
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	27.81	44.11	19.48	29.72	53.07
Copper (Cu)	0.99	0.17	1.42	6.62	1.16
Microbiology					
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	2.50	2.00	1.75	4.00	5.00
Total Fungi x 10 ³ cfu/g	1.75	1.75	1.52	3.20	3.25
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	2.45	3.50	1.90	3.65	1.90
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.05	1.00	1.03	1.20	1.05

Appendix 6a: Physicochemical and microbiological properties of soil samples from study wet season

Physico-chemical Properties	SS1T	SS1B	SS2T	SS2B	SS3T	SS3B
Parameters	SS1T	SS1B	SS2T	SS2B	SS3T	SS3B
pH	5.90	5.80	5.70	5.00	5.50	5.10
Electrical Conductivity, µS/cm	40.00	40.00	60.00	40.00	90.00	80.00
Colour	Brownish	Brownish	Greyish Brown	Brownish	Brownish	Brownish
Texture	Loamy	Loamy - Clayey	Loamy - Clayey	Clayey	Loamy - Clayey	Clayey
Oxidation-Reduction Potential, ± mV	213.80	309.10	106.40	174.80	161.10	155.20
Available PO ₄ -P, mg/kg	12.21	6.42	4.38	2.61	3.68	2.87
Total Nitrogen, %	0.002	0.007	0.008	0.046	0.003	0.004
Bulk Density, g/ml	1.11	1.20	1.12	1.20	1.14	1.25
Porosity, %	56.00	62.00	54.00	61.00	52.00	70.00
Permeability, ml/s	0.39	0.27	0.37	0.34	0.28	0.22
CEC, meq/100g	2.92	3.30	5.68	5.43	6.24	7.71
Anions, mg/kg						
Ammonium (NH ₄),	19.05	1.40	14.03	19.35	28.11	3.34
Nitrate (NO ₃)	0.11	<0.01	1.70	0.77	0.62	0.31
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.07	0.31	1.26	0.29	2.30	1.57
Sodium (Na)	1.07	0.84	1.22	0.54	1.99	1.27
Calcium (Ca)	0.69	0.48	0.49	0.25	0.21	2.81
Magnesium (Mg)	1.04	1.67	1.22	1.03	2.03	2.04
Organics						
Organic Carbon, %	0.55	0.32	0.33	0.44	0.18	0.36
Total Hydrocarbon Content, mg/kg	1.82	<0.01	0.66	<0.01	0.44	<0.01

PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	2.29	<0.10	0.49	<0.10	0.17	<0.10
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	785.171	1403	1980	1806	2040	1794
Manganese, (Mn)	3.690	18.750	24.716	137.110	200.061	163.281
Cadmium (Cd)	2.909	3.337	3.046	3.597	3.657	3.332
Chromium (Cr)	3.221	19.136	0.7105	14.815	7.200	14.589
Lead (Pb)	2.871	8.063	4.099	3.814	7.690	11.102
Nickel (Ni)	20.502	23.154	22.118	27.333	26.217	30.930
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	10.292	125.096	106.450	133.154	251.734	37.438
Copper (Cu)	0.193	1.645	3.699	3.420	2.596	7.546
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	5.50	4.50	6.00	4.50	6.00	1.30
Total Fungi x 10 ³ cfu/g	4.50	1.30	3.85	3.58	3.75	1.88
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.50	1.30	1.82	1.06	1.45	1.54
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.05	1.00	1.03	1.03	1.03	1.08

Appendix 6b: Physicochemical and microbiological properties of soil samples from the study area in the wet season, Cont'd.

Parameter	SS4T	SS4B	SS5T	SS5B	SS6T	SS6B
Physico-chemical Properties						
pH	5.4	4.9	5.7	5.4	5.8	5.2
Electrical Conductivity, μ S/cm	60.00	160.00	40.00	30.00	100.00	160.00
Colour	Brownish	Brownish	Brownish	Brownish	Brownish	Reddish brown
Texture	Loamy	Loamy	Loamy – Sandy	Clayey - Sandy	Clayey – Loamy	Clayey – Loamy
Oxidation –Reduction Potential, \pm mV	213.40	277.60	269.30	209.90	149.20	160.30
Available PO ₄ -P, mg/kg	12.23	2.88	7.09	7.23	0.20	1.97
Total Nitrogen , %	0.004	0.011	0.008	0.0014	0.015	0.002
Bulk Density, g/ml	1.16	1.25	1.15	1.21	1.15	1.20
Porosity, %	76.00	32.00	64.00	60.00	66.00	62.00
Permeability, ml/s	0.38	0.35	0.36	0.33	0.37	0.35
CEC, meq/100g	4.59	4.52	6.16	6.45	6.60	4.94
Anions, mg/kg						
Ammonium (NH ₄),	24.92	20.28	18.37	11.94	22.80	19.02
Nitrate (NO ₃)	0.31	0.70	<0.01	<0.01	0.31	0.17
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.40	1.27	1.84	2.00	2.89	1.53
Sodium (Na)	1.12	1.15	1.49	1.31	1.08	1.05

Calcium (Ca)	0.05	0.04	0.98	0.59	0.55	0.32
Magnesium (Mg)	2.01	2.05	2.04	2.03	2.09	2.04
Organics						
Organic Carbon, %	0.279	0.718	0.550	0.698	0.119	0.28
Total Hydrocarbon Content, mg/kg	0.21	0.19	<0.01	<0.01	0.16	0.09
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.24	0.17	<0.05	<0.05	0.97	0.41
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	1980	1941	2021	2100	2089	2037
Manganese, (Mn)	216.37	170.08	285.34	41.06	451.46	209.44
Cadmium (Cd)	3.424	3.914	3.357	2.946	3.075	3.031
Chromium (Cr)	15.35	4.16	20.08	32.59	27.85	29.37
Lead (Pb)	10.624	0.287	6.508	2.010	1.053	2.106
Nickel (Ni)	31.402	31.166	32.933	34.996	39.768	36.645
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	35.253	57.937	61.175	54.565	35.125	29.578
Copper (Cu)	6.053	4.989	6.219	9.453	12.369	9.356
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	1.10	1.70	5.00	5.50	5.00	1.20
Total Fungi x 10 ³ cfu/g	1.03	2.25	3.58	1.30	1.03	1.50
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.45	1.35	1.35	1.90	1.45	1.10
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.00	1.03	1.03	1.08	1.05	1.05

Appendix 6c: Physicochemical and microbiological properties of soil samples from the study area in the wet season, Cont'd

Parameter	SS7T	SS7B	SS8T	SS8B	SS9T	SS9B
Physico-chemical Properties						
pH	5.2	5.1	5.6	5.1	5.4	5.3
Electrical Conductivity, μ S/cm	100.00	60.00	190.00	160.00	60.00	40.00
Colour	Brown	Brown	Grey	Brownish	Grey	Brownish - Grey
Texture	Loamy - Clayey	Loamy - Clayey	Loamy - Clayey	Clayey	Loamy - Clayey	Clayey
Oxidation -Reduction Potential, \pm mV	181.40	166.30	170.90	214.10	265.60	390.10
Available PO ₄ -P, mg/kg	1.33	5.05	0.76	2.87	0.97	1.33
Total Nitrogen , %	0.014	0.0014	0.0011	0.0021	0.0031	0.019
Bulk Density, g/ml	1.08	1.14	1.05	1.11	1.08	1.13
Porosity, %	62.00	60.00	64.00	50.00	52.00	48.00

Permeability, ml/s	0.36	0.25	0.38	0.16	0.41	0.17
CEC, meq/100g	5.09	4.24	4.80	4.92	6.35	5.06
Anions, mg/kg						
Ammonium (NH ₄),	25.46	23.40	21.56	14.63	25.60	21.56
Nitrate (NO ₃)	<0.01	<0.01	0.62	1.55	0.31	1.24
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.39	1.02	0.92	1.23	2.73	1.94
Sodium (Na)	1.28	1.00	1.12	1.18	1.24	0.79
Calcium (Ca)	0.33	0.21	0.76	0.48	0.29	0.23
Magnesium (Mg)	2.03	1.97	1.99	2.02	2.09	2.094
Organics						
Organic Carbon, %	0.08	0.72	0.80	0.44	0.28	0.72
Total Hydrocarbon Content, mg/kg	0.44	<0.01	0.24	<0.01	<0.01	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.91	<0.02	0.38	<0.02	<0.02	<0.02
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	1953	1902	1884	1977	2001	1979
Manganese, (Mn)	356.69	251.19	163.80	269.51	66.93	44.03
Cadmium (Cd)	1.52	0.55	0.52	1.25	2.97	1.39
Chromium (Cr)	35.051	24.441	19.704	27.662	33.925	34.293
Lead (Pb)	1.914	1.436	2.680	6.317	6.030	5.743
Nickel (Ni)	35.938	42.419	44.086	47.014	43.479	40.592
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	36.718	26.593	20.615	26.919	42.733	73.530
Copper (Cu)	11.692	9.301	6.537	10.075	5.216	11.070
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	4.00	1.54	4.00	6.00	1.60	3.50
Total Fungi x 10 ³ cfu/g	1.05	1.69	3.50	3.50	1.03	1.10
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.25	1.77	1.75	1.30	1.33	1.20
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.05	1.08	1.05	1.05	1.00	1.10

Appendix 6d: Physico-chemical and microbiological properties of soil samples from the study area in the wet season, Cont'd

Parameter	SS10T	SS10B	SS11T	SS11B	SS12T	SS12B
Physico-chemical Properties						
pH	5.1	5.2	5.2	5.6	5.5	5.2
Electrical Conductivity, µS/cm	90.00	50.00	170.00	50.00	60.00	80.00

Colour	Brownish	Reddish-Brown	Brownish	Brown	Dark – Brown	Grey
Texture	Loamy – Sandy	Loamy Sandy	Loamy	Loamy - Sandy	Clayey	Sandy - Clayey
Oxidation –Reduction Potential, ± mV	211.10	209.00	203.20	189.20	210.90	212.60
Available PO ₄ -P, mg/kg	2.61	2.59	7.44	1.45	2.28	1.46
Total Nitrogen , %	0.021	0.011	0.018	0.04	0.015	0.009
Bulk Density, g/ml	1.07	1.14	1.08	1.14	1.11	1.18
Porosity, %	64.00	60.00	62.00	58.00	52.00	64.00
Permeability, ml/s	0.41	0.37	0.38	0.35	0.35	0.30
CEC, meq/100g	4.36	4.45	6.20	3.79	4.96	4.18
Anions, mg/kg						
Ammonium (NH ₄),	14.22	18.99	15.19	19.27	12.09	7.98
Nitrate (NO ₃)	3.25	1.24	<0.01	<0.01	0.62	0.53
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	0.95	0.99	1.82	0.49	1.23	0.72
Sodium (Na)	0.99	1.14	1.10	1.09	1.40	1.28
Calcium (Ca)	0.39	0.26	0.24	0.19	0.28	0.15
Magnesium (Mg)	2.03	2.05	2.04	2.01	2.04	2.02
Organics						
Organic Carbon, %	0.56	0.21	0.32	0.16	0.54	0.14
Total Hydrocarbon Content, mg/kg	0.11	<0.01	<0.01	<0.01	0.48	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.59	<0.02	<0.02	<0.02	0.56	<0.02
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	2054	2062	2043	1775	2035	1979
Manganese, (Mn)	66.396	78.746	121.158	59.023	33.628	17.096
Cadmium (Cd)	2.609	2.775	2.579	2.811	2.781	2.695
Chromium (Cr)	34.483	21.599	28.873	35.340	46.040	77.681
Lead (Pb)	5.551	4.381	5.551	2.534	9.092	4.594
Nickel (Ni)	32.462	18.146	11.135	19.737	23.978	24.685
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	29.293	27.338	23.080	20.041	23.645	20.345
Copper (Cu)	18.809	20.454	12.507	3.638	12.742	18.201
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	4.50	4.00	5.00	1.87	1.37	1.60
Total Fungi x 10 ³ cfu/g	3.38	1.30	3.50	1.03	1.02	1.06
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.40	1.45	1.82	1.25	1.03	1.08
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.00	1.08	1.68	1.01	1.15	1.02

Appendix 6e: Physico-chemical and microbiological properties of soil samples from the study area in the wet season, Cont'd

Parameter	SS13T	SS13B	SS14T	SS14B	SS15T	SS15B
Physico-chemical Properties						
pH	5.5	5.1	5.7	5.9	5.1	4.2
Electrical Conductivity, $\mu\text{S}/\text{cm}$	50.00	40.00	90.00	50.00	80.00	90.00
Colour	Dark - Brown	Brown	Grey	Grey	Brown	Brown
Texture	Sandy - Clayey	Clayey	Loamy - Clayey	Clayey	Clayey	Clayey
Oxidation –Reduction Potential, \pm mV	195.40	211.80	175.40	199.40	225.30	390.10
Available $\text{PO}_4\text{-P}$, mg/kg	1.00	1.34	4.60	1.33	9.91	9.76
Total Nitrogen , %	0.009	0.005	0.009	0.008	0.039	0.011
Bulk Density, g/ml	1.10	1.21	1.11	1.25	1.11	1.23
Porosity, %	66.00	42.00	54.00	50.00	60.00	56.00
Permeability, ml/s	0.63	0.33	0.39	0.18	0.35	0.23
CEC, meq/100g	4.53	5.18	5.62	5.81	5.86	6.14
Anions, mg/kg						
Ammonium (NH_4),	16.49	13.20	11.45	7.64	25.53	21.09
Nitrate (NO_3)	<0.01	<0.01	4.31	3.09	1.70	2.72
Nitrite (NO_2)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.42	1.78	1.73	2.26	2.17	2.36
Sodium (Na)	0.99	1.14	1.17	1.08	1.13	1.32
Calcium (Ca)	0.09	0.19	0.63	0.42	0.51	0.37
Magnesium (Mg)	2.04	2.06	2.08	2.03	2.06	2.09
Organics						
Organic Carbon, %	0.26	0.82	0.35	0.16	1.84	0.36
Total Hydrocarbon Content, mg/kg	0.18	<0.01	0.05	<0.01	0.19	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.23	<0.02	0.19	<0.02	0.33	<0.02
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	1874	1954	1986	2017	2066	2015
Manganese, (Mn)	105.016	197.579	283.892	240.148	185.778	153.234
Cadmium (Cd)	2.683	3.001	2.909	3.381	3.136	3.485
Chromium (Cr)	29.557	38.272	38.272	36.188	7.359	8.715
Lead (Pb)	8.135	10.337	8.422	4.690	6.317	2.776
Nickel (Ni)	26.276	28.927	33.405	13.256	21.740	23.095
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Zinc (Zn)	34.308	65.804	29.671	34.344	28.013	29.666
Copper (Cu)	13.903	14.110	13.461	14.373	18.560	18.740
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	3.20	4.50	1.07	3.50	1.10	6.15
Total Fungi x 10 ³ cfu/g	1.35	3.50	1.20	1.04	1.05	1.03
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.75	1.55	1.29	1.10	1.07	1.03
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.03	1.03	1.03	1.02	1.00	1.03

Appendix 6f: Physicochemical and microbiological properties of soil samples from the study area in the wet season, (Cont'd)

Parameter	SS16T	SS16B	SS17T	SS17B	SS18T	SS18B
Physico-chemical Properties						
pH	5.0	5.1	5.4	5.3	5.8	5.6
Electrical Conductivity, μ S/cm	100.00	120.00	60.00	40.00	30.00	40.00
Colour	Brown	Grey	Dark Brown	Brown	Brown	Dark Brown
Texture	Clayey	Clayey Sandy	Loamy Clayey	Clayey	Loamy	Sandy Clayey
Oxidation –Reduction Potential, \pm mV	278.00	241.40	201.40	211.20	109.40	119.60
Available PO ₄ -P, mg/kg	4.08	12.23	14.29	0.31	10.89	3.22
Total Nitrogen , %	0.015	0.026	0.005	0.011	0.017	0.0010
Bulk Density, g/ml	1.10	1.18	1.08	1.18	1.02	1.15
Porosity, %	90.00	86.00	76.00	72.00	88.00	84.00
Permeability, ml/s	0.38	0.36	0.35	0.32	0.36	0.34
CEC, meq/100g	5.42	5.48	6.84	7.79	6.45	4.76
Anions, mg/kg						
Ammonium (NH ₄),	12.40	9.91	20.28	16.49	25.87	3.09
Nitrate (NO ₃)	5.72	2.79	0.16	0.24	4.80	3.61
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	2.04	1.99	3.03	3.05	2.45	1.33
Sodium (Na)	1.02	1.23	1.36	1.37	1.16	1.12
Calcium (Ca)	0.30	0.28	0.58	1.25	0.75	0.23
Magnesium (Mg)	2.06	2.09	1.87	2.11	2.09	2.06
Organics						
Organic Carbon, %	0.22	0.22	0.49	0.28	0.76	0.47
Total Hydrocarbon Content, mg/kg	0.22	0.19	0.14	0.11	0.17	0.13
PAH, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Oil & grease, mg/kg	0.36	0.22	0.17	0.09	0.21	0.18
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	2926	2146	2119	2059	1970	1937
Manganese, (Mn)	73.194	55.322	158.544	233.181	231.506	257.521
Cadmium (Cd)	3.810	3.920	3.853	3.730	4.110	3.455
Chromium (Cr)	36.756	32.388	51.345	35.998	32.967	9.284
Lead (Pb)	2.893	11.581	3.824	7.848	0.861	8.901
Nickel (Ni)	23.330	29.516	31.343	36.409	37.823	36.115
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	25.346	39.209	104.580	223.776	61.808	20.498
Copper (Cu)	14.483	16.017	19.652	27.101	6.142	15.838
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	1.70	1.15	1.35	1.90	1.10	1.05
Total Fungi x 10 ³ cfu/g	1.07	1.20	1.05	1.06	1.52	1.05
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.35	2.43	1.08	1.03	1.05	1.03
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.00	1.01	1.00	1.03	1.03	1.00

Appendix 6f: Physicochemical and microbiological properties of soil samples from the study area in the wet season, (Cont'd)

Parameter	SS19T	SS19B	SS20T	SS20B	SS21T	SS21B
Physico-chemical Properties						
pH	5.1	5.7	5.1	5.2	4.7	4.5
Electrical Conductivity, µS/cm	40.00	90.00	60.00	70.00	110.00	140.00
Colour	Dark Brown	Dark Brown	Brown	Brown	Dark brown	Brown
Texture	Loamy - Clayey	Loamy - Clayey	Loamy Clayey	Clayey	Loamy	Loamy
Oxidation –Reduction Potential, ± mV	204.60	164.50	221.60	206.90	211.40	201.80
Available PO ₄ -P, mg/kg	4.70	1.33	0.28	12.13	7.49	0.96
Total Nitrogen , %	0.005	0.002	0.001	0.00	0.005	0.002
Bulk Density, g/ml	1.06	1.03	1.13	1.23	1.17	1.28
Porosity, %	76.00	80.00	80.00	76.00	76.00	70.00
Permeability, ml/s	0.33	0.33	0.33	0.31	0.34	0.30
CEC, meq/100g	6.10	6.56	5.17	5.74	6.14	7.56
Anions, mg/kg						
Ammonium (NH ₄),	26.50	19.33	25.56	21.56	10.52	13.02
Nitrate (NO ₃)	0.31	0.31	<0.001	0.31	3.40	13.92
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Cations, meq/100g						
Potassium (K)	2.57	2.58	1.70	2.32	2.22	2.75
Sodium (Na)	1.08	1.33	1.02	0.99	1.31	2.29
Calcium (Ca)	0.69	0.55	0.39	0.31	0.54	1.42
Magnesium (Mg)	1.77	2.09	2.07	2.40	2.07	2.11
Organics						
Organic Carbon, %	0.50	0.27	0.50	0.88	0.16	0.55
Total Hydrocarbon Content, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	2009	1958	2013	2062	1997	1705
Manganese, (Mn)	465.58	456.87	38.24	35.93	314.55	431.07
Cadmium (Cd)	3.38	2.92	2.88	3.09	2.63	3.12
Chromium (Cr)	27.47	35.99	16.48	15.92	35.24	30.88
Lead (Pb)	6.125	6.221	10.337	4.221	4.40	12.16
Nickel (Ni)	15.318	6.186	2.298	15.907	32.816	17.537
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	39.791	45.266	453.552	43.371	55.544	53.456
Copper (Cu)	17.662	19.652	18.436	21.684	20.191	17.759
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	1.45	1.90	1.70	1.33	4.50	1.15
Total Fungi x 10 ³ cfu/g	1.05	1.52	1.05	1.06	1.05	1.03
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	1.03	1.03	1.35	1.00	3.50	1.03
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.03	1.03	1.04	1.03	1.06	1.03

Appendix 6g: Physicochemical and microbiological properties of soil samples from the study area in the wet season, (Cont'd)

Parameter	SS22T	SS22B	SS23T	SS23B	SS24T	SS24B
Physico-chemical Properties						
pH	5.70	6.50	5.50	5.60	5.50	5.40
Electrical Conductivity, $\mu\text{S}/\text{cm}$	120.00	100.00	60.00	50.00	80.00	90.00
Colour	Brown	Brown	Brown	Dark Brown	Dark Brown	Dark Brown
Texture	Clayey	Clayey	Loamy - Clayey	Loamy - Clayey	Clayey	Clayey
Oxidation –Reduction Potential, \pm mV	301.40	291.20	206.60	17.30	221.60	206.00
Available $\text{PO}_4\text{-P}$, mg/kg	0.36	5.12	7.46	12.23	2.65	1.45
Total Nitrogen , %	0.002	0.005	0.001	0.007	0.008	0.006
Bulk Density, g/ml	1.15	1.26	1.14	1.23	1.17	1.28
Porosity, %	84.00	80.00	86.00	80.00	82.00	78.00
Permeability, ml/s	0.35	0.33	0.37	0.33	0.34	0.32
CEC, meq/100g	5.04	5.49	6.57	6.25	5.75	5.34
Anions, mg/kg						
Ammonium (NH_4),	19.59	20.28	10.99	12.08	8.30	10.80
Nitrate (NO_3)	1.70	5.88	0.32	0.28	1.55	4.18
Nitrite (NO_2)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.33	1.34	1.22	0.99	2.61	1.26
Sodium (Na)	1.29	1.22	1.36	1.16	1.14	0.88
Calcium (Ca)	0.34	0.35	0.14	0.36	0.79	0.69
Magnesium (Mg)	2.08	2.09	1.99	2.08	2.09	2.03
Organics						
Organic Carbon, %	0.44	0.32	0.16	0.14	0.08	1.04
Total Hydrocarbon Content, mg/kg	<0.01	<0.01	0.26	<0.01	0.11	<0.01
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.02	<0.02	0.37	<0.02	0.46	<0.02
BTEX, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Heavy Metals, mg/kg						
Iron (Fe)	1907	1952	2042	2002	1841	2035
Manganese, (Mn)	203.728	246.929	87.616	244.381	49.661	42.647
Cadmium (Cd)	3.093	2.744	3.043	3.240	3.602	3.969
Chromium (Cr)	30.693	18.378	49.715	47.935	35.809	18.757
Lead (Pb)	19.046	10.050	6.364	5.934	5.838	13.687
Nickel (Ni)	34.996	22.388	14.710	7.365	32.580	28.451
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Zinc (Zn)	22.723	48.254	159.421	42.982	136.377	37.579
Copper (Cu)	17.786	20.232	24.049	21.628	42.844	23.314
Microbiology						
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	1.89	1.56	1.35	4.50	5.10	6.00
Total Fungi x 10 ³ cfu/g	1.50	1.75	1.10	1.50	1.85	1.03
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.12	1.17	1.30	3.50	1.05	1.05
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.05	1.05	1.06	1.05	1.01	1.05

Appendix 6h: Physico-chemical and microbiological properties of soil samples from the study area in the wet season, (Cont'd)

Parameter	SS25T	SS25B	SS26T	SS26B
Physico-chemical Properties				
pH	5.0	4.3	4.8	4.6
Electrical Conductivity, $\mu\text{S}/\text{cm}$	100.00	120.00	216.00	214.96
Colour	Brownish	Brownish	Brownish	Brownish
Texture	Sandy Clayey	Clayey	Loamy Clayey	Clayey
Oxidation –Reduction Potential, \pm mV	311.10	306.40	295.1	254.0
Available $\text{PO}_4\text{-P}$, mg/kg	5.12	2.19	4.21	0.26
Total Nitrogen , %	0.009	0.001	0.006	0.002
Bulk Density, g/ml	1.17	1.29	1.24	1.36
Porosity, %	84.00	80.00	62.40	52.00
Permeability, ml/s	0.35	0.33	0.46	0.33
CEC, meq/100g	7.21	7.75	6.28	5.11
Anions, mg/kg				
Ammonium (NH_4),	20.74	15.46	16.24	14.22
Nitrate (NO_3)	0.77	2.17	0.68	0.29
Nitrite (NO_2)	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g				
Potassium (K)	2.92	3.19	2.35	2.55
Sodium (Na)	1.15	1.50	1.24	1.39
Calcium (Ca)	0.96	1.24	0.64	0.62
Magnesium (Mg)	2.19	1.25	1.86	1.99
Organics				
Organic Carbon, %	0.36	0.28	1.69	0.42
Total Hydrocarbon Content, mg/kg	<0.02	<0.02	<0.02	<0.02
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.01	<0.01	<0.01	<0.01
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg				
Iron (Fe)	3197	2128	2992	1475
Manganese, (Mn)	678.58	982.10	524.30	511.47
Cadmium (Cd)	3.97	1.07	0.69	0.48
Chromium (Cr)	13.07	25.01	29.66	14.61
Lead (Pb)	9.76	3.54	3.26	1.42
Nickel (Ni)	33.58	22.09	1.24	0.99
Vanadium (V)	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	91.89	50.11	96.52	57.32

Copper (Cu)	28.36	21.40	36.44	31.28
Microbiology				
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.55	1.20	1.24	1.63
Total Fungi x 10 ³ cfu/g	1.75	1.25	0.52	0.33
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.94	1.75	1.28	0.77
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	0.85	0.63	0.55

Appendix 6i: Physico-chemical and microbiological properties of soil samples from the study area in the wet season, (Cont'd)

Parameter	SSC1T	SSC1B	SSC2T	SSC2B
Physico-chemical Properties				
pH	5.6	5.1	5.3	5.2
Electrical Conductivity, μ S/cm	110.00	140.00	160.00	180.00
Colour	Brown	Dark Brown	Dark Brown	Dark Brown
Texture	Loamy - Clayey	Loamy - Clayey	Clayey	Clayey
Oxidation –Reduction Potential, \pm mV	226.90	170.40	209.60	217.30
Available PO ₄ -P, mg/kg	4.91	7.21	9.86	17.99
Total Nitrogen , %	0.017	0.004	0.002	0.021
Bulk Density, g/ml	1.15	1.16	1.13	1.24
Porosity, %	64.00	52.00	49.0	46.00
Permeability, ml/s	0.35	0.33	0.33	0.27
CEC, meq/100g	5.83	6.57	34.05	26.91
Anions, mg/kg				
Ammonium (NH ₄),	8.34	9.84	8.63	7.30
Nitrate (NO ₃)	1.50	0.22	1.86	9.71
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g				
Potassium (K)	1.66	2.68	1.01	0.98
Sodium (Na)	1.30	1.17	1.14	1.28
Calcium (Ca)	0.29	0.62	29.81	22.59
Magnesium (Mg)	2.01	2.09	2.04	2.06
Organics				
Organic Carbon, %	0.82	0.16	0.20	0.55
Total Hydrocarbon Content, mg/kg	<0.02	<0.02	2.41	<0.02
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	<0.01	<0.01	2.65	<0.01
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg				
Iron (Fe)	1928	1229	1748	1778

Manganese, (Mn)	253.522	199.385	222.741	216.392
Cadmium (Cd)	3.197	2.848	3.265	3.026
Chromium (Cr)	42.440	42.630	30.125	33.725
Lead (Pb)	10.911	14.069	9.092	19.812
Nickel (Ni)	6.481	6.716	14.906	27.572
Vanadium (V)	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	30.355	37.424	77.184	159.282
Copper (Cu)	20.689	22.844	23.397	24.696
Microbiology				
Total Heterotrophic Bacteria x 10 ⁴ cfu/g	5.95	6.00	6.02	6.50
Total Fungi x 10 ³ cfu/g	1.75	1.00	1.50	2.25
Hydrocarbon Utilising Bacteria x 10 ⁴ cfu/g	3.00	4.50	2.50	4.00
Hydrocarbon Utilising Fungi x 10 ³ cfu/g	1.03	1.04	1.04	1.03

Appendix 7a: Soils physico-chemical and microbiological properties of the study area in the dry season

Parameter	SS1T	SS1B	SS2T	SS2B	SS3T	SS3B
Physico-chemical Properties						
pH	5.6	5.3	4.8	4.8	5.2	5.5
Electrical Conductivity, $\mu\text{S}/\text{cm}$	45.00	44.30	49.10	9.00	85.00	110.70
Colour	Brownish	Brownish	Greyish Brown	Brown	Brownish	Brownish
Texture	Loamy	Loamy - Clayey	Loamy - Clayey	Clayey	Loamy - Clayey	Clayey
Oxidation –Reduction Potential, $\pm \text{mV}$	-32.60	-36.90	-23.30	-37.10	-21.40	-37.10
Available PO ₄ -P, mg/kg	25.16	3.80	22.45	27.08	17.53	15.20
Total Nitrogen, %	0.02	0.03	0.02	0.06	0.04	0.02
Bulk Density, g/cm ³	1.02	1.16	1.06	1.19	1.10	1.21
Porosity, %	66.00	50.00	64.00	58.00	64.00	48.00
Permeability, ml/s	0.34	0.30	0.32	0.29	0.31	0.29
CEC, meq/100g	32.33	44.28	40.58	22.86	11.47	29.99
Anions, mg/kg						
Ammonium (NH ₄),	37.44	22.31	41.66	45.63	51.10	54.70
Nitrate (NO ₃)	9.39	7.39	12.47	15.25	16.94	19.56
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	0.86	0.66	0.13	0.62	0.74	1.28
Sodium (Na)	0.66	0.97	0.97	0.95	0.90	1.07
Calcium (Ca)	28.66	40.34	38.65	19.06	7.42	25.22
Magnesium (Mg)	2.16	2.30	0.83	2.23	2.40	2.42

Organics						
Percent Organic Carbon, %	1.21	1.99	1.99	1.29	0.79	1.40
Total Hydrocarbon Content, mg/kg	0.40	0.07	0.61	<0.031	0.61	0.49
PAH, mg/kg	0.06	<0.05	0.08	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.59	0.09	0.62	<0.02	0.63	0.51
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	1636	1987	1186	2467	2357	2635
Manganese, (Mn)	34.14	41.38	11.69	46.20	136.86	176.89
Cadmium (Cd)	0.96	1.86	0.05	0.06	1.29	0.38
Chromium (Cr)	0.62	47.74	12.82	10.76	55.17	40.04
Lead (Pb)	21.34	27.95	37.16	32.98	42.35	39.00
Nickel (Ni)	30.79	11.56	10.29	11.83	41.62	12.54
Vanadium (V)	0.16	<0.05	0.24	0.28	0.06	<0.05
Zinc (Zn)	26.75	12.72	408.73	52.63	21.37	406.71
Copper (Cu)	4.43	17.54	2.90	2.14	20.32	5.65
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	2.20	2.00	2.00	1.60	1.88	2.50
Total Fungi x 10 ³ cfu/g	1.30	1.25	1.25	1.49	1.70	2.00
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.20	1.43	1.43	1.40	1.50	1.10
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.05	1.09	1.00	1.20	1.09	1.03

Appendix 7b: Soils physico-chemical and microbiological properties of the study area in the dry season, Cont'd

Parameter	SS4T	SS4B	SS5T	SS5B	SS6T	SS6B
Physico-chemical Properties						
pH	5.6	5.4	5.2	4.8	5.1	5.4
Electrical Conductivity, μ S/cm	145.50	236.50	129.60	86.80	55.20	56.10
Colour	Brownish	Brownish	Brownish	Brownish	Brownish	Reddish brown
Texture	Loamy	Loamy	Loamy – Sandy	Clayey - Sandy	Clayey – Loamy	Clayey – Loamy

Oxidation –Reduction Potential, ± mV	-34.30	-60.50	-29.00	-35.00	-27.40	-22.00
Available PO ₄ -P, mg/kg	21.67	21.644	14.51	19.58	17.95	12.69
Total Nitrogen , %	0.002	0.042	0.037	0.025	0.010	0.025
Bulk Density, g/m ³	1.13	1.15	1.01	1.14	1.08	1.21
Porosity, %	68.00	66.00	63.00	60.00	68.00	64.00
Permeability, ml/s	0.37	0.33	0.32	0.29	0.31	0.27
CEC, meq/100g	18.225	66.450	5.969	37.688	25.537	26.171
Anions, mg/kg						
Ammonium (NH ₄),	52.50	54.35	36.13	37.29	52.05	51.65
Nitrate (NO ₃)	30.18	60.06	27.41	31.72	12.47	30.18
Nitrite (NO ₂)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cations, meq/100g						
Potassium (K)	1.53	1.75	1.03	1.08	1.62	1.66
Sodium (Na)	1.00	26.25	0.99	0.58	1.29	1.12
Calcium (Ca)	13.58	36.29	1.80	33.78	20.22	21.39
Magnesium (Mg)	2.12	2.16	2.16	2.39	2.41	2.00
Organics						
Percent Organic Carbon, %	0.99	2.69	1.39	0.52	2.91	1.21
Total Hydrocarbon Content, mg/kg	0.88	<0.10	1.00	0.24	0.69	0.10
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.95	0.08	1.12	0.41	0.78	0.14
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	2485	1893	2021	2681	2749	2834
Manganese, (Mn)	320.09	323.55	264.69	240.22	261.30	292.58
Cadmium (Cd)	0.29	0.75	0.26	<0.02	0.23	<0.02
Chromium (Cr)	56.55	14.21	<0.02	13.03	57.50	11.50
Lead (Pb)	48.13	8.54	22.95	38.83	39.89	44.53
Nickel (Ni)	45.03	30.93	15.98	16.71	13.23	15.78
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	116.98	44.34	35.72	53.78	36.47	39.13
Copper (Cu)	21.73	17.68	3.79	167.65	18.22	2.05
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.75	1.75	1.50	1.45	1.75	4.50
Total Fungi x 10 ³ cfu/g	1.45	1.35	1.00	1.35	1.70	3.50
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.45	1.60	1.70	1.25	1.50	1.25
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.04	1.09	1.10	1.07	1.20	1.04

**Appendix 7c: Soils physico-chemical and microbiological properties in
the dry season, Cont'd**

Parameter	SS7T	SS7B	SS8T	SS8B	SS9T	SS9B
Physico- chemical Properties						
pH	4.6	5.1	5.0	4.6	4.9	5.4
Electrical Conductivity, $\mu\text{S}/\text{cm}$	56.40	38.90	10.6.60	98.30	156.30	101.60
Colour	Brown	Brown	Grey	Brownish	Grey	Brownish -Grey
Texture	Loamy – Clayey	Loamy – Clayey	Loamy – Clayey	Clayey	Loamy - Clayey	Clayey
Oxidation –Reduction Potential, \pm mV)	-32.1	-4.50	-25.6	-21.3	+27.90	+44.20
Available $\text{PO}_4\text{-P}$, mg/kg	16.40	19.99	2.76	7.72	45.59	25.28
Total Nitrogen , %	0.01	0.02	0.01	0.04	0.04	0.04
Bulk Density, g/m^3	1.00	1.11	0.96	1.14	1.13	1.21
Porosity, %	65.00	58.00	52.00	42.00	54.00	39.00
Permeability, ml/s	0.15	0.12	0.13	0.08	0.31	0.1 7
CEC, meq/100g	67.75	17.26	25.94	14.16	18.86	35.55
Anions, mg/kg						
Ammonium (NH_4),	54.70	55.55	53.60	55.40	65.50	44.78
Nitrate (NO_3)	22.64	26.33	5.85	7.35	8.16	12.17
Nitrite (NO_2)	<0.02	0.03	<0.02	0.14	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.72	1.19	0.86	0.59	1.07	1.55
Sodium (Na)	25.96	0.45	1.00	1.00	0.89	1.25
Calcium (Ca)	37.90	13.17	22.24	10.47	14.52	30.39
Magnesium (Mg)	2.17	2.46	1.83	2.16	2.38	1.07
Organics						
Percent Organic Carbon, %	0.18	0.06	0.27	0.23	2.79	1.79
Total Hydrocarbon Content, mg/kg	0.78	0.65	0.21	0.14	0.29	0.30
PAH, mg/kg	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.79	0.67	0.23	0.16	0.31	0.32
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	1848	2369	25.35	2192	2646	2900
Manganese, (Mn)	191.62	166.32	125.78	40.77	30.09	28.60
Cadmium (Cd)	8.26	2.22	<0.05	3.05	3.50	0.91
Chromium (Cr)	2.14	56.65	20.57	75.17	50.80	10.87
Lead (Pb)	6.45	38.33	39.84	35.32	41.42	27.29

Nickel (Ni)	22.54	43.01	10.69	7.17	13.24	18.96
Vanadium (V)	0.07	<0.05	0.25	<0.05	0.19	<0.05
Zinc (Zn)	35.08	29.85	13.85	16.27	39.45	50.24
Copper (Cu)	31.32	5.58	1.43	5.89	25.75	9.40
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.10	2.50	1.60	1.50	4.00	4.20
Total Fungi x 10 ³ cfu/g	1.30	2.00	1.20	1.20	2.00	2.200
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.35	1.20	1.95	1.40	1.40	1.45
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	1.03	1.03	1.00	1.00	1.00

Appendix 7d: Soils physico-chemical and microbiological properties in the dry season, Cont'd

Parameter	SS10T	SS10B	SS11T	SS11B	SS12T	SS12B
Physico-chemical Properties						
pH	4.9	4.6	5.3	4.9	4.8	4.2
Electrical Conductivity, $\mu\text{S/cm}$	94.50	96.70	174.90	180.20	41.50	52.80
Colour	Brownish	Reddish-Brown	Brownish	Brown	Dark – Brown	Grey
Texture	Loamy – Sandy	Loamy Sandy	Loamy	Loamy - Sandy	Clayey	Sandy - Clayey
Oxidation –Reduction Potential, \pm mV	+54.50	+45.90	-17.80	-32.20	+82.00	+26.70
Available PO ₄ -P, mg/kg	7.77	7.67	19.97	21.89	21.84	15.02
Total Nitrogen , %	0.04	0.01	0.02	0.02	0.01	0.03
Bulk Density, g/m ³	1.12	1.25	0.94	1.05	1.26	1.98
Porosity, %	64.20	62.00	68.00	65.00	58.00	54.00
Permeability, ml/s	0.38	0.40	0.37	0.38	0.33	0.30
CEC, meq/100g	39.45	9.90	23.06	18.05	8.28	10.00
Anions, mg/kg						
Ammonium (NH ₄ ⁺),	43.02	30.66	41.26	34.02	40.60	28.34
Nitrate (NO ₃)	23.52	15.05	10.52	8.96	17.53	16.22
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.91	3.07	1.24	1.27	0.27	0.28
Sodium (Na)	21.25	0.69	1.04	0.95	1.39	0.95
Calcium (Ca)	14.05	3.89	18.30	14.06	5.30	7.22
Magnesium (Mg)	2.05	2.25	2.49	1.26	1.30	1.55
Organics, mg/kg						
Percent Organic Carbon, %	1.79	0.42	1.30	1.21	1.61	0.90
Total Hydrocarbon Content, mg/kg	0.10	<0.01	0.08	0.31	0.26	0.21
PAH, mg/kg	<0.05	<0.05	0.06	<0.05	0.08	<0.05
Oil & grease, mg/kg	0.12	<0.01	0.10	0.33	0.27	0.23
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	1964	2181	2578	2608	1511	1796
Manganese, (Mn)	80.86	128.70	206.51	180.75	3.74	20.51
Cadmium (Cd)	1.32	0.95	2.53	0.96	0.18	0.24
Chromium (Cr)	2.29	17.62	48.53	105.45	<0.05	49.37
Lead (Pb)	9.88	31.85	43.60	37.41	19.73	41.07
Nickel (Ni)	23.93	45.38	13.58	16.47	13.79	22.14
Vanadium (V)	<0.05	<0.05	0.06	<0.05	<0.05	<0.05
Zinc (Zn)	27.87	44.22	30.92	28.62	463.79	8.77
Copper (Cu)	17.45	10.99	22.37	21.79	10.21	9.32
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.35	2.50	3.75	1.75	4.50	1.35
Total Fungi x 10 ³ cfu/g	1.20	2.00	2.20	1.25	4.20	1.30
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.30	1.20	1.75	1.15	1.13	1.35
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	1.00	1.00	1.00	1.00	1.03

Appendix 7e: Soils physico-chemical and microbiological properties in the dry season, Cont'd

Parameter	SS13T	SS13B	SS14T	SS14B	SS15T	SS15B
Physico-chemical Properties						
pH	4.7	4.7	4.9	6.0	4.5	5.0
Electrical Conductivity, $\mu\text{S}/\text{cm}$	71.0	66.00	320.00	323.40	152.30	52.90
Colour	Dark - Brown	Brown	Grey	Grey	Brown	Brown
Texture	Sandy - Clayey	Clayey	Loamy - Clayey	Clayey	Clayey	Clayey
Oxidation -Reduction Potential, \pm mV	+40.40	+32.90	+17.30	+8.10	+3.60	+22.60
Available PO ₄ -P, mg/kg	5.31	18.49	13.77	20.36	17.21	16.31
Total Nitrogen , %	0.63	0.05	0.06	0.01	0.01	0.04
Bulk Density, g/cm ³	0.94	1.03	1.08	1.13	1.16	1.25
Porosity, %	74.00	78.00	71.00	74.00	76.00	78.00
Permeability, ml/s	0.36	0.31	0.38	0.34	0.34	0.30

CEC, meq/100g	25.37	22.72	33.23	25.35	21.65	11.88
Anions, mg/kg						
Ammonium (NH ₄),	13.47	40.70	26.03	30.60	66.05	64.85
Nitrate (NO ₃)	14.90	19.58	20.84	17.68	18.55	1943
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	4.53	1.06	0.97	0.87	1.43	1.29
Sodium (Na)	0.57	1.33	1.37	0.91	0.60	0.89
Calcium (Ca)	17.07	18.73	29.11	20.99	11.26	7.01
Magnesium (Mg)	2.24	2.36	2.02	2.45	2.33	2.45
Organics						
Percent Organic Carbon, %	2.99	1.40	1.20	0.82	1.39	2.09
Total Hydrocarbon Content, mg/kg	0.49	0.11	0.49	0.46	0.31	0.29
PAH, mg/kg	<0.05	<0.05	0.06	<0.05	0.09	<0.05
Oil & Grease, mg/kg	0.51	0.18	0.50	0.49	0.33	0.31
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	2209	2651	1704	1721	2110	2691
Manganese, (Mn)	237.17	55.37	114.07	124.80	181.14	160.62
Cadmium (Cd)	0.34	<0.05	1.16	1.74	1.41	0.33
Chromium (Cr)	8.20	12.76	22.95	16.80	30.21	27.43
Lead (Pb)	36.35	41.26	18.55	23.16	24.81	35.57
Nickel (Ni)	34.43	15.90	18.60	21.52	11.87	15.95
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	60.14	26.46	54.05	48.96	38.89	23.09
Copper (Cu)	18.07	0.18	2.55	2.68	4.63	21.61
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.75	2.50	2.25	1.50	2.25	1.35
Total Fungi x 10 ³ cfu/g	1.55	1.50	1.75	1.35	2.05	1.20
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.02	1.40	1.70	1.50	1.45	1.05
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	1.03	1.05	1.07	1.00	1.00

Appendix 7f: Soils physico-chemical and microbiological properties in the dry season, Cont'd

Parameter	SS16T	SS16B	SS17T	SS17B	SS18T	SS18B
Physico-chemical Properties						
pH	4.5	4.5	4.9	5.0	4.4	5.0
Electrical Conductivity, μ S/cm	95.30	72.30	408.00	410.00	94.00	84.70
Colour	Brown	Grey	Dark Brown	Brown	Brown	Dark Brown
Texture	Clayey	Clayey Sandy	Loamy Clayey	Clayey	Loamy	Sandy Clayey
Oxidation–Reduction Potential, \pm mV	+29.10	+38.50	+61.20	+59.80	-41.20	-37.30

Available PO ₄ -P, mg/kg	5.41	12.61	23.02	15.02	15.12	15.61
Total Nitrogen , %	0.01	0.03	0.02	0.01	0.03	0.01
Bulk Density, g/cm ³	1.04	1.15	1.01	1.09	0.88	0.98
Porosity	76.00	78.00	76.00	80.00	72.00	76.00
Permeability, ml/s	0.38	0.33	0.31	0.34	0.35	0.31
CEC, meq/100g	10.43	7.27	25.08	27.73	20.31	18.95
Anions, mg/kg						
Ammonium (NH ₄),	30.71	16.89	40.60	32.06	53.90	54.65
Nitrate (NO ₃)	15.34	18.99	20.31	10.81	17.82	8.77
Nitrite (NO ₂)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g						
Potassium (K)	1.17	2.03	2.08	2.19	2.44	1.08
Sodium (Na)	0.89	0.99	1.12	1.26	1.91	1.24
Calcium (Ca)	5.96	2.06	19.39	0.36	1.28	0.96
Magnesium (Mg)	2.39	2.18	2.48	0.63	2.14	1.68
Organics						
Percent Organic Carbon, %	2.99	0.99	0.04	1.52	0.80	2.52
Total Hydrocarbon Content, mg/kg	032	0.30	0.46	0.21	0.23	0.21
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.35	0.32	0.48	0.23	0.25	0.22
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	26.50	2099	2658	2336	1936	2118
Manganese, (Mn)	118.26	115.42	380.21	211.31	131.43	121.41
Cadmium (Cd)	2.30	4.13	0.19	3.30	2.44	6.39
Chromium (Cr)	53.91	6.97	35.66	26.80	31.44	40.41
Lead (Pb)	35.22	21.77	37.91	38.14	25.63	32.43
Nickel (Ni)	18.41	22.62	20.98	31.50	18.44	21.12
Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	35.59	33.26	34.15	50.32	48.72	43.73
Copper (Cu)	13.71	4.80	26.77	20.42	31.42	32.99
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.60	3.50	2.00	1.75	1.50	1.30
Total Fungi x 10 ³ cfu/g	1.30	2.00	1.75	1.70	1.30	1.20
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.50	1.33	1.15	1.40	1.10	1.10
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.00	1.03	1.03	1.09	1.00	1.07

**Appendix 7g: Soils physico-chemical and microbiological properties in
the dry season, Cont'd**

Parameter	SS19T	SS19B	SS20T	SS20B	SS21T	SS21B
Physico-chemical Properties						
pH	5.6	5.2	4.4	4.1	4.5	4.2
Electrical Conductivity, $\mu\text{S}/\text{cm}$	86.00	90.60	195.00	114.70	228.30	305.70
Colour	Dark Brown	Dark Brown	Brown	Brown	Dark brown	Brown
Texture	Loamy - Clayey	Loamy - Clayey	Loamy Clayey	Clayey	Loamy	Loamy
Oxidation –Reduction Potential, \pm mV	+14.30	-2.00	+279.00	+333.00	+29.60	+48.80
Available $\text{PO}_4\text{-P}$, mg/kg	12.59	10.21	15.09	9.29	14.57	13.77
Total Nitrogen , %	0.06	0.02	0.06	0.06	0.02	0.04
Bulk Density, g/cm^3	1.01	1.07	0.68	0.94	1.15	1.23
Porosity	72.00	74.00	72.00	76.00	72.00	76.00
Permeability, ml/s	0.32	0.29	0.32	0.29	0.32	0.29
CEC, meq/100g	14.96	26.32	12.68	18.39	50.59	37.43
Anions, mg/kg						
Ammonium (NH_4),	55.90	59.55	71.20	66.60	33.57	24.83
Nitrate (NO_3)	26.15	12.27	10.52	9.06	5.99	9.50
Nitrite (NO_2)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cations, meq/100g						
Potassium (K)	1.21	1.12	0.24	1.51	2.09	1.80
Sodium (Na)	0.87	1.15	0.54	1.09	1.46	19.68
Calcium (Ca)	10.66	22.03	9.04	13.56	44.63	13.79
Magnesium (Mg)	2.21	2.04	2.36	2.43	2.48	2.14
Organics						
Percent Organic Carbon, %	0.51	0.14	0.51	0.89	1.40	0.92
Total Hydrocarbon Content, mg/kg	0.38	0.36	0.34	0.28	1.21	0.98
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & Grease, mg/kg	0.40	0.38	<0.10	<0.10	<0.10	<0.10
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	1916	2569	2399	2789	2736	1870
Manganese, (Mn)	187.74	204.30	35.63	45.45	334.49	245.22
Cadmium (Cd)	3.28	1.38	0.82	2.07	1.83	6.98
Chromium (Cr)	19.06	11.03	40.78	11.45	50.54	12.98
Lead (Pb)	29.92	34.99	46.70	40.52	44.11	4.27
Nickel (Ni)	38.08	13.87	24.16	14.45	20.64	32.52

Vanadium (V)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	44.25	26.07	18.05	46.28	79.17	43.60
Copper (Cu)	9.93	10.54	6.39	13.70	24.77	20.64
Microbiology						
Total Heterotrophic Bacteria x 10 ³ cfu/g	1.40	1.35	1.70	1.60	1.50	1.60
Total Fungi x 10 ³ cfu/g	1.30	1.15	1.45	1.20	1.20	1.00
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.10	1.07	1.10	1.20	1.55	1.45
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.07	1.03	1.00	1.10	1.04	1.04

**Appendix 7h: Soils physico-chemical and microbiological properties in
the dry season, Cont'd**

Parameter	SS22T	SS22B	SS23T	SS23B	SS24T	SS24B
Physico-chemical Properties						
pH	4.8	4.8	5.3	5.3	5.2	4.7
Electrical Conductivity, $\mu\text{S}/\text{cm}$	121.40	118.60	604.00	742.00	103.00	106.40
Colour	Brown	Brown	Brown	Dark Brown	Dark Brown	Dark Brown
Texture	Clayey	Clayey	Loamy - Clayey	Loamy - Clayey	Clayey	Clayey
Oxidation -Reduction Potential, $\pm \text{mV}$	+48.20	+46.40	+73.20	+48.60	+53.80	+45.70
Available $\text{PO}_4\text{-P}$, mg/kg	15.21	15.71	10.12	12.59	15.04	13.77
Total Nitrogen, %	0.06	0.01	0.01	0.03	0.02	0.01
Bulk Density, g/cm^3	0.66	0.84	0.53	0.80	0.86	0.98
Porosity	76.00	80.00	82.00	84.00	80.00	82.00
Permeability, ml/s	0.33	0.31	0.36	0.32	0.33	0.32
CEC, $\text{meq}/100\text{g}$	24.92	15.05	80.82	45.31	51.42	8.52
Anions, mg/kg						
Ammonium (NH_4),	35.83	44.37	34.98	25.03	22.67	15.83
Nitrate (NO_3)	2.05	16.36	26.88	14.90	14.32	20.74
Nitrite (NO_2)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cations, $\text{meq}/100\text{g}$						
Potassium (K)	0.96	1.06	0.28	0.24	0.98	1.29
Sodium (Na)	1.24	1.08	24.57	0.87	21.69	0.51
Calcium (Ca)	9.44	10.49	53.93	42.96	26.64	4.31
Magnesium (Mg)	2.58	2.41	2.09	1.23	2.12	2.39
Organics						
Percent Organic Carbon, %	2.79	1.79	1.80	1.39	1.20	0.90
Total Hydrocarbon Content, mg/kg	0.62	0.54	0.63	0.45	0.61	0.56
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.71	0.58	0.75	0.51	0.88	0.72
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Heavy Metals, mg/kg						
Iron (Fe)	2111	2395	1587	2247	1789	2576
Manganese, (Mn)	186.25	302.38	55.56	45.11	16.38	44.87
Cadmium (Cd)	3.42	1.44	3.62	<0.05	7.59	3.63
Chromium (Cr)	29.33	52.91	25.51	29.96	15.73	64.99
Lead (Pb)	18.43	41.43	2.68	33.48	<0.002	37.11
Nickel (Ni)	30.12	38.90	24.68	11.97	28.79	13.31
Vanadium (V)	0.55	0.42	0.15	0.16	<0.05	<0.05
Zinc (Zn)	60.42	20.82	15.51	21.79	12.93	24.90
Copper (Cu)	18.43	17.29	12.99	0.75	15.45	11.22
Microbiology						

Total Heterotrophic Bacteria x 10 ³ cfu/g	2.25	2.25	2.05	2.00	1.15	2.50
Total Fungi x 10 ³ cfu/g	1.60	2.00	1.25	1.40	1.10	1.75
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.02	1.45	1.40	1.37	1.07	1.35
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.03	1.03	1.04	1.05	1.02	1.05

Appendix 7i: Soils physico-chemical and microbiological properties in the dry season, Cont'd

Parameter	SS25T	SS25B	SS26T	SS26B
Physico-chemical Properties				
pH	4.8	4.4	5.1	4.9
Electrical Conductivity, $\mu\text{S}/\text{cm}$	130.90	206.20	204.00	255.00
Colour	Brownish	Brownish	Brownish	Brownish
Texture	Sandy Clayey	Sandy Clayey	Loamy - Clayey	Clayey
Oxidation–Reduction Potential, $\pm \text{mV}$	+58.80	+68.40	+43.40	+51.90
Available $\text{PO}_4\text{-P}$, mg/kg	12.61	12.12	10.51	4.06
Total Nitrogen, %	0.07	0.02	0.07	0.01
Bulk Density, g/cm^3	0.78	0.91	0.84	0.92
Porosity, %	66.00	40.00	42.00	366.00
Permeability, ml/s	0.45	0.24	0.33	0.11
CEC, meq/100g	15.98	54.58	27.75	32.21
Anions, mg/kg				
Ammonium (NH_4),	56.00	50.25	58.55	55.40
Nitrate (NO_3)	21.62	19.87	11.46	18.04
Nitrite (NO_2)	<0.02	<0.02	<0.02	<0.02
Cations, meq/100g				
Potassium (K)	1.96	1.51	2.69	2.02
Sodium (Na)	0.92	1.11	0.81	0.96
Calcium (Ca)	49.26	14.56	2.94	1.77
Magnesium (Mg)	2.05	2.08	1.99	0.58
Organics				
Percent Organic Carbon, %	2.81	0.51	0.21	0.19
Total Hydrocarbon Content, mg/kg	0.36	0.11	0.15	0.77
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05
Oil & grease, mg/kg	0.39	0.15	0.17	0.85
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01
Heavy Metals				
Iron (Fe)	2685	2799	2234	2496
Manganese, (Mn)	190.76	251.01	131.42	199.32
Cadmium (Cd)	1.92	<0.05	0.31	0.21
Chromium (Cr)	40.20	23.75	18.37	13.93
Lead (Pb)	41.51	38.67	30.43	33.33
Nickel (Ni)	7.40	14.68	26.25	16.82
Vanadium (V)	0.14	<0.05	0.28	<0.05
Zinc (Zn)	68.56	38.70	43.62	39.41

Copper (Cu)	16.08	6.91	6.30	8.43
Microbiology				
Total Heterotrophic Bacteria x 10 ³ cfu/g	2.10	1.75	2.50	2.00
Total Fungi x 10 ³ cfu/g	2.00	1.35	1.75	1.45
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.35	1.60	1.85	1.85
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.03	1.03	0.99	0.86

Appendix 7j: Soils physico-chemical and microbiological properties in the dry season, Cont'd

Parameter	SSC1T	SSC1B	SSC2T	SSC2B
Physico-chemical Properties				
pH	5.4	5.7	5.8	5.7
Electrical Conductivity, µS/cm	225.00	301.80	123.00	87.60
Colour	Brown	Brown	Grey	Brownish
Texture	Loamy - Clayey	Clayey	Loamy - Clayey	Clayey
Oxidation –Reduction Potential, ± mV	+40.70	+22.90	+22.20	+14.60
Available PO ₄ -P, mg/kg	13.06	11.21	15.06	12.06
Total Nitrogen , %	0.04	0.02	0.05	0.03
Bulk Density, g/cm ³	1.07	1.14	1.04	1.10
Porosity	52.00	44.00	74.00	51.00
Permeability, ml/s	0.23	0.31	0.32	0.29
CEC, meq/100g	66.05	36.41	15.41	26.33
Anions, mg/kg				
Ammonium (NH ₄),	42.69	38.22	52.39	44.61
Nitrate (NO ₃)	1.46	2.92	13.15	22.50
Nitrite (NO ₂)	<0.01	0.16	<0.01	0.03
Cations, meq/100g				
Potassium (K)	1.45	1.27	0.89	0.92
Sodium (Na)	23.76	2.29	0.94	0.57
Calcium (Ca)	38.96	31.51	11.24	23.00
Magnesium (Mg)	1.88	2.36	2.35	2.04
Organics				
Percent Organic Carbon, %	0.63	0.21	2.91	0.44
Total Hydrocarbon Content, mg/kg	<0.01	<0.01	3.33	0.32
PAH, mg/kg	<0.05	<0.05	<0.05	<0.05
Oil & Grease, mg/kg	<0.10	<0.10	4.39	0.39
BTEX, mg/kg	<0.02	<0.02	<0.02	<0.02
Phenol, mg/kg	<0.01	<0.01	<0.01	<0.01
Heavy Metals				
Iron (Fe)	1803	2560	2439	1859

Manganese, (Mn)	193.31	183.35	147.17	119.64
Cadmium (Cd)	0.79	<0.05	0.28	0.14
Chromium (Cr)	2.44	44.10	53.54	<0.05
Lead (Pb)	4.99	33.73	39.25	14.26
Nickel (Ni)	22.02	10.60	10.12	19.14
Vanadium (V)	<0.05	<0.05	<0.05	<0.05
Zinc (Zn)	150.12	225.63	51.17	43.77
Copper (Cu)	10.70	30.31	13.36	1.25
Microbiology				
Total Heterotrophic Bacteria x 10 ³ cfu/g	2.50	2.00	1.50	3.25
Total Fungi x 10 ³ cfu/g	1.75	1.49	1.39	3.23
Hydrocarbon Utilising Bacteria x 10 ² cfu/g	1.50	1.35	1.06	1.35
Hydrocarbon Utilising Fungi x 10 ² cfu/g	1.35	1.04	1.04	1.05

Appendix 8a Vegetation species composition

SPECIES	COMMON NAME	FAMILY	HABIT	LIFE FORM	SPECIES DISTRIBUTION											
					VG 1	VG 2	VG 3	SS 9	SS 19	SS 11	SS 5	SS 13	SS 4	SS 14	SS 22	
<i>Elaeis guineensis</i>	Oil Palm / <i>Lein</i> =Ijaw	PALMAE	Tree	mP	√√ √	√√	√√	√√	√	√√		√√	√√	√√	√√	
<i>Musanga cecropioides</i>	Umbrella Tree	MORACEAE	T/S	mP	√√		√√	√	√	√	√	√	√	√√	√√	
<i>Spondianthus preussii</i>	<i>Kuru</i> = Ijaw	EUPHORBIACEAE	T/S	mP	√√	√	√	√								
<i>Uapaca guineensis</i>		EUPHORBIACEAE	Tree	mP	√							√				
<i>Trichoscypha arborea</i>		ANACARDIACEAE	Tree	mP	√			√								
<i>Psydrax subcordata</i>		RUBIACEAE	T/S	mp	√			√		√			√			
<i>Funtumia elastica</i>	Lagos rubber	APOCYNACEAE	Tree	mP	√√			√		√				√		
<i>Pentadesma butyracea</i>	<i>Akanti</i> = Ijaw	CLUSIACEAE	Tree	mP	√		√	√		√	√					
<i>Alchornea laxiflora</i>	Christmas bush	EUPHORBIACEAE	Shrub	np	√√ √		√√	√√	√√	√√	√	√	√√	√√		
<i>Irvingia gabonensis</i>	<i>Okpukpa; Ogboin</i> = Ijaw	IRVINGIACEAE	Tree	MP	√	√√	√	√√	√√			√√	√√		√√ √	
<i>Anthocleista liebrechtsiana</i>		GENTIANACEAE	Tree	mp	√			√						√√		
<i>Laccosperma secundiflorum</i>	Rattan palm	PALMAE	Liana	Liana											√√	
<i>Anthocleista nobilis</i>	Cabbage tree	GENTIANACEAE	T/S	mp	√√		√	√√								
<i>Thalia welwitschii</i>		MARANTACEAE	Herb	np			√						√			
<i>Marantochloa mannii</i>		MARANTACEAE	Herb	np		√										
<i>Albizia adianthifolia</i>		MIMOSOIDEAE	Tree	mp		√	√	√		√		√	√	√	√	
<i>Coffea canephora</i>		RUBIACEAE	Shrub	np		√		√								
<i>Raphia hookeri</i>	Wine Palm	PALMAE	Tree	mp		√										
<i>Paullinia pinnata</i>		SAPINDACEAE	Liana	Liana		√		√								

Spondias mombin		ANACARDIACEAE	T/S	mP		√			√	√		√		√	
Pycnanthus angolensis		MYRISTICACEAE	Tree	mP	√	√	√	√		√	√	√	√	√	
Triumfetta cordifolia		MALVACEAE/MALVOIDEAE	Herb	np	√	√	√	√	√	√		√			
Lophira alata		OCHNACEAE	Tree	MP		√	√			√		√			
Centrosema pubescens		FABACEAE/FABOIDEAE	Climber	Ch		√				√	√				
Aspilia africana		ASTERACEAE	Herb	np		√	√		√	√	√	√		√	√√
Acanthus montanus		ACANTHACEAE	Herb	Ch		√		√							
Costus afer	Monkey Sugar Cane	ZINGIBERACEAE	Herb	np	√	√	√	√	√	√√	√	√	√		
Milicia excelsa	Iroko	MORACEAE	Tree	MP		√									
Newbouldia laevis		BIGNONIACEAE	T/S	mP		√			√	√					
Ricinodendron heudelotii		EUPHORBIACEAE	T/S	MP		√	√	√	√	√√		√			√
Cleistopholis patens		ANNONACEAE	T/S	mP		√	√	√√		√	√	√√	√	√	√
Bambusa vulgaris	Bamboo	POACEAE	Tree	mP		√	√			√		√	√	√	
Schrankia leptocarpa		MIMOSOIDEAE	Shrub	np		√√									
Harungana madagascariensis		HYPERICACEAE	Shrub	np		√			√	√					
Vitex grandifolia		VERBENACEAE	T/S	mp		√	√	√	√	√		√	√	√	
Ceiba pentandra	Silk cotton	BOMBACACEAE	T/S	MP	√	√	√	√		√		√	√		
Ficus ovata		MORACEAE	Tree	mP	√		√							√	
Treculia africana	Bush Beans: <i>Oyein</i> =Ijaw; African breadfruit	MORACEAE	Tree	MP			√	√√							√
Dracaena mannii		AGAVACEAE	Tree	mP				√							
Ficus mucoso		MORACEAE	Tree	MP		√					√		√		
Fleroya ledermannii	<i>Abura</i>	RUBIACEAE	T/S	mP	√	√		√	√	√√	√	√√		√√	
Calamus deeratus	Rattan palm	PALMAE	Liana	Liana				√					√		
Cyrtosperma senegalensis		ARACEAE	Cr	Cr	√			√							

Sagittaria sagittifolia		ALISMATACEAE	Cr	Cr				√							
Chromolaena odorata		ASTERACEAE	Herb	np		√√	√√	√	√	√√	√√	√√	√	√	√√
Stachytarpheta indica		VERBENACEAE	Herb	np		√	√			√		√			√
Zanthoxylum gillettii		RUTACEAE	Tree	mP		√						√			√
Dioscorea spp	Wild yam	DIOSCOREACEAE	Climber	Climber								√			
Mucuna flagellipes		FABACEAE/FABOIDEAE	Climber	Climber								√			
Tetracera potatoria		DILLENIACEAE	Liana	Liana				√				√			
Ficus exasperata	Sand paper tree	MORACEAE	Tree	mP		√	√			√		√			
Alstonia boonei	Stool wood	APOCYNACEAE	Tree	MP	√√	√	√	√	√	√√	√	√	√	√√	√
Melastomastrum capitatum		MELASTOMATAEAE	Ch	Ch				√√							
Guarea thompsonii	<i>Ako = Ijaw</i> ; Black Guarea	MELIACEAE	T/S	MP				√		√		√		√	√
Terminalia superba	<i>Afara</i>	COMBRETACEAE	T/S	MP						√					
Dryopteris filix mas		DRYOPTERIDACEAE	Fern	Cr						√					
Cola glabrescens		MALVACEAE/STERCULIOIDEAE	Tree	MP				√						√	
Clappertonia ficifolia		MALVACEAE/MALVOIDEAE	Shrub	np	√			√						√√	

KEY: Relative Frequency: √ = less than 25%; √√ = up to 50%; √√√ = Over 50%/Dominant/Cultivated.

np = Nanophanerophytes, **mp** = Microphanerophytes, **mP** = Mesophanerophytes, **MP** = Megaphanerophytes, **Ch** = Chamaephytes, **HCr** = Hemicryptophytes.

Appendix 8b: Results of phytochemical analysis**DRY SEASON DATA**

Parameter	VG1	VG2	VG3	VG4	VG5	VGC1	VGC2	MEAN	MINIMU M	MAXIMU M
Nutrient Elements (mg/kg)										
Potassium (K)	2143	2086	2197	2198	2148	2199	2183	2164.85	2086	2199
Sodium (Na)	313.60	318.43	323.45	573.63	353.04	395.19	306.27	369.091	306.277	573.632
Calcium (Ca)	1503	5682	6339	5644	5016	2188	1429	3971.57	1429	6339
Magnesium (Mg)	241.741	250.03	215.359	245.902	251.087	237.947	229.706	238.8246	215.359	251.087
Organics (mg/kg)										
Total Petroleum Hydrocarbon	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031
PAH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heavy Metals (mg/kg)										
Iron (Fe)	179.915	135.986	155.463	232.711	300.182	173.737	136.623	187.8024	135.986	300.182
Manganese, (Mn)	23.216	183.975	143.466	11.082	396.335	24.971	104.819	126.8377	11.082	396.335
Cadmium (Cd)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium (Cr)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nickel (Ni)	10.804	8.828	9.754	6.976	17.224	11.483	148.78	30.54986	6.976	148.78
Vanadium (V)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (Zn)	17.78	50.573	25.535	33.143	53.804	15.098	13.369	29.90029	13.369	53.804
Copper (Cu)	8.36	19.879	13.599	14.047	18.826	10.637	10.137	13.6407	8.36	19.879

WET SEASON DATA

Parameter	Elements / Compounds	VG1	VG2	VG3	VG4	VG5	VGC1	VGC2	Mean	Minimum	Maximum
Nutrient Elements (mg/kg)											
	Potassium (K)	2735	2734	2419	3022	3627	1958	2379	2696.286	1958	3627
	Sodium (Na)	252.407	294.201	247.568	250.53	355.867	354.574	117.795	267.5631	117.795	355.867
	Calcium (Ca)	5147	6329	4770	3462	5377	5384	5856	5189.286	3462	6329
	Magnesium (Mg)	275.937	247.956	253.282	279.123	207.203	274.276	282.543	260.0457	207.203	282.543
Organics (mg/kg)											
	Total Petroleum Hydrocarbon	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031
	PAH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heavy Metals (mg/kg)											
	Iron (Fe)	452.186	229.021	161.006	121.961	439.033	143.773	226.19	253.31	121.961	452.186
	Manganese, (Mn)	44.373	146.051	186.483	53.996	216.384	345.848	447.803	205.8483	44.373	447.803
	Cadmium (Cd)	3.069	2.552	2.705	2.116	1.809	2.269	2.955	2.496429	1.809	3.069
	Chromium (Cr)	3.689	19.877	5.533	1.639	5.943	13.32	14.959	9.28	1.639	19.877
	Lead (Pb)	22.52	<0.002	35.175	25.523	34.21	<0.002	<0.002	29.357	22.52	35.175
	Nickel (Ni)	40.487	47.418	65.431	53.983	63.175	54.202	52.504	53.88571	40.487	65.431
	Vanadium (V)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Zinc (Zn)	220.804	256.519	251.585	217.286	282.363	264.669	30.343	217.6527	30.343	282.363
	Copper (Cu)	19.174	15.628	22.19	16.382	40.883	17.361	17.521	21.30557	15.628	40.883

APPENDIX 9a: Phytoplankton population in the study area during the dry season

	Sample Points										Control		To	%T	
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	Tot	%To	1			2
Baccillariophyce															
<i>Achnanthes</i>	0	0	76	27	38	0	44	0	59	244	1.03	25	0	25	0.44
<i>Achnanthes</i>	0	29	83	5	28	0	0	29	63	237	1.00	18	49	67	1.18
<i>Amphiprora</i>	49	8	45	0	41	0	45	43	24	255	1.08	26	22	48	0.85
<i>Amphora ovals</i>	38	17	32	0	28	10	34	32	35	226	0.96	42	11	53	0.94
<i>Aulocosiera</i>	6	39	11	42	3	45	10	12	18	186	0.79	52	3	55	0.97
<i>Bacillaria</i>	0	0	0	37	8	0	0	0	0	45	0.19	18	61	79	1.39
<i>Bacillaria</i>	0	0	45	4	0	0	5	0	0	54	0.23	33	35	68	1.20
<i>Bacteriastrium</i>	10	36	7	17	18	10	0	0	0	98	0.42	0	0	0	0.00
<i>Biddulphia aurita</i>	10	36	14	38	6	41	11	15	12	183	0.78	15	36	51	0.90
<i>Biddulphia laevis</i>	66	0	0	42	15	0	15	0	11	149	0.63	32	80	11	1.98
<i>Biddulphia</i>	41	5	0	0	0	28	93	15	111	293	1.24	69	75	14	2.54
<i>Chaetoceros</i>	2	41	10	45	0	48	7	10	86	249	1.06	45	9	54	0.95
<i>Cheatoceros</i>	37	18	29	3	27	10	31	31	43	229	0.97	0	76	76	1.34
<i>Cheatoceros</i>	11	54	0	0	0	0	19	0	0	84	0.36	41	39	80	1.41
<i>Cheatoceros</i>	5	68	48	5	3	33	0	51	9	222	0.94	0	0	0	0.00
<i>Corethrona sp</i>	3	0	83	56	86	54	82	81	0	445	1.89	43	11	54	0.95
<i>Coscinodiscus</i>	0	69	0	60	0	61	0	0	27	217	0.92	81	0	81	1.43
<i>Coscinodiscus</i>	7	0	35	10	0	0	26	12	27	117	0.50	0	35	35	0.62
<i>Coscinodiscus</i>	0	1	0	106	9	48	13	35	0	212	0.90	2	41	43	0.76
<i>Coscinodiscus</i>	4	7	0	0	0	73	0	73	0	157	0.67	0	22	22	0.39
<i>Coscinodiscus</i>	32	19	28	9	21	12	28	27	45	221	0.94	21	27	48	0.85
<i>Cosinosira</i>	0	1	10	0	0	0	0	0	12	23	0.10	0	0	0	0.00
<i>Cyclotella</i>	39	0	19	0	0	0	10	6	45	119	0.50	6	0	6	0.11
<i>Cyclotella striata</i>	34	18	28	7	25	10	29	28	81	260	1.10	83	0	83	1.46
<i>Cymbella ovalis</i>	5	39	11	43	0	45	9	12	5	169	0.72	76	0	76	1.34
<i>Diatoma hiemale</i>	2	69	54	8	75	33	67	45	0	353	1.50	29	56	85	1.50
<i>Ditylum</i>	9	0	0	20	11	31	26	37	5	139	0.59	45	0	45	0.79
<i>Eunotia gracilis</i>	15	28	18	29	10	37	15	20	0	172	0.73	36	14	50	0.88
<i>Fragillariopsis</i>	89	0	86	111	91	94	91	83	104	749	3.18	32	16	48	0.85
<i>Fragillriopsis</i>	22	42	28	81	83	21	93	0	82	452	1.92	101	91	19	3.39
<i>Gyrosigma</i>	25	37	27	45	21	37	15	28	0	235	1.00	0	65	65	1.15
<i>Hantzschia</i>	19	28	24	24	15	28	17	22	57	234	0.99	20	28	48	0.85
<i>Lauderia borealis</i>	17	28	19	28	12	35	17	21	71	248	1.05	24	24	48	0.85
<i>Leptocylindricus</i>	28	34	24	14	0	0	0	91	104	295	1.25	60	0	60	1.06
<i>Melosia</i>	9	0	38	10	0	4	0	0	32	93	0.39	36	19	55	0.97
<i>Navicula</i>	35	71	45	0	3	21	91	6	48	320	1.36	22	39	61	1.08

	Sample Points										Tot	%To	Control		To	%T
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	1			2			
<i>Navicula</i>	10	36	12	38	5	45	11	15	12	184	0.78	0	62	62	1.09	
<i>Navicula gracilis</i>	30	53	21	83	0	52	0	10	9	258	1.09	5	3	8	0.14	
<i>Navicula minima</i>	0	0	21	17	0	5	0	0	0	43	0.18	0	0	0	0.00	
<i>Nitzschia</i>	31	27	21	71	24	36	26	12	0	248	1.05	0	10	10	0.18	
<i>N. linearis</i>	15	14	21	0	8	5	36	40	0	139	0.59	42	18	60	1.06	
<i>N. longissima</i>	4	4	0	93	0	18	0	0	0	119	0.50	0	18	18	0.32	
<i>Odontella</i>	0	2	0	0	45	0	5	62	0	114	0.48	93	0	93	1.64	
<i>Pinnularia</i>	11	51	41	89	48	0	50	0	21	311	1.32	59	106	16	2.91	
<i>P. interrupta</i>	32	20	28	10	21	13	28	27	0	179	0.76	31	16	47	0.83	
<i>P.maior</i>	0	0	0	38	3	35	31	18	0	125	0.53	0	0	0	0.00	
<i>Planktonella sol</i>	29	28	22	57	20	4	15	29	20	224	0.95	0	0	0	0.00	
<i>Pleurosigma</i>	0	0	11	0	47	0	0	10	36	104	0.44	15	7	22	0.39	
<i>P. elongatum</i>	14	43	0	0	10	40	36	12	28	183	0.78	69	41	11	1.94	
<i>Rhizosolenia</i>	0	34	0	35	14	0	0	0	24	107	0.45	8	4	12	0.21	
<i>R. simplex</i>	11	0	85	0	87	18	0	25	0	226	0.96	0	27	27	0.48	
<i>R. styliformis</i>	56	0	49	0	48	0	50	54	8	265	1.12	75	0	75	1.32	
<i>Skeletonmema sp</i>	0	91	0	91	0	105	0	0	27	314	1.33	0	82	82	1.45	
<i>Surirella caproni</i>	0	7	0	9	0	45	0	0	25	86	0.36	3	0	3	0.05	
<i>S. robusta</i>	0	0	20	32	0	24	45	0	21	142	0.60	7	17	24	0.42	
<i>Synedra acus</i>	20	20	13	28	13	39	21	0	0	154	0.65	11	38	49	0.86	
<i>S. rumpens</i>	43	11	36	0	32	10	38	36	4	210	0.89	28	17	45	0.79	
<i>S. ulna</i>	0	5	0	0	0	9	11	19	10	54	0.23	5	4	9	0.16	
<i>Tabellaria</i>	0	3	0	10	19	35	32	18	0	117	0.50	21	21	42	0.74	
<i>Thalassionema</i>	0	21	2	0	0				19	42	0.18	61	45	10	1.87	
<i>T. nitzschoides</i>	1	42	9	45	0	48	7	10	111	273	1.16	10	43	53	0.94	
<i>Thalassiosira sp.</i>	34	27	20	0	73	0	61	91	29	335	1.42	0	0	0	0.00	
<i>Thalassiothrix</i>	35	9	0	81	0	8	0	3	2	138	0.59	28	59	87	1.53	
<i>Thalassiothrix sp.</i>	15	49	36	4	0	0	34	7	41	186	0.79	21	26	47	0.83	
<i>Triceratium sp</i>	13	29	18	31	10	38	15	19	35	208	0.88	12	38	50	0.88	
Sub-Total	1073	1468	1463	1788	1204	1501	1495	1382	1698	130	55.42	1737	1686	34	60.3	
Chlorophyta																
<i>Staurastrum</i>	0	0	73	31	71	11	61	69	0	316	1.34	109	0	10	1.92	
<i>Closterium</i>	42	15	35	0	32	10	37	34	29	234	0.99	54	0	54	0.95	
<i>Eudorina sp</i>	45	10	42	0	38	3	38	42	0	218	0.92	0	89	89	1.57	
<i>Halosphaera</i>	0	39	75	0	27	69	32	10	0	252	1.07	0	105	10	1.85	
<i>H. spheroides</i>	35	24	19	35	12	40	6	42	17	230	0.98	48	0	48	0.85	
<i>Pandorina</i>	0	32	38	0	35	28	5	20	20	178	0.75	15	13	28	0.49	
<i>Phacolus</i>	27	18	56	45	0	11	42	21	83	303	1.28	0	24	24	0.42	
<i>Phaeocystis</i>	75	6	56	56	45	22	13	49	38	360	1.53	0	10	10	0.18	

	Sample Points										Tot	%To	Control		To	%T
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	1			2			
<i>Pleodorina sp</i>	0	0	0	0	12	0	89	0	0	101	0.43	0	0	0	0.00	
<i>Scenedesmus</i>	10	7	21	24	0	10	15	4	10	101	0.43	50	0	50	0.88	
<i>Scenedesmus</i>	45	10	31	0	21	15	39	0	0	161	0.68	0	15	15	0.26	
<i>Scenedesmus</i>	0	44	4	47	0	51	0	6	38	190	0.81	12	39	51	0.90	
<i>Micrasterias sol</i>	2	0	5	33	0	16	25	25	32	138	0.59	17	0	17	0.30	
<i>Micrasterias</i>	0	18	0	10	0	12	13	50	0	103	0.44	0	10	10	0.18	
Sub-Total	281	223	455	281	293	298	415	372	267	288	12.23	305	305	61	10.7	
Cyanophyta																
<i>Anabaena flos-</i>	72	8	15	19	48	67	25	95	5	354	1.50	0	14	14	0.25	
<i>A. spiroides</i>	0	8	40	29	15	0	0	0	0	92	0.39	0	17	17	0.30	
<i>Aphanozemenun</i>	18	8	20	18	10	17	11	15	22	139	0.59	9	6	15	0.26	
<i>Gleocapsa</i>	0	0	0	0	0	0	0	0	5	5	0.02	0	36	36	0.64	
<i>G. turgida</i>	0	0	86	19	25	20	49	0	5	204	0.86	0	24	24	0.42	
<i>Isocystis</i>	0	62	0	56	0	60	0	0	11	189	0.80	32	15	47	0.83	
<i>Isocystis sp.</i>	103	0	94	0	109	0	125	94	28	553	2.34	21	27	48	0.85	
<i>Lyngbya lutea</i>	0	37	57	4	38	0	0	5	0	141	0.60	0	19	19	0.34	
<i>L.</i>	21	45	31	43	0	21	0	65	28	254	1.08	34	36	70	1.24	
<i>L. kutzingiana</i>	16	0	0	0	18	0	21	0	53	108	0.46	25	7	32	0.56	
<i>Merismopedia</i>	59	0	57	0	65	0	56	60	0	297	1.26	26	21	47	0.83	
<i>Microcystis</i>	0	54	0	54	0	56	0	3	0	167	0.71	24	24	48	0.85	
<i>Oscillatoria</i>	19	0	12	94	0	0	0	0	0	125	0.53	6	109	11	2.03	
<i>O. limosa</i>	8	0	25	5	35	17	10	0	0	100	0.42	0	31	31	0.55	
<i>O. pseudomina</i>	32	18	28	9	21	11	29	28	148	324	1.37	4	56	60	1.06	
<i>O. terebriformis</i>	0	57	0	56	0	59	0	0	47	219	0.93	11	41	52	0.92	
<i>O. bonnemaisonii</i>	60	0	72	0	71	0	59	65	49	376	1.59	10	45	55	0.97	
<i>Phormidium sp</i>	92	0	0	73	0	0	0	0	0	165	0.70	6	0	6	0.11	
<i>P. brevis</i>	0	0	13	0	21	29	27	19	0	109	0.46	21	27	48	0.85	
<i>P. forseolarum</i>	10	39	67	0	7	93	54	11	0	281	1.19	0	105	10	1.85	
<i>P. molle</i>	0	69	0	65	0	65	0	0	4	203	0.86	21	27	48	0.85	
<i>P. uncinatum</i>	0	7	17	4	0	0	23	16	9	76	0.32	0	21	21	0.37	
<i>P. tenue</i>	28	29	22	31	83	53	89	111	53	499	2.12	10	30	40	0.71	
<i>Pseudoanabaena</i>	15	28	19	28	11	35	17	21	38	212	0.90	14	37	51	0.90	
<i>Synchococcus</i>	57	0	54	0	51	0	50	56	22	290	1.23	22	26	48	0.85	
Sub-Total	610	469	729	607	628	603	645	664	527	548	23.24	296	801	10	19.3	
Dinophyta																
<i>Ceratium</i>	0	0	83	28	45	29	50	0	9	244	1.03	0	0	0	0.00	
<i>Ceratium sp</i>	22	60	0	78	0	0	0	0	0	160	0.68	0	4	4	0.07	
<i>Ceratium tripos</i>	20	25	25	20	15	25	18	23	0	171	0.73	0	109	10	1.92	
<i>Dinophysis</i>	0	0	0	28	5	0	0	5	0	38	0.16	0	28	28	0.49	

	Sample Points												Control		To	%T
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	Tot	%To	1	2			
<i>Gonyaulax sp</i>	0	31	24	0	0	0	0	0	10	65	0.28	0	0	0	0.00	
<i>Gonyaulax</i>	46	7	10	11	0	24	17	89	82	286	1.21	35	21	56	0.99	
<i>Pyrocystis sp.</i>	28	23	27	12	20	20	25	25	25	205	0.87	0	76	76	1.34	
Sub-Total	116	146	169	177	85	98	110	142	126	116	4.96	35	238	27	4.82	
Euglenophyta																
<i>Euglena acus</i>	21	14	45	0	15	28	0	0	72	195	0.83	34	40	74	1.31	
<i>Euglena caudata</i>	0	45	39	0	64	4	21	10	27	210	0.89	9	32	41	0.72	
<i>Euglena obtusa</i>	19	9	28	31	35	18	0	21	11	172	0.73	0	17	17	0.30	
<i>Euglena tripteris</i>	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0.00	
<i>Phacus caudatus</i>	27	28	19	0	19	0	15	91	28	227	0.96	0	105	10	1.85	
<i>Trachelomonas</i>	35	38	12	40	15	0	0	0	34	174	0.74	28	0	28	0.49	
Sub-Total	102	134	143	71	148	50	36	122	172	978	4.15	71	194	26	4.68	
Total No. of cells	2182	2440	2959	2924	2358	2550	2701	2682	2790	235		2444	3224	56		
No. of Species of	74	89	86	78	80	80	79	78	80			76	89			
	73	88	85	77	79	79	78	77	79			75	88			
Margalefs index	9.4953	11.282	10.634	9.6482	10.173	10.071	9.8716	9.7538	9.9574			9.61366	10.893			
Menhinniks index	1.5841	1.8017	1.5809	1.4424	1.6474	1.5842	1.5200	1.5061	1.5145			1.53731	1.5674			

APPENDIX 9b: Phytoplankton population in the study area during the wet season																
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total	
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2			
Baccillariophyceae																
<i>Achnanthes affinis</i>	0	0	76	27	38	0	44	0	59	244	1.03	25	0	25	0.44	
<i>Achnanthes echrenbergii</i>	0	29	83	5	28	0	0	29	63	237	1.00	18	49	67	1.18	
<i>Amphiprora costata</i>	49	8	45	0	41	0	45	43	24	255	1.08	26	22	48	0.85	
<i>Amphora ovals</i>	38	17	32	0	28	10	34	32	35	226	0.96	42	11	53	0.94	
<i>Aulocosiera granulate</i>	6	39	11	42	3	45	10	12	18	186	0.79	52	3	55	0.97	
<i>Bacillaria paradoxa</i>	0	0	0	37	8	0	0	0	0	45	0.19	18	61	79	1.39	
<i>Bacillaria paxillifera</i>	0	0	45	4	0	0	5	0	0	54	0.23	33	35	68	1.20	
<i>Bacteriastrum delicatulum</i>	10	36	7	17	18	10	0	0	0	98	0.42	0	0	0	0.00	
<i>Biddulphia aurita</i>	10	36	14	38	6	41	11	15	12	183	0.78	15	36	51	0.90	
<i>Biddulphia laevis</i>	66	0	0	42	15	0	15	0	11	149	0.63	32	80	112	1.98	
<i>Biddulphia longicuris</i>	41	5	0	0	0	28	93	15	111	293	1.24	69	75	144	2.54	
<i>Chaetoceros mulleri</i>	2	41	10	45	0	48	7	10	86	249	1.06	45	9	54	0.95	
<i>Cheatoceros decipens</i>	37	18	29	3	27	10	31	31	43	229	0.97	0	76	76	1.34	
<i>Cheatoceros didyma</i>	11	54	0	0	0	0	19	0	0	84	0.36	41	39	80	1.41	
<i>Cheatoceros emeroli</i>	5	68	48	5	3	33	0	51	9	222	0.94	0	0	0	0.00	
<i>Corethrone sp</i>	3	0	83	56	86	54	82	81	0	445	1.89	43	11	54	0.95	
<i>Coscinodiscus centalis</i>	0	69	0	60	0	61	0	0	27	217	0.92	81	0	81	1.43	
<i>Coscinodiscus concinniformis</i>	7	0	35	10	0	0	26	12	27	117	0.50	0	35	35	0.62	
<i>Coscinodiscus concinnus</i>	0	1	0	106	9	48	13	35	0	212	0.90	2	41	43	0.76	
<i>Coscinodiscus radiate</i>	4	7	0	0	0	73	0	73	0	157	0.67	0	22	22	0.39	
<i>Coscinodiscus rothii</i>	32	19	28	9	21	12	28	27	45	221	0.94	21	27	48	0.85	
<i>Cosinosira oestrupi</i>	0	1	10	0	0	0	0	0	12	23	0.10	0	0	0	0.00	
<i>Cyclotella meneghianina</i>	39	0	19	0	0	0	10	6	45	119	0.50	6	0	6	0.11	
<i>Cyclotella striata</i>	34	18	28	7	25	10	29	28	81	260	1.10	83	0	83	1.46	

APPENDIX 9b: Phytoplankton population in the study area during the wet season															
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2		
<i>Cymbella ovalis</i>	5	39	11	43	0	45	9	12	5	169	0.72	76	0	76	1.34
<i>Diatoma hiemale</i>	2	69	54	8	75	33	67	45	0	353	1.50	29	56	85	1.50
<i>Ditylum brightwelli</i>	9	0	0	20	11	31	26	37	5	139	0.59	45	0	45	0.79
<i>Eunotia gracilis</i>	15	28	18	29	10	37	15	20	0	172	0.73	36	14	50	0.88
<i>Fragillariopsis atlantica</i>	89	0	86	111	91	94	91	83	104	749	3.18	32	16	48	0.85
<i>Fragillriopsis oceanica</i>	22	42	28	81	83	21	93	0	82	452	1.92	101	91	192	3.39
<i>Gyrosigma</i>	25	37	27	45	21	37	15	28	0	235	1.00	0	65	65	1.15
<i>Hantzschia amphioxys</i>	19	28	24	24	15	28	17	22	57	234	0.99	20	28	48	0.85
<i>Lauderia borealis</i>	17	28	19	28	12	35	17	21	71	248	1.05	24	24	48	0.85
<i>Leptocylindricus sp.</i>	28	34	24	14	0	0	0	91	104	295	1.25	60	0	60	1.06
<i>Melosia moniliformis</i>	9	0	38	10	0	4	0	0	32	93	0.39	36	19	55	0.97
<i>Navicula bacillum</i>	35	71	45	0	3	21	91	6	48	320	1.36	22	39	61	1.08
<i>Navicula cuspidata</i>	10	36	12	38	5	45	11	15	12	184	0.78	0	62	62	1.09
<i>Navicula gracilis</i>	30	53	21	83	0	52	0	10	9	258	1.09	5	3	8	0.14
<i>Navicula minima</i>	0	0	21	17	0	5	0	0	0	43	0.18	0	0	0	0.00
<i>Nitzschia closterium</i>	31	27	21	71	24	36	26	12	0	248	1.05	0	10	10	0.18
<i>N. linearis</i>	15	14	21	0	8	5	36	40	0	139	0.59	42	18	60	1.06
<i>N. longissima</i>	4	4	0	93	0	18	0	0	0	119	0.50	0	18	18	0.32
<i>Odontella sinensis</i>	0	2	0	0	45	0	5	62	0	114	0.48	93	0	93	1.64
<i>Pinnularia appendiculata</i>	11	51	41	89	48	0	50	0	21	311	1.32	59	106	165	2.91
<i>P. interrupta</i>	32	20	28	10	21	13	28	27	0	179	0.76	31	16	47	0.83
<i>P. maior</i>	0	0	0	38	3	35	31	18	0	125	0.53	0	0	0	0.00
<i>Planktonella sol</i>	29	28	22	57	20	4	15	29	20	224	0.95	0	0	0	0.00
<i>Pleurosigma angulatum</i>	0	0	11	0	47	0	0	10	36	104	0.44	15	7	22	0.39
<i>P. elongatum</i>	14	43	0	0	10	40	36	12	28	183	0.78	69	41	110	1.94
<i>Rhizosolenia erensis</i>	0	34	0	35	14	0	0	0	24	107	0.45	8	4	12	0.21

APPENDIX 9b: Phytoplankton population in the study area during the wet season															
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2		
<i>R. simplex</i>	11	0	85	0	87	18	0	25	0	226	0.96	0	27	27	0.48
<i>R. styliformis</i>	56	0	49	0	48	0	50	54	8	265	1.12	75	0	75	1.32
<i>Skeletonmema sp</i>	0	91	0	91	0	105	0	0	27	314	1.33	0	82	82	1.45
<i>Surirella caproni</i>	0	7	0	9	0	45	0	0	25	86	0.36	3	0	3	0.05
<i>S. robusta</i>	0	0	20	32	0	24	45	0	21	142	0.60	7	17	24	0.42
<i>Synedra acus</i>	20	20	13	28	13	39	21	0	0	154	0.65	11	38	49	0.86
<i>S. rumpens</i>	43	11	36	0	32	10	38	36	4	210	0.89	28	17	45	0.79
<i>S. ulna</i>	0	5	0	0	0	9	11	19	10	54	0.23	5	4	9	0.16
<i>Tabellaria fenestrata</i>	0	3	0	10	19	35	32	18	0	117	0.50	21	21	42	0.74
<i>Thalassionema bacillare</i>	0	21	2	0	0				19	42	0.18	61	45	106	1.87
<i>T. nitzschoides</i>	1	42	9	45	0	48	7	10	111	273	1.16	10	43	53	0.94
<i>Thalassiosira sp.</i>	34	27	20	0	73	0	61	91	29	335	1.42	0	0	0	0.00
<i>Thalassiothrix nitzschoides.</i>	35	9	0	81	0	8	0	3	2	138	0.59	28	59	87	1.53
<i>Thalassiothrix sp.</i>	15	49	36	4	0	0	34	7	41	186	0.79	21	26	47	0.83
<i>Triceratium sp</i>	13	29	18	31	10	38	15	19	35	208	0.88	12	38	50	0.88
Sub-Total	1073	1468	1463	1788	1204	1501	1495	1382	1698	13072	55.42	1737	1686	3423	60.39
Chlorophyta															
<i>Staurastrum seligerum</i>	0	0	73	31	71	11	61	69	0	316	1.34	109	0	109	1.92
<i>Closterium lineatum</i>	42	15	35	0	32	10	37	34	29	234	0.99	54	0	54	0.95
<i>Eudorina sp</i>	45	10	42	0	38	3	38	42	0	218	0.92	0	89	89	1.57
<i>Halosphaera viridis</i>	0	39	75	0	27	69	32	10	0	252	1.07	0	105	105	1.85
<i>H. spheroids</i>	35	24	19	35	12	40	6	42	17	230	0.98	48	0	48	0.85
<i>Pandorina</i>	0	32	38	0	35	28	5	20	20	178	0.75	15	13	28	0.49
<i>Phacolus</i>	27	18	56	45	0	11	42	21	83	303	1.28	0	24	24	0.42

APPENDIX 9b: Phytoplankton population in the study area during the wet season															
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2		
<i>Phaeocystis globosa</i>	75	6	56	56	45	22	13	49	38	360	1.53	0	10	10	0.18
<i>Pleodorina sp</i>	0	0	0	0	12	0	89	0	0	101	0.43	0	0	0	0.00
<i>Scenedesmus excelcia</i>	10	7	21	24	0	10	15	4	10	101	0.43	50	0	50	0.88
<i>Scenedesmus quadricauda</i>	45	10	31	0	21	15	39	0	0	161	0.68	0	15	15	0.26
<i>Scenedesmus acuminatus</i>	0	44	4	47	0	51	0	6	38	190	0.81	12	39	51	0.90
<i>Micrasterias sol</i>	2	0	5	33	0	16	25	25	32	138	0.59	17	0	17	0.30
<i>Micrasterias truncata</i>	0	18	0	10	0	12	13	50	0	103	0.44	0	10	10	0.18
Sub-Total	281	223	455	281	293	298	415	372	267	2885	12.23	305	305	610	10.76
Cyanophyta															
<i>Anabaena flos-aquae</i>	72	8	15	19	48	67	25	95	5	354	1.50	0	14	14	0.25
<i>A. spiroides</i>	0	8	40	29	15	0	0	0	0	92	0.39	0	17	17	0.30
<i>Aphanozemenum flos-aquae</i>	18	8	20	18	10	17	11	15	22	139	0.59	9	6	15	0.26
<i>Gleocapsa rupestris</i>	0	0	0	0	0	0	0	0	5	5	0.02	0	36	36	0.64
<i>G. turgida</i>	0	0	86	19	25	20	49	0	5	204	0.86	0	24	24	0.42
<i>Isocystis planktonica</i>	0	62	0	56	0	60	0	0	11	189	0.80	32	15	47	0.83
<i>Isocystis sp.</i>	103	0	94	0	109	0	125	94	28	553	2.34	21	27	48	0.85
<i>Lyngbya lutea</i>	0	37	57	4	38	0	0	5	0	141	0.60	0	19	19	0.34
<i>L. aeruginneocoerulea</i>	21	45	31	43	0	21	0	65	28	254	1.08	34	36	70	1.24
<i>L. kutzingiana</i>	16	0	0	0	18	0	21	0	53	108	0.46	25	7	32	0.56
<i>Merismopedia elegans</i>	59	0	57	0	65	0	56	60	0	297	1.26	26	21	47	0.83
<i>Microcystis aeuroginosa</i>	0	54	0	54	0	56	0	3	0	167	0.71	24	24	48	0.85
<i>Oscillatoria formosa</i>	19	0	12	94	0	0	0	0	0	125	0.53	6	109	115	2.03
<i>O. limosa</i>	8	0	25	5	35	17	10	0	0	100	0.42	0	31	31	0.55
<i>O. pseudomina</i>	32	18	28	9	21	11	29	28	148	324	1.37	4	56	60	1.06

APPENDIX 9b: Phytoplankton population in the study area during the wet season															
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2		
<i>O. terebriformis</i>	0	57	0	56	0	59	0	0	47	219	0.93	11	41	52	0.92
<i>O. bonnemaisonii</i>	60	0	72	0	71	0	59	65	49	376	1.59	10	45	55	0.97
<i>Phormidium sp</i>	92	0	0	73	0	0	0	0	0	165	0.70	6	0	6	0.11
<i>P. brevis</i>	0	0	13	0	21	29	27	19	0	109	0.46	21	27	48	0.85
<i>P. forseolarum</i>	10	39	67	0	7	93	54	11	0	281	1.19	0	105	105	1.85
<i>P. molle</i>	0	69	0	65	0	65	0	0	4	203	0.86	21	27	48	0.85
<i>P. uncinatum</i>	0	7	17	4	0	0	23	16	9	76	0.32	0	21	21	0.37
<i>P. tenue</i>	28	29	22	31	83	53	89	111	53	499	2.12	10	30	40	0.71
<i>Pseudoanabaena</i>	15	28	19	28	11	35	17	21	38	212	0.90	14	37	51	0.90
<i>Synchococcus aquatilis</i>	57	0	54	0	51	0	50	56	22	290	1.23	22	26	48	0.85
Sub-Total	610	469	729	607	628	603	645	664	527	5482	23.24	296	801	1097	19.35
Dinophyta															
<i>Ceratium hirundinella</i>	0	0	83	28	45	29	50	0	9	244	1.03	0	0	0	0.00
<i>Ceratium sp</i>	22	60	0	78	0	0	0	0	0	160	0.68	0	4	4	0.07
<i>Ceratium tripos</i>	20	25	25	20	15	25	18	23	0	171	0.73	0	109	109	1.92
<i>Dinophysis caudata</i>	0	0	0	28	5	0	0	5	0	38	0.16	0	28	28	0.49
<i>Gonyaulax sp</i>	0	31	24	0	0	0	0	0	10	65	0.28	0	0	0	0.00
<i>Gonyaulax hurida</i>	46	7	10	11	0	24	17	89	82	286	1.21	35	21	56	0.99
<i>Pyrocystis sp.</i>	28	23	27	12	20	20	25	25	25	205	0.87	0	76	76	1.34
Sub-Total	116	146	169	177	85	98	110	142	126	1169	4.96	35	238	273	4.82
Euglenophyta															
<i>Euglena acus</i>	21	14	45	0	15	28	0	0	72	195	0.83	34	40	74	1.31
<i>Euglena caudata</i>	0	45	39	0	64	4	21	10	27	210	0.89	9	32	41	0.72
<i>Euglena obtusa</i>	19	9	28	31	35	18	0	21	11	172	0.73	0	17	17	0.30

APPENDIX 9b: Phytoplankton population in the study area during the wet season															
	SAMPLE POINTS									Total	%Total	CONTROL		Total	%Total
	S1	SW2	SW 3	SW 4	SW5	SW 6	SW7	SW 8	SW9			1	2		
<i>Euglena tripteris</i>	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0.00
<i>Phacus caudatus</i>	27	28	19	0	19	0	15	91	28	227	0.96	0	105	105	1.85
<i>Trachelomonas sp</i>	35	38	12	40	15	0	0	0	34	174	0.74	28	0	28	0.49
Sub-Total	102	134	143	71	148	50	36	122	172	978	4.15	71	194	265	4.68
Total No. of cells 1000/l	2182	2440	2959	2924	2358	2550	2701	2682	2790	23586		2444	3224	5668	
No. of Species of Phytoplankton	74	89	86	78	80	80	79	78	80			76	89		
	73	88	85	77	79	79	78	77	79			75	88		
Margalefs index	9.49	11.28	10.63	9.65	10.12	10.079	9.87	9.75	9.96			9.61	10.89		
Menhinniks index	1.58	1.80	1.58	1.44	1.65	1.58	1.52	1.51	1.51			1.54	1.577		

APPENDIX 10a: Zooplankton population during the dry season																
	Sample Points										Total	%Tot	Control		Total	%Tot
	S1	SW	SW3	SW	SW	SW	SW	SW	SW	SW			1	2		
GENIUS / SPECIES																
Rotifers																
<i>Ceptialodella</i>	5	0	9	0	7	2	12	19	12	66	5.03	4	22	26	7.26	

<i>Trichocerca</i>	28	0	0	0	25	30	28	0	0	111	8.46	10	0	10	2.79
<i>Brachionus fulcatus</i>	14	8	0	15	15	0	10	37	9	108	8.23	7	0	7	1.96
<i>Kellicotia</i>	0	5	0	1	9	15	9	0	12	51	3.89	0	1	1	0.28
<i>Keratella longispina</i>	1	4	2	2	4	7	1	0	3	24	1.83	0	10	10	2.79
<i>Keratella tropica</i>	11	15	17	0	0	15	18	22	17	115	8.77	18	22	40	11.17
<i>Lecane</i>	4	2	0	5	1	13	4	22	34	85	6.48	7	2	9	2.51
Sub-Total	63	34	28	23	61	82	82	100	87	560	42.68	46	57	103	28.77
Brachiopods															
<i>Diaphanosoma</i>	8	15	31	1	11	0	2	7	0	75	5.72	21	10	31	8.66
<i>Daphnia</i>	0	1	2	6	10	6	0	0	0	25	1.91	7	1	8	2.23
<i>Ceriodaphnia</i>	2	6	0	4	2	0	5	1	13	33	2.52	11	15	26	7.26
Sub-Total	10	22	33	11	23	6	7	8	13	133	10.14	39	26	65	18.16
Copepods															
<i>Acartia clausii</i>	15	8	0	2	17	16	28	4	17	107	8.16	34	9	43	12.01
<i>Paracalanus species</i>	9	25	14	0	15	4	15	15	0	97	7.39	0	14	14	3.91
<i>Centropages</i>	3	21	26	5	27	11	14	0	9	116	8.84	22	16	38	10.61
<i>Diaptomus</i>	12	5	0	1	2	0	0	0	0	20	1.52	6	3	9	2.51
<i>Thermodiaptomus</i>	17	0	15	11	15	17	0	0	15	90	6.86	1	0	1	0.28
<i>Tropodiaptomus</i>	9	0	4	0	1	18	2	0	11	45	3.43	17	17	34	9.50
<i>Arctodiaptomus</i>	10	0	0	14	10	31	0	21	11	97	7.39	9	21	30	8.38
Sub-Total	75	59	59	33	87	97	59	40	63	572	43.60	89	80	169	47.21
Insects/Insect Larvae	15	7	3	1	0	0	11	0	5	42	3.20	7	11	18	5.03
Fish/Fish eggs/Larvae	1	0	1	0	2	0	0	1	0	5	0.38	2	1	3	0.84
Total No. of zooplankton (100/l)	16	122	124	68	173	185	159	149	168	1312		18	17	358	
No. of Species of zooplankton	17	13	11	13	17	13	14	10	13			16	16		
	16	12	10	12	16	12	13	9	12			15	15		
Margalefs index	3.1	2.49	2.07	2.84	3.11	2.29	2.56	1.79	2.34	0	#NU	2.8	2.9		
Menhinniks index	1.2	1.09	0.898	1.45	1.22	0.88	1.03	0.73	0.93	0	#DIV	1.1	1.1		

APPENDIX 10b: Zooplankton population during the wet season															
	Sample Points										Control				
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	Total	%Total	1	2	Total	
GENIUS / SPECIES															
Rotifers															
<i>Ceptialodella</i>	2	2	10	14	7	43	17	15	20	130	6.65	17	0	17	3.917050691
<i>Trichocerca</i>	13	0	4	15	0	12	25	11	28	108	5.52	35	15	50	11.52073733
<i>Brachionus fulcatus</i>	0	4	5	10	0	88	0	7	28	142	7.26	5	14	19	4.377880184
<i>Kellicotia</i>	2	17	16	28	4	17	10	0	0	94	4.81	2	4	6	1.382488479
<i>Keratella longispina</i>	7	50	28	26	5	9	21	0	2	148	7.57	14	7	21	4.838709677
<i>Keratella tropica</i>	0	20	0	15	31	16	21	6	22	131	6.70	15	0	15	3.456221198
<i>Lecane</i>	4	0	2	18	7	7	27	0	10	75	3.83	0	15	15	3.456221198
Sub-Total	28	93	65	126	54	192	121	39	110	828	42.33	88	55	143	32.94930876
Brachiopods															
<i>Diaphanosoma</i>	1	6	32	0	8	0	43	17	15	122	6.24	15	21	36	8.294930876
<i>Daphnia</i>	0	0	15	0	14	35	12	25	11	112	5.73	28	15	43	9.907834101
<i>Ceriodaphnia</i>	15	0	10	15	28	15	0	0	0	83	4.24	0	4	4	0.921658986
Sub-Total	16	6	57	15	50	50	55	42	26	317	16.21	43	40	83	19.12442396
Copepods															
<i>Acartia clausii</i>	9	2	2	10	43	17	35	7	15	140	7.16	13	0	13	2.995391705
<i>Paracalanus species</i>	9	13	0	4	12	25	4	0	9	76	3.89	28	57	85	19.58525346

APPENDIX 10b: Zooplankton population during the wet season															
	Sample Points										Control				
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	Total	%Total	1	2	Total	%Total
<i>Centropages</i>	0	7	11	2	0	0	11	0	7	38	1.94	0	34	34	7.834101382
<i>Diaptomus</i>	0	3	11	4	5	2	16	19	4	64	3.27	14	0	14	3.225806452
<i>Thermodiaptomus</i>	5	4	0	2	7	27	7	2	9	63	3.22	5	28	33	7.603686636
<i>Tropodiaptomus</i>	14	10	31	0	21	11	21	10	0	118	6.03	0	0	0	0
<i>Arctodiaptomus</i>	9	8	18	30	17	36	67	5	11	201	10.28	4	0	4	0.921658986
Sub-Total	46	47	73	52	105	118	161	43	55	700	35.79	64	119	183	42.16589862
Insects/Insect Larvae	4	57	4	19	4	0	4	1	0	93	4.75	0	0	0	0
Fish/Fish eggs/Larvae	0	1	4	2	7	1	1	2	0	18	0.92	18	7	25	5.760368664
Total No. of zooplankton (100/l)	184	350	398	407	429	721	679	251	382	3801		408	435	843	
No. of Species of zooplankton	13	15	16	16	16	16	17	13	14			14	12		
	12	14	15	15	15	15	16	12	13			13	11		
Margalefs index	2.30	2.39	2.51	2.49	2.47	2.28	2.45	2.17	2.18			2.16	1.81		
Menhinniks index	0.96	0.80	0.80	0.79	0.77	0.59	0.65	0.82	0.71			0.69	0.57		

APPENDIX 11a: Benthic invertebrates of the study area during the dry season

	Sample Points											Control				
	S1	SW2	SW3	SW 4	SW5	SW 6	SW7	SW8	SW9	Tota l	%Total	1	2	Total	%Total	
Annelids																
<i>Chaetogaster</i>	0	4	0	2	2	0	1	1	0	10	3.28	0	1	1	2.13	
<i>Lumbriculus</i>	1	6	6	1	3	4	9	0	0	30	9.84	2	0	2	4.26	
<i>Branchiura</i>	3	2	0	1	0	1	0	0	3	10	3.28	0	5	5	10.64	
<i>Tubifex</i>	0	4	1	4	1	3	2	0	0	15	4.92	0	3	3	6.38	
Sub-Total	4	16	7	8	6	8	12	1	3	65	21.31	2	9	11	23.40	
Decapods																
Mysis	1	8	4	5	6	0	20	3	0	47	15.41	1	0	1	2.13	
Desmoscaris sp (larvae)	0	7	30	0	2	1	1	0	0	41	13.44	0	0	0	0.00	
Macrobrachium sp (larvae)	0	0	2	0	3	7	6	1	5	24	7.87	1	0	1	2.13	
Sub-Total	1	15	36	5	11	8	27	4	5	112	36.72	2	0	2	4.26	
Ephemeroptera																
<i>Baetidae</i>	2	0	1	1	5	10	0	0	4	23	7.54	2	1	3	6.38	
<i>Oliguneridae</i>	1	0	2	0	0	1	2	1	0	7	2.30	0	0	0	0.00	
Sub-Total	3	0	3	1	5	11	2	1	4	30	9.84	2	1	3	6.38	
Hemiptera																
<i>Naucoridae</i>	0	0	0	1	1	0	8	0	0	10	3.28	1	0	1	2.13	
<i>Belostomatidae</i>	0	0	1	0	0	2	20	0	0	23	7.54	2	3	5	10.64	
Sub-Total	0	0	1	1	1	2	28	0	0	33	10.82	3	3	6	12.77	
Coleoptera																
<i>Dysticidae</i>	0	0	0	0	0	0	0	1	0	1	0.33	2	1	3	6.38	
<i>Gyrinidae</i>	2	2	0	1	2	0	2	0	2	11	3.61	2	0	2	4.26	
Sub-Total	2	2	0	1	2	0	2	1	2	12	3.93	4	1	5	10.64	
Odonata																
<i>Lubellulidae</i>	0	1	1	2	0	3	0	4	0	11	3.61	0	0	0	0.00	

<i>Gomphidae</i>	1	0	0	0	0	0	2	1	0	4	1.31	2	0	2	4.26
<i>Macromidae</i>	7	6	1	6	0	2	1	0	1	24	7.87	6	3	9	19.15
Sub-Total	8	7	2	8	0	5	3	5	1	39	12.79	8	3	11	23.40
Diptera															
Chironomid larvae	1	1	4	2	4	1	0		1	14	4.59	3	6	9	19.15
Total counts/ml/stn	19	41	53	26	29	35	74	12	16	305		24	23	47	
No. of Species of Benthos	7	10	11	11	10	11	12	7	6			11	8		
	6	9	10	10	9	10	11	6	5			10	7		
Margalefs index	2.04	2.42	2.52	3.07	2.67	2.81	2.56	2.41	1.80	0	#NUM!	3.15	2.23		
Menhinniks index	1.61	1.56	1.51	2.16	1.86	1.86	1.39	2.02	1.51	0	#DIV/0!	2.25	1.67		

APPENDIX 11b: Benthic invertebrates of the study area during the wet season

	Sample Points										Control		Tot	%To	
	S1	SW	SW	SW	S	SW	S	S	S	Tot	%To	1			2
Annelids															
<i>Chaetogaster</i>	0	6	0	4	5	0	2	0	0	17	5.11	3	1	4	3.67
<i>Lumbriculus</i>	0	0	1	12	12	19	4	1	0	49	14.71	3	2	5	4.59
<i>Branchiura</i>	2	10	9	7	19	0	10	0	1	58	17.42	6	17	23	21.10
<i>Tubifex</i>	0	0	2	0	5	13	2	0	1	23	6.91	7	8	15	13.76
Sub-Total	2	16	12	23	41	32	18	1	2	147	44.14	19	28	47	43.12
Decapods															
Mysis	0	0	3	2	3	2	0	1	0	11	3.30	2	1	3	2.75
Desmoscaris sp	2	1	1	4	0	1	5	0	1	15	4.50	3	5	8	7.34
Macrobrachium sp	0	0	3	1	0	0	0	0	1	5	1.50	3	3	6	5.50
Sub-Total	2	1	7	7	3	3	5	1	2	31	9.31	8	9	17	15.60
Ephemeroptera															
<i>Baetidae</i>	0	2	0	1	3	1	0	0	0	7	2.10	2	1	3	2.75
<i>Oliguneriidae</i>	0	0	0	4	10	0	0	1	1	16	4.80	2	1	3	2.75
Sub-Total	0	2	0	5	13	1	0	1	1	23	6.91	4	2	6	5.50
Hemiptera															
<i>Naucoridae</i>	0	0	0	0	2	0	0	0	9	11	3.30	1	1	2	1.83
<i>Belostomatidae</i>	0	1	0	0	0	0	0	1	6	8	2.40	1	0	1	0.92
Sub-Total	0	1	0	0	2	0	0	1	15	19	5.71	2	1	3	2.75
Coleoptera															
<i>Dysticidae</i>	2	1	2	0	0	2	16	0	2	25	7.51	1	1	2	1.83
<i>Gyrinidae</i>	0	2	0	0	0	1	1	2	0	6	1.80	2	5	7	6.42
Sub-Total	2	3	2	0	0	3	17	2	2	31	9.31	3	6	9	8.26
Odonata															
<i>Lubellulidae</i>	2	1	0	0	0	14	6	1	0	24	7.21	5	3	8	7.34
<i>Gomphidae</i>	1	0	3	3	0	4	1	5	2	19	5.71	3	2	5	4.59
<i>Macromidae</i>	3	1	2	8	0	2	4	0	1	21	6.31	3	3	6	5.50
Sub-Total	6	2	5	11	0	20	11	6	3	64	19.22	11	8	19	17.43
Diptera															
Chironomid larvae	0	1	0	0	0	4	3	8	2	18	5.41	3	5	8	7.34
Total	24	51	52	92	11	122	10	32	52	648		97	11	210	
No. of Species of	6	10	9	10	8	11	10	8	12			17	16		
Margalefs index	1.	2.2	2.0	1.9	1.4	2.0	1.9	2.0	2.7			3.	3.		
Menhinniks index	1.	1.4	1.2	1.0	0.7	0.9	0.9	1.4	1.6			1.	1.		

Appendix 12

Social Investments in the Gbaran node (Gbaran Integrated Oil and Gas Project

SN	LOCATION	PROJECT
GBARAIN/EKPETIAMA CLUSTER		
	OBUNAGHA	OBUNAGHA HEALTH POST CONSTRUCTION
	AGBIA	100M CONCRETE PAVEMENT TO CORPERS' LODGE
	AYAMA	AUDITORIUM
	OKOTIAMA	CONSTRUCTION OF AUDITORIUM
	OBUNAGHA	ULTRA MODERN AUDITORIUM
	AGBIA	3 ROOM & PARLOUR APARTMENTS
	OBUNAGHA	SUPPLY OF HEALTH POST EQUIPMENT, FURNITURE AND DRUGS
	AYAMA	TOWN HALL VERANDA
	OBUNAGHA	CONSTRUCTION OF OBUNAGHA INTERNAL ROAD (550M)
	OBUNAGHA	CONSTRUCTION OF OBUNAGHA INTERNAL ROAD (500M)
	OKOLOBIRI	CONSTRUCTION OF OKOLOBIRI INTERNAL ROAD (500M)
	OBUNAGHA	PROCUREMENT OF 2 32-SEATER BUSES
	OBUNAGHA	PROCUREMENT OF GENERATOR FOR OBUNAGHA
	OBUNAGHA	SUPPLY OF DIESEL FOR OBUNAGHA COMMUNITY
	OBUNAGHA	OBUNAGHA GENERATOR HOUSE/33,000 LITRE DIESEL TANK
	Obunagha	Health Post Construction
		Health Post Equipping
OKORDIA/ZARAMA CLUSTER		

SN	LOCATION	PROJECT
	ZARAMA-EPIE	131M CONCRETE PAVEMENT (CP1)
	ZARAMA-EPIE	COMMUNITY AUDITORIUM INTERLOCKING
	ZARAMA-EPIE	COMMUNITY AUDITORIUM FENCE & GATEHOUSE
	NEW JERUSALEM	CONSTRUCTION OF NEW JERUSALEM AUDITORIUM
	ZARAMA-EPIE	75M CONCRETE PAVEMENT (CP2)
	ZARAMA-EPIE	131M CONCRETE PAVEMENT (CP3)
	New Jerusalem	Six-classroom block construction
	New Jerusalem	Six-classroom block furnishing
	Community - extension fund	Description (extension)
	Zarama-Epie	Support to HRH

Appendix 13
Social Impact Assessment Questionnaire
INTERVIEW/ FOCUSED GROUP DISCUSSION SCHEDULE

<p>COMMUNITY HISTORY What is the settlement history of this community?</p>
<p>TRADITIONAL GOVERNANCE AND SOCIAL ORGANISATION How is this community governed traditionally? What is the hierarchy of traditional leadership in this community? What is the process of ascension to traditional governance position in this community? Are there sacred grounds and taboos (culturally significant sites in the community)? What are the names and where are these located in the community? What is the nature of family organization in this community?</p>
<p>ECONOMIC LIVELIHOOD SOURCES/INCOME What is the major occupation(s) in this community? What are the other sources of income apart from the major occupations? What is the level of income that is derived from these sources? What is the highest and lowest income level in the community? Has there been a change (if yes state why)</p>
<p>SOCIAL INFRASTRUCTURE What are the existing social infrastructure such as schools, roads hospital in this community? Are you satisfied with the current state of infrastructure in the community? If you are not satisfied give reasons</p>
<p>POPULATION AND SOCIO- DEMOGRAPHIC INFORMATION What do you think is the total population in this area? What is the ratio of male to female? How many of the school age children are in public schools Do you have more school age children in public school than in Private school.</p>
<p>LAND TENURE/LAND USE How is land owned in this community? Is it by the community, individuals or families? Are men and women equally entitled to land and land resources?</p>
<p>LIFE STYLE What do you consider as the traditional lifestyles in this community? Have there been changes? Explain why</p>
<p>SECURITY/PUBLIC SAFETY What is the state of security and public safety in this community? Are there emergent threats to security and public safety in this community?</p>
<p>COMMUNITY EXPECTATIONS AND CONCERNS ABOUT PROPOSED PROJECT What is/are your expectations from the proposed SPDC project? Inventory of Community Expectations and concerns</p>

STANDARD TEMPLATE FOR IA / EES BASELINE REPORTING

COMPREHENSIVE LISTING OF ALL STAKEHOLDER COMMUNITIES INDICATING:

State(s)

Local Government Area(s)

language group(s)

SETTLEMENT HISTORY)

History can be obtained from oral sources complimented with written records on all stakeholder communities being studied. (Note that the History of one community cannot be generalised for all communities. Each community has its peculiar history. Reflect and give specific and comprehensive history of each community).

Traditional Governance System and Social Organisations

Traditional Marriage Arrangements,

Family and inheritance

RELIGION, CUSTOMS, BELIEF SYSTEMS AND CULTURAL HERITAGE

Culture and tradition (Dominant cultural practices)

Religion and worship

Cultural Heritage, Shrines and taboos (actual location of cultural artefacts, shrines and sacred grounds in each community)

Community	Name of Shrine/Cultural Heritage	Symbolism of Cultural Heritage	Location of Shrine	Distance to proposed project

Cultural mores and Sanctions

Calendar of cultural calendar

POLITICAL STRUCTURE AND GOVERNANCE

Community power structure and Traditional Governance for each community (Provide the diagram of the hierarchy of traditional authority).

Hierarchy of Influence/Line of Authority

Reflect on Succession issues

Reflect the prevailing situation with regard to the emergence of new power brokers such as youths; women and elites in the communities

Reflect the prevailing relationship between the traditional leadership and modern governance institutions i.e. Federal, States and Local government administrations)

Conflict and Conflict resolution mechanism in community

Conflicts Profile and Conflict Resolution Status in Host Communities

LAND OWNERSHIP AND LAND USE

Total Land area of the community

Land ownership/access and Tenure system

Land Acquisition Methods In Communities

Available Land use pattern/Nature of pressure on land resources in stakeholder communities (provide picture)

Common Uses of natural resources (Communal Forest or Swamp Resources) (provide pictures)

POPULATION AND SOCIO- DEMOGRAPHIC INFORMATION

Baseline population of each stakeholder community from the 1991 population Census and projected to at least 30years from project commencement.

Population of Project Communities

Community	1991						
	M	F	Total				

Population Size, Growth and Distribution (Use Bar/Pie Charts)

Marital Status (Compliment Qualitative information with Bar/Pie Charts)

Household Size (Compliment Qualitative information with Bar/Pie Charts)

Household Structure (Age and Gender distribution) (Compliment Qualitative information with Bar/Pie Charts)

Age and Age-Sex Structure (Compliment Qualitative information with Bar/Pie Charts)

Educational Attainment in Communities (Compliment Qualitative information with Bar/Pie Charts)

Dependency ratio (Compliment Qualitative information with Bar/Pie Charts)

LIVELIHOOD AND MICRO ECONOMY

Major economic activities (Compliment Qualitative information with Bar/Pie Charts)

Employment Status (Compliment Qualitative information with Bar/Pie Charts)

Income levels

Occupation, Employment and Income Generating Activities (Compliment Qualitative information with Bar/Pie Charts, /Pictures)

Distribution of Inhabitants by Occupational Engagements (Compliment Qualitative information with Bar/Pie Charts/Pictures)

Number of Years of Experience in Primary Occupation of inhabitants

Constraints in major Production activities in the project communities

Income Levels and Distribution (Provide Table of income ranges)

Household Monthly Income levels and Distribution (Compliment Qualitative information with Bar/Pie Charts)

Unemployment Distribution in the Communities (Compliment Qualitative information with Bar/Pie Charts)

Household Consumption and Expenditure Patterns (Compliment Qualitative information with Bar/Pie Charts)

Annual savings Patterns by Communities (Compliment Qualitative information with Bar/Pie Charts)

Perception of Respondents on trend of Primary Occupation (Compliment Qualitative information with Bar/Pie Charts)

INFRASTRUCTURAL FACILITIES AND QUALITY OF LIFE

Road Infrastructure (Provide pictures)

Housing and recreational facilities (provide pictures)

Educational Facilities (Provide pictures)

Electricity supply and Household Energy (provide pictures)

Water supply Facilities Provide (Provide pictures)

Transport and Communication

Recreational Facilities and Security

Table: Summary of Infrastructure Available in Host Communities

Community	Electricity	School	Road	School	Health care facilities	Water	

HOUSING AND HOUSE TYPES

Housing Type/Quality and Conditions (Provide pictures of house types)

Respondents' House Ownership Status (Compliment Qualitative information with pie chart/)

Possession of Household Properties

10. PERCEPTIONS, NEEDS, INTERESTS, CONCERNS AND EXPECTATIONS FROM PROPOSED PROJECT

Social Problems in the Communities

Table: Expectations and Priority Needs of Communities

Communities	Expected benefits/Impacts and Expectations

Perceptions, Concerns and Expectations (provide pictures)

Social Problems in the Communities (Provide picture evidence)

Community Concerns/suggestion to mitigate and enhance socioeconomic impacts

Concerns and Priority Interest of Communities

Communities	Expected benefits/Impacts and Expectations

Appendix 14
Health Impact Assessment Questionnaire

This questionnaire should be used to collect data during walkthrough surveys in the concerned community or interviews with key informants such as Community Leaders, Health Personnel, Community Liaison Officers, etc.

All questions contained in this questionnaire are optional and will be kept strictly confidential.

Name of project <small>(i.e. NAG, Pipelines, CPF etc)</small>	Name of project:
Name of Community	How long has this project been in this community?

1. Health facilities inventory (describe the type of facilities found in the community)

Describe the type of facilities found in the Community	Health Post (s) <input type="checkbox"/>	How many?
	Primary Health Centre (s) <input type="checkbox"/>	How many?
	Hospital (s) <input type="checkbox"/>	How many?
	Patient Medicine Store (s) <input type="checkbox"/>	How many?
	Traditional Birth Attendants <input type="checkbox"/>	How many?

2. quality of healthcare facilities/health seeking behaviours of community members

What type of care is available at this facility?	Immunization <input type="checkbox"/> Treatment of minor ailments <input type="checkbox"/> Surgery <input type="checkbox"/> Other <input type="checkbox"/> Please specify
How easily do you access the health care generally?	Easily accessible <input type="checkbox"/> Not easily accessible <input type="checkbox"/>

Where do you or your family members go to when you are ill <i>(Tick more than one if applicable)</i>	Health Centre/Hospital <input type="checkbox"/>
	Patent Medicine Dealer <input type="checkbox"/>
	Traditional Medicine Practitioner <input type="checkbox"/>
	Church <input type="checkbox"/>
	Others <input type="checkbox"/> Please specify

Are you satisfied with the services you receive at this facility above?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
Are there any changes you would like to see in the facility?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If Yes to questions... above, please suggest areas of improvement			

3. public perception of health impacts of the project on the community

Environmental Impact Assessment of Uzu Field Development Project

Is the presence of the project beneficial to members of the community?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If Yes, please list the ways in which it is beneficial			
If No, list how the company's presence has adversely affected the community			

Is there any history of past pollution of air/water /soil in the community prior to the project?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If yes, please state the type of pollution			

Do you have any health concerns related to the project impact on members of your community?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If yes, please state your specific concerns			

Which of these practices in the community has the project affected negatively? <i>Hunting</i> <input type="checkbox"/> <i>Farming</i> <input type="checkbox"/> <i>Fishing</i> <input type="checkbox"/> <i>Others</i> please specify
Which of these practices in the community has the project affected positively? <i>Hunting</i> <input type="checkbox"/> <i>Farming</i> <input type="checkbox"/> <i>Fishing</i> <input type="checkbox"/> <i>Others</i> please specify
Since this project commenced, have you noticed any of the following? <i>New water bodies</i> <input type="checkbox"/> <i>Changes in flow of existing water bodies</i> <input type="checkbox"/> <i>Drums with stagnant water around/near houses</i> <input type="checkbox"/>
Which of the following vector-related diseases are present in your community? Malaria <input type="checkbox"/> Sleeping sickness <input type="checkbox"/> Onchocerciasis <input type="checkbox"/> Schistosomiasis <input type="checkbox"/>
What are the other common diseases in this community? Please list
If there are any members of the community that have it, how do you think they got it? Please specify

Has the price of housing/accommodation increased because of the presence of Shell facilities?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
Are there any squatter settlements that arose on account of the presence of the Shell facility?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
Are there more people residing in your community because of the presence of Shell facility?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>

Do you know any members of the community who have died from any of the diseases listed above?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If yes to question above, please describe the nature of the disability	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
If yes to question above, how many? Please specify			

Do you have any member of your household that has any of the following diseases?	Yes	No	Don't Know
<i>Tuberculosis</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Cancer</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Asthma</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Heart Trouble</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Intestinal diseases</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Paralysis</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Rashes/Scabies</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Diarrhea</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>STIs</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Skin diseases</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Hearing problems or diseases</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>Others, Please specify</i>			

5. HEALTH & lifestyle habits

Lifestyle Habits	Do many people smoke in this community?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
	Are there any problems in the community caused by taking too much alcohol?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>
	Do people use other substances e.g. marijuana (“igbo”) in the community?	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Don't Know <input type="checkbox"/>

APPENDIX 15 UZU EIA EENGAGEMENTS ATTENDANCE

EIA SCOPING WORKSHOP FOR UZU FIELD DEVELOPMENT PROJECT

PAYMENT ACKNOWLEDGMENT (A6,000.00)

SN	NAME	Community	SIGN
✓1	POLZI F. DIMPE	OKOLOBIRI	
✓2	Rev. Jude Okporine	"	
✓3	H.R.H. SABU. M. KALORU	KOROBAMA	
✓4	HRH KOKO. E. G. FORGE	OKOTIAMA	
✓5	HRH Kingsley DURBA	NEDUGO	
✓6	HRH JESSEY T. AZI	ILIMBO-AMIA	
✓7	DEPUTY YASUO NICOLEMUS	OKOLOBIRI	
✓8	H.H. Chifietie J. Elijah	Obunagha	
✓9	HAITCHE OGBOGIDI ALPHANUS	AGBIA	
✓10	HRH EZE WILCOX	NYAMBIRI	
✓11	OCIDI ANUME	NYAMBIRI-ZARAMA	
✓12	OLOTA VIOLET	NYAMBIRI-ZARAMA	
✓13	OSOPUGU BENJAMIN	NYAMBIRI-ZARAMA	
✓14	EBIOWE - P. SOGWIE	IGBOENE	
✓15	SAITOU WHITE W.	KOROBAMA	
✓16	DURBA TIMINIPRE	NEDUGO	
✓17	Awara A. Odonkumo	NEDUGO	
✓18	Ifemi unuou	OBUNAGHA	
✓19	Julius V. Bomby	OKOTIAMA	
✓20	Inebanaton Josiah	OGBOLOMA	
✓21	Lucky B. Warikore	OGBOLOMA	
✓22	AKANZA DAVID	AGBIA	
✓23	KING NIONIO READY	ZARAMA CLAN	
✓24	TYKO EUPHIMU	OKUTANG	
✓25	Aziaye Tosanu	Obunagha	
✓26	Ogbogidi Roseline	Agbia	

SN	NAME	Community	Sign
37	FRANK REGINA	OKOLOBIRI	
38	DISIN LOVINA	NEJUGO	
29	WARPAMERE	Okpana	
30	WARIOWEI, Imomolimi	KORO ANIA	
31	DAUBISERE OTAWORO	KUMBOTAMA	
32	ISISINDA, Wilson	EPIE-ZARAMA	
33	Chf. Mubano Jandun ESP	Epie-Zarama	
34	EZEKIEL, BOKIZIBE (MRS)	IGBOGENE + PIE	
35	U. N. AGORO	IGBOGENE - EPIE	
36	Ebowei sorgwa . T		
37	OSUKLEVIA EDITH	EPIE-ZARAMA	
38	ADIKADIE GODWILL		
39	Owoide Pious	Ogboloma	
40	Adia Perkosufa	Kumbo-ama	
41	Dennis Panebi	Kumbo-ama	
42	Obonah - I. Timi	Okordia / Zarama	
43	Kemebigba Gesuwa	Agbaja	
44	ASINUBI, NBUIMI	Obongha	
45	Comr Martins Ebije	Korosomaa	
46	WOZI EBILA	OGOLO LOMA	