ENVIRONMENTAL IMPACT ASSESSMENT

OF

THE PROPOSED UTAPATE FIELD DEVELOPMENT PROJECT

(DRAFT REPORT)

SUBMITTED TO FEDERAL MINISTRY OF ENVIRONMENT
ABUJA

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LIST OF ABBREVIATIONS AND ACRONYMS

°C	Degree Celsius
µg	Microgram
AAS	Atomic Absorption Spectrophotometer
ALARP	As Low as Reasonably Practicable
APHA	American Public Health Association
API	American Petroleum Institute
BCG	Bacillus Calmette Guerin
BDL	Below Detectable Limit
BH	Borehole
BOD	Biochemical Oxygen Demand
BOGT	Bonny Oil and Gas Terminal
Ca	Calcium
CAPEX	Capital Expenditure
Cd	Cadmium
CDC	Community Development Committee
CDP	Community Development Project
Cfu/g	Colony Forming Units Per grams
Cfu/ml	Colony Forming Units Per Mile
CH_4	Methane
Cl	Chlorine
Co	Cobalt
COD	Chemical Oxygen Demand
CPF	Central Processing Facilities
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPF	Early Production Facility
FDP	Field Development Project
Fe	Iron
FEPA	Federal Environmental Protection Agency

FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
FPTP	Fixed Platform Transshipment Point
G-MoU	Global Memorandum of Understanding
GPS	Global Positioning System
HIA	Health Impact Assessment
HIV	Human Immunodeficiency Virus
HPWBM	High Performance Water Based Muds
KOP	kick-off points
LGA	Local Government Area
MASP	Maximum allowable surface pressure
Mg	Milligrams
mg/kg	Milligrams per Kilograms
MMscf/d	Million Standard Cubic Feet Per Day
N	Nitrogen
Na	Sodium
NAG	Non Associated Gas
NAPIMS	National Petroleum Investment Management Services
ND	Not Detected
NGO	Non-Governmental Organization
Ni	Nickle
NO_2	Nitrogen IV Oxide
NPC	National Population Commission
NPDC	Nigeria Petroleum Development Company
NOx	Oxide of Nitrogen
OML	Oil Mining Lease
Pb	lead
PO_4	Phosphate
PPm	Part per million
psi	Pounds per square inch
QA	Quality Assurance
QC	Quality Control
RoW	Right of Way
SMP	Single Point Mooring
SOBM	Synthetic oil-base mud
Sp	Species
SPV	Special Vehicle Purpose contract
SPDC	The Shell Petroleum Development Company of Nigeria Limited
STIs	Sexually Transmissible Infections
SW	South West
TDS	Total Dissolved Solids
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
TSS	Total Suspended Solids
V	Vanadium
WBM	Water-base mud
WH	Well Head
WHO	World Health Organization
WQI	Water Quality Index
Zn	Zinc

EXECUTIVE SUMMARY

Introduction

ES 0.1 Background Information

Nigerian Petroleum Development Company (NPDC) is the sole operator of OML 13 in Akwa Ibom State, Nigeria. OML 13, hitherto operated by Shell Petroleum Development Company (SPDC). SPDC divested from the field in 2011 and the block was handed over by Department of Petroleum Resources (DPR) to NPDC in February 2017 in a bid to drive and actualize Government's projections of increasing crude oil and gas output.

To have baseline information on the state of the Utapate Field that is planned for re -entry, NPDC conducted an Environmental Impact Assessment (EIA) study of the OML 13 proposed Utapate Field EPF, New Flow station, a short-term Fixed Platform Transhipment Point (FPTP), drilling sites (Locations 1A, 1B; 2A,2B; 3A, 3B & Alt-1; UTA-A,B,C,D, UTA-9, UTA-13), tank farm and FLB etc.), pipelines from wells to common manifold, pipelines from common manifold to EPF/MFS; pipeline from EPF/MFS to Tank Farm . OML 13 is situated in the south east onshore of the prolific Niger Delta hydrocarbon belt in Akwa Ibom state. This field which transverses dry land in the north to mangrove swamps, beaches and shallow marine (Atlantic Ocean) to the south, covers a total area of 1,987km2

This report presents the environmental baseline description and impact assessment of Utapate Field. The baseline was produced using a two-season field data gathering. Fieldwork was conducted between Thursday 19th to 2nd October 2019 for the wet season and January 26th to 31st, 2020 for the dry season.

ES 0.2: Study Objectives

The main objective of this EIA is to predict possible changes on the ecosystem that may result from the proposed project. The general objectives of the study include the following:

- Determine the status of baseline and ambient conditions of the environment (biophysical, socio-economic and health).
- Determine and evaluate the additional "pollution load" and potential impacts of the new proposed project activities on the biophysical, social and health environment of the area.
- Identify and evaluate the potential socio-economic effects of the project on communities including impacts on cultural properties, social infrastructures, natural resources and lifestyles / values.
- Develop an appropriate and cost-effective mitigation measures and Environmental Management Plan (EMP) for sustainable development.

ES 0.3 Administrative and Legal Framework

In Nigeria, it is a regulatory requirement that the proponent of a major project submit an EIA study report for approval before project execution. This section presents a review of some of the relevant statutory requirements for the proposed project. The information contained in this section is derived from The Federal Ministry of Environment, Housing and Urban Development, the Government of Nigeria Laws and regulations, Akwa Ibom State Ministry of Environment edicts, International conventions and agreements to which Nigeria is a signatory and NPDC's HSE policies:

- ✓ Environmental Impact Assessment Act No. 86, 1992
- ✓ EIA Sectorial Guidelines (Oil & Gas Industry Projects)
- ✓ National Guidelines on Environmental Management Systems in Nigeria, 1999
- ✓ Department of Petroleum resources (DPR) EGASPIN, 1991 as Revised in 2002
- ✓ Federal Environment Protection Agency (FEPA) Act No. 58, 1988;
- ✓ Federal Environmental Protection Agency Decree 59 of 1992 sections, EIA Decree 86 of 1992.
- ✓ FMENV National Environmental Protection Regulations 1991 - S.1.8, S.1.9 and S.1.15 for Industrial Effluent, Gaseous Emissions, Pollution Abatement, Solid and Hazardous Waste Management in Nigeria.
- ✓ The Mineral Oil (safety) regulations; The Harmful Waste (Criminal Provisions) Act No 42 of 1988;
- ✓ Petroleum Act of 1969 (Cap 350, LFN, 1991)
- ✓ Akwa-Ibom Environmental Protection and Waste Management Agency Law No.8 of 2000
- ✓ International Regulations and Conventions Relating to Environmental Protection in Nigeria
- ✓ World Bank Guidelines on Environmental Assessment (EA) (1991)

ES 0.4 Scope of this Study

The proposed project shall be executed in conformity with NPDC's policy on the preservation of the environment. In order to fully protect the environment during the project execution, an Environmental Impact Assessment (EIA) was commissioned.

The general scope of the EIA covered all the activities that constitute the project. It outlined the techniques and methodologies used in data generation and gathering, including the description of the data sources and impact identification, prediction, evaluation and management. The following categories were covered:

- Baseline Data Acquisition
    - ✓Literature Review
    - ✓Field Work
    - ✓Laboratory Analysis
    - ✓Data Analysis and interpretation
- Consultation/Stakeholder Engagement
- Evaluation and Prediction of Potential Impacts
- Determination of Appropriate Mitigation Measures
- Development of an Environmental Management Plan
- Report Preparation

ES 0.5 Need for the Project

Nigeria is rich in mineral resources, of which the most exploited at present is crude oil. The country is among the world's largest exporter of crude petroleum. The Nigerian economy is largely dependent on its oil sector, which accounts for more than 80% of government revenue, over 95% of total exports, and over 90% of the country's foreign exchange earnings.

Nigeria's proven oil reserves are estimated at 37 billion barrels, which are found mainly in relatively simple geological structures along the country's coastal Niger Delta basin ("Niger Delta"), thus making the area one of the world's richest oil and gas provinces.

The Nigerian government is desirous to increase oil production capacity to 4 million barrels per day (640×10^3 m^3/day) in the next few years.
The operator's intention to embark on early field production will verify available data and hence achieve optimal exploitation of the proven discoveries and production potentials of the Field. Ultimately, this will add to Nigeria's proven reserves as well as daily production in the coming years.
The implementation of Utapate FDP will contribute other numerous benefits including those listed below will accrue to Nigeria because of the project:

- Employment opportunities
- Transfer of Technical know-how and capacity building
- Contribution to macro-economic progress of Akwa Ibom State and Nigeria

ES 0.6 Envisaged sustainability

The envisaged sustainability of the Utapate field oil reserve is categorized as follows:

Economic Sustainability

The OML 13 Field development project is economically sustainable due to the adequate oil and gas reserves in the block and the favourable gas policy implementation in Nigeria further drives the economic sustainability of this project. Also under the proposed development strategy, the project is expected to deliver a 57.1% in equity returns and achieve accounting payback by 2023 (economic payback at 15% discount is achieved in 2025). The project will therefore contribute substantially to the revenue accruable to the Federal Government of Nigeria, NPDC, its financial partners and the host communities

Technical sustainability

The Utapate field development project is technically sustainable because, innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project

Environmental sustainability

For all its activities, it is NPDC's policy to carry out environmental assessments with the view to identifying all significant impacts of the project and putting measures in place to limit the nature and extent of any negative impacts to as low as reasonably practicable.
This proposed field development is envisaged to be environmentally sustainable as it is expected to be implemented in accordance with this policy and in particular with the recommendations of this EIA. The incorporation of the findings and recommendations of this EIA at the various stages of the project development and strict adherence to the environmental management plan (EMP) will ensure environmental sustainability.

ES 0.7 Project Alternatives

The operator is a well-experienced and efficient oil and gas operator and as such restricts its designs to optimal practicable designs. In this regard, two concepts have been identified for the proposed field development project:

Option 1: Implement proposed Utapate field development project and undertake evacuation of stabilized crude via single point mooring system.

Option 2: Implement proposed Utapate field development project and evacuate stabilized crude oil via land pipeline.
The above scenarios only differ in terms of crude oil evacuation route as both options have the same design concepts and entails similar project activities.

ES 0.8 Project Overview

Historically, the previous operator (SPDC) modified the development and operations of Utapate field from land to marine-based. This was likely done to improve field access at a time when road access was restricted. NPDC's objectives and development philosophy includes conversion from marine to land operations; cluster drilling to reduce footprint; and an accelerated development that achieves first oil in Q3 2020.

From facilities perspective, Utapate field development has been split into two distinct phases, which both comply with the zero-flare policy set out by the operator:

Utapate field development Phase-1

Phase-1 is a short-term plan which comprises leasing of Early Production Facility ("EPF") of 2 x 30 M bpd capacity. The produced fluid will be stabilized, stored and pumped to an offshore platfarm, via above ground and sub-sea pipeline, from where the crude is evacuated through vessels to the FSO. Gas will be separated and compressed for use through 8 inch flowlines into injection well(s) and the remaining used as fuel gas. The EPF's will be manned for operations that consist of hydrocarbon separation, gas compression and injection, crude pumping, water treatment and disposal and metering. Phase-I development is expected to cover, approximately, the first two (2) years of the field development, during which the following activities are anticipated to be completed and brought on stream: re-entry of six (6) existing wells (i.e. UTAS-1,3,4; UTAS-5; UTAS-6;and UTAS-11); drilling of 10 oil development wells, 2 gas injection wells and 2 water disposal wells. The gas injection would require compression for the associated gas.

Utapate field development Phase-2

Phase-2 development is planned for an integrated field development concept for the overall OML 13 block. It involves construction of a new main flow station(MFS) with capacity of 2x50 Mbpd and central processing facilities (CPF) as an onshore operational facility with a nominal crude storage capacities of 2 million barrels storage tanks with pumps, metered and exported crude via single point mooring(SPM) offloading into VLCC tanker located in Imo River Estuary. Operational metering on the tanker export line from onshore terminal will be provided. The facilities will be designed to handle up to 200 MMscfd (AG+NAG) raw gas to be monetized through a Special Vehicle Purpose contract (SPV) and water injection system design for up to 100,000 stb/d. Produced water is to be processed for re-injection and for buffer, routed to treated water tanks post processing, should injection system be offline.

Total of 46 new wells have been proposed for full redevelopment of Utapate field. These comprise 20 oil producers, 6 re-entry/sidetrack, 2 gas injector, 11 water injectors, 2 water disposal, and 5 NAG producers. The drilling activities are planned to span from Q3 -2019 to Q2-2022.The OML 13 Utapate facilities, flowline and wells will be decommissioned at the end of economic life as proposed under the decommissioning strategy and will meet the requirements of the applicable regulations.

ES 0.9 Project Location

The Utapate field is located within OML 13 in Eastern Obolo Local Government Area of Akwa-Ibom State. This field transverses dry land in the north to mangrove swamps, beaches and shallow marine (Atlantic Ocean) to the south, covers a total area of 1,987km2.

ES 0.10 Abandonment Strategy

The OML 13 Utapate assets comprising of wells, surface facilities, flowlines, trunk lines etc., which have reached the end of their economic life, shall be abandoned in conformity with statutory requirements (DPR, Federal Ministry of Environment). Field site shall be restored to environmentally safe and clean condition prior to returning to their original owners/ communities.

The ultimate intent is to restore the host environment as close as possible to what existed before emplacement of the facilities. The process shall ensure that no residual risk to life and the environment is left behind after the abandonment. At the end of the fields' life the wells will be properly abandoned to eliminate any possibility migration from normally pressured zones (water or hydrocarbon) to depleted reservoirs or to the surface. Prior to abandonment, pipings and equipment shall be positively isolated from sources of hydrocarbon and cleared of their hydrocarbon inventories using environmentally friendly substances (water, nitrogen, non-toxic foam, etc.) for the flushing / purging. Effluents shall be received at locations where they can be safely managed and where they can do the least damage to the environment.

The operator plans to set up a decommissioning team to plan and implement decommissioning activities, which include but not limited to:

- Wells Decommissioning
- Facilities Decommissioning
- Demolition and site clean-up
- Disposal of wastes
- Rehabilitation of site

ES 0.11 Description of the Existing Environment

Climate and Meteorology

The study area is in south-south parts of Nigeria sharing the same climatic condition with Uyo, the Akwa Ibom State capital. Using the 30-year climatic data (1985 – 2014) of Uyo obtained from the Nigerian Meteorological Agency (NIMET, 2016), the proposed project location has climate characterized with both the dry and wet seasons associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. Its annual rainfall varies from 3200 to 5100 mm with monthly levels of 19.0 – 349.9 mm coming in every month of the year. The mean relative humidity of the study area ranges between 75 and 90% using the 30-year climatic data from NIMET with the mean monthly level indicating June through September as wettest and December through March as driest. The minimum air temperatures in the proposed project area are 22.2 – 24.0 °C with a mean of 23.1 °C while its maximum levels are 28.3 – 31.6 °C with an average of 31.6 °C. The highest air temperature occurs between January and March while the lowest is between June and August. The period of the highest air temperature falls in the dry season of the area and the lowest air temperature are observed to be in the wet season of the year. Surface wind speed in the area is characterized by small diurnal variation influenced by both land and sea breezes resulting from the alternate warming of the land and sea.

Air Quality Assessment

In this study, CH_4, SO2, VOC and H_2S were not detected (<0.01 ppm). Carbon monoxide concentrations were low, Mean CO concentration was 0.02±0.14 ppm and 0.074±0.255 ppm in wet and dry season respectively. In all the sampling locations, the daily CO concentrations were within the 10 ppm limit of both the Federal Ministry of Environment (FMEnv) and that of the Department of Petroleum Resources (DPR). The daily SO2 equivalents of the measured concentrations were within its 0.01 ppm FMEnv limit and within the 100 – 150 µg/m^3 (0.04 – 0.06 ppm) DPR limit. Similarly the daily NO2 in the study area were within its 75 – 113 µg/m^3 (0.04 – 0.06 ppm) FMEnv limit and its 150 µg/m^3 (0.08 ppm). Mean NOx concentration was below 0.001 ppm in the wet season but was 0.002±0.003 ppm in the dry season. NOx was mostly undetected in the control stations except in the wet season (AQN C1 – 0.005 ppm).

Particulates Pollutants

Suspended particulate matter (SPM) was detected in all the sampling locations during the study (Tables 4.2a and b). In the project site, the measured SPM concentrations mean in the wet and dry seasons were 8.91µg/m^3 and 14.23µg/m^3 for $SPM_{2.5}$, and 36.76µg/m^3 and 59.84µg/m^3 for SPM_{10} respectively. Their 24-hour extrapolated mean concentrations are 2.67 and 4.27 µg/m^3 for $SPM_{2.5}$, and 11.03 and 17.95 µg/m^3 for SPM_{10} respectively. Both particulate fractions are within WHO 25 and 50 µg/m^3 daily limits for $SPM_{2.5}$ and SPM_{10} grade particles respectively. Though the measured particulates concentrations were slightly higher in the proposed project site than at the Control sites, the 600 µg/m^3 TSP 1-hour limit of the Federal Ministry of Environment was not breached in any of the sampling locations.

The measured gaseous pollutants concentrations at the proposed project area were similar to what were obtained at the control sites. Since, VOCs CO and SPM could also be the products of combustion in the atmospheric environment, their detection in the proposed site and at the control points could be attributed to vehicular emissions and electric power generators, domestic cooking activities and domestic waste burning were additional sources identified during the study. Other source includes dust resuspension.

Investigated Air shed Classification

Since all the monitored air pollutants were within their set limits, the study area airshed can be classified as un-degraded airshed using the World Bank classification. It can also be described as having a high carrying capacity to sustain activities of the proposed project.

Ambient Noise

As presented in Tables 4.2, the measured ambient noise levels during the The range ambient noise levels during the wet season study was 35.60 – 90.40 dB(A) whereas in the dry season it was 33.5 – 88.6 dB(A). There corresponding mean values were computed to be 56.42 and 54.85 dB(A) which is within the 90 dB(A) 8-hour limit of the FMEnv.

These measured noise levels at the project and control sites are similar and in none of the sampling locations were above the 90 dB(A) shop floor limit of both the Federal Ministry of Environment and the Department of Petroleum Resources was not exceeded in any location in the two seasons.

Distant vehicles/ boat and domestic activities are the major sources of noise observed in the area during the study in addition to the natural sources including wind and river.

Soil pH and Electrical Conductivity

pH value range from 3.79-8.18 at the surface and 3.84-8.77 at the subsurface. The mean values therefore are 5.64 and 5.65 at the surface and subsurface respectively. This shows that there is no significant variation in pH values at the two layers of the soil around the study area. Again, the mean control values are 5.61(surface) and 5.51(subsurface). Therefore, based on soil pH general range and classification, the soil of the study area and its environs is distinctly acidic in nature. For the study, the EC range from 15 to 371µS/cm at the surface and 19 to 350µS/cm at the subsurface. Average sampled mean are 123µS/cm and 120µS/cm at the surface and subsurface respectively. However, a slight lower mean EC was observed at the controls. The mean control values at surface and subsurface are 112µS/cm and 109µS/cm respectively. Overall, it was observed that the EC values tend to decree downward the soil both for the study area and controls.

Soil Anions

The nitrate (NO_3) concentrations in soil samples within the project area range from 2.50 to 110mg/kg at the surface and 2.93-110mg/kg at the subsurface. The average values for NO_3 at the surface and subsurface were 20.89 mg/kg and 20.47 mg/kg respectively. On the controls, respective surface and subsurface means are 14.67 mg/kg and 12.4 mg/kg. The mean values within the proposed project area are higher than the controls. In addition, it was also observed that NO_3 decreases with depth for both sampled and controls. Nitrate is a more readily available form of Nitrogen for plant uptake and expresses a fraction of the total Nitrogen present in soil.

Phosphate concentrations ranged from 0.03 to 4.87mg/kg at the surface and from 0.03 to 4.66 mg/kg at the subsurface in soil sampled from the project site; mean values of the surface and subsurface however are 1.01 mg/kg and 0.96mg/kg respectively. The surface and subsurface mean Phosphate in sampled soils are higher than the controls. Phosphorus as Phosphate controls a lot of plant physiological processes.
Ammonia (NH^3) values in surface and subsurface range from 0.06 to 51 mg/kg and 0.06 to 4.57 mg/kg respectively. The mean values for the two soil layers within the study area extent however are 0.61 mg/kg and 0.37mg/kg; these values are higher than the controls. The difference could be link to anthropogenic activities within study area extent compared to the remote/control samples.

Sulphate (SO_4^{2-}) mean values for surface soil and subsurface soils are 8.48 mg/kg and 8.12 mg/kg while their ranges are 0.42 mg/kg to 29.61 mg/kg and 0.22 mg/kg to 27.52 mg/kg respectively. Sulphate mean values observed at the two layers of the sampled soil within the study area are lower than the controls mean of 11.77 mg/kg (control surface) and 9.01 mg/kg (control subsurface).
Furthermore, Chloride is known to combine with other prevalent cations to degrade concrete structures and as such negatively impacting on integrity of such structures. Chloride (Cl-) values range from 137.46 mg/kg to 4361.15 mg/kg at the subsoil while their mean values are 325.89 mg/kg and 432.04 mg/kg respectively.

Exchangeable Cations

Potassium (K) in the soil samples of the project area range from 0.35 to 1.92 mg/kg and 0.36 to 1.67 mg/kg at surface and subsurface, respectively. In addition, their respective means are 0.61 mg/kg and 0.62 mg/kg. Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. It also helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. Similarly, the same mean values were observed for Sodium (Na) at the two layers of the soils. Magnesium values range from 7.24 to 17.03 mg/kg (surface soil) and 7.2 to 15.87 mg/kg (subsurface soil). Each of the observed exchangeable bases (macronutrients) analyzed for the study are higher than at the controls both at the surface and subsurface. The exchangeable cations within the study area are high; hence, farming activities is practicable. Pockets of cultivated lands were also observed during the field data gathering. In other words, the soils are suitable for agriculture.

Hydrocarbon

Oil & Grease

Oil and grease observed ranged from 0.01 to 7.62 mg/kg at the surface and 0.03 to 12.00 mg/kg in the subsurface soils while their corresponding means are 1.2 mg/kg and 1.13 mg/kg. The observed THC in the surface soils range 0.01 to 2.15 mg/kg and 0.02 to 2.11 mg/kg in subsurface with corresponding of 0.59 mg/kg and 0.55 mg/kg. Controls means are 0.73(surface) and 0.33mg/kg (subsurface). In the observed samples however, TPH range are 0.01 to 0.85

mg/kg and 0.01 to 0.33 mg/kg at the surface and subsurface respectively. Corresponding means are 0.12 mg/kg and 0.11 while control surface and subsurface means are 0.16 mg/kg and 0.06 mg/kg. PAH mean was 0.04. It was noted that PAH concentrations vary greatly between top and sub soils. In addition, controls mean PAH was 0.02 and was not detected in the control subsoils. Traces of Benzene, Toluene, Ethybenzene and Xylene (BTEX) observed in the samples of the study area soils are within the target value (0.05mg/kg) of the DPR. BTEX observed however range from 0.01 to 0.03 mg/kg and 0.01 to 0.02 mg/kg at the surface and subsurface soils respectively. The corresponding means are 0.02 mg/kg and 0.01 mg/kg.

Heavy Metals

In order to establish status of the soil environment of the project area, results of the soil heavy metals were compared with the DPR target and intervention values. Arsenic (As) was not detected in all the sampled soils of the proposed project area of influence as well as the control points. Cadmium (Cd) in surface and subsurface soil samples has mean concentrations 0.33 mg/kg each. In other words, there is no difference in the observed Cd at the surface and subsurface. However, their range differs. Cd range at surface was 0.18 mg/kg to 0.54 mg/kg while 0.03 mg/kg to 0.68 mg/kg was observed at the subsurface. Further, the observed mean Cd at controls is slightly higher than the project area means.

Chromium (Cr) values at the surface and subsurface ranged from 0.01 mg/kg to 1.24 mg/kg and 0.02 mg/kg to 0.32 mg/kg respectively. Cr means values (0.33 mg/kg) at the surface and subsurface was the same. In other words, there is no variation in Cr mean values at the two soil layers for the study.

Mean concentration of Copper (Cu) in soils of the study area varied from 2.2 mg/kg to 12.15 mg/kg in the surface and subsurface while it ranges from 0.20 to 5.54 mg/kg and 1.05 to 5.43 mg/kg in the respective order. The mean values of Cu of the study area were higher than the mean controls; however, they are both within critical limit of 5-20 $mgkg^{-1}$ (FAO, 1978). Copper can be retained in soils by adsorption via non-specific and specific interactions, as well as precipitation reaction with hydroxides, carbonates, phosphates and silicates (McBride, 1989; McLaren, 2003)

Mercury (Hg) surface value ranged from 0.19 to 3.6 mg/kg and from 0.09 to 97.36 mg/kg at the subsurface. As shown in Table 4.6, the mean Hg values of the study area were slightly higher than the controls both at the surface and subsurface. However, mercury mean values for both the sampled and controls are well above DPR target values of 0.0 3 mg/kg. As shown in Appendix x1, Hg was observed in all the samples including controls.

As obtained in many other parameters for the study, traces of Lead (Pb) were observed in all the samples. It concentrations range from 0.55 to 3.19 mg/kg at the surface and from 0.66 to 2.66 mg/kg at the subsurface while their respective means are 1.62 and 1.59 mg/kg. These mean were slightly lower than Pb controls means of 1.73 mg/kg and 1.66 at surface and subsurface respectively. However, they are found to be within the limit of DPR.

Total Organic Carbon (TOC)

In the study area, organic carbon contents varied from 0.42 to 3.68% with mean values of 1.64% at the surface and varied from 0.22 to 3.28% and mean values of 5.49 in subsurface soils. Based on Udo, 1986; classification range, the TOC of the study area is medium while it is low in the controls.

Depth-induced Variation

Most of the soils parameters analyze show no significant variation base on depth (0-30cm). Some of the physicochemical concentrations that show significant variation in terms of soil depth (15-30cm) are Chloride (Cl-) and Copper (Cu), Table 4.6. While those that show significant variation from 15-30cm based mechanical/physical properties of soil within the study area are silt and clay (Table 4.3) however, based on spread, results vary geographically as shown in Appendix 3. It could therefore be noted that within the study area extent, there is no significant variation in soil properties based on depth.

Soil Microbiology

Total Coliform Count (TCC)
TCC values range from 3 to 1100MPN/100ml and from 0.2 to 1100 MPN/100ml in the surface and subsurface soils respectively. Corresponding means are 6.64 MPN/100ml and 32.16 MPN/100ml. As shown in Table 7, control values range from 21 to 75 MPN/100ml and from 11 to 2011-20 MPN/100ml at the surface and subsurface soils respectively. This shows that TCC in the surface is higher than the surface soils.

Faecal Clofiform was observed, that surface and subsurface values range from 3 to 1100 MPN/100ml and from 3 to 240 MPN/100ml respectively with corresponding means of 47.61 MPN/100ml and 15.12 MPN/100ml. The findings from the microbiological examination of the soil samples also indicated the presence of relatively high densities of heterotrophic microbiota in both surface and subsurface soil samples. Specifically, THBC ranged from 3.0 x 10^4 to 1.09 x 10^6 cfu/ml in the surface soil and 1.8 x 10^4 to 2.9 x 10^6cfu/ml in the subsurface soils of the project environment. The total heterotrophic fungi (THFC) assessment indicated some appreciable presence of fungi community in the soil samples across the project associated landscape. Specifically, respective surface and subsurface soil samples of THFC ranged from 1.0 x 10^4 to 4.8 x 10^5cfu/ml and from 1.0 x 10^4 to 9.0 x 10^5cfu/ml while the controls ranged from 4.0 x 10^4 to 3.2 x 10^5 cfu/ml and from 7.0 x10^4 to 4.2 x 10^5 cfu/ml in the surface and subsurface soils respectively. The results show that there is no significant depth difference between Total Heterotrophic Fungi count in the proposed project environment.

Land Use / Cover
Synoptic quantitative and graphic result of the landuse study for the Utapate field is shown in Table 4.9 and Figure 4.6 respectively. As shown in the Table, twelve broad landuse/landcover types were identified within study area.

Table 4.9: Landuse/Landcover for Utapate Field in OML13

Landuse	Area(Ha)	Percent (%) Cover
Creek	321.482	2.52
Pool	12.714	0.1
Ocean	6047.838	47.32
Sand Bar/Deposit	24.418	0.19
Mangrove/Swamp vegetation	2804.069	21.94
Built-up Area	275.326	2.15
Light Forest Vegetation	2321.908	18.17
Cultivated/Fallow Land	645.607	5.05
Cleared Land	37.684	0.29
Open Space/Bare Surface	243.188	1.9
Mudflat	34	0.27
Abandoned Installation Area	11.775	0.09
Total	**12,780**	**100**

Source: EES Study for Utapate Field in OML13

Vegetation Characteristics

General Vegetation Description
The physiognomy of the vegetation cover varied slightly due to the proximity of human settlements, and has influenced the biodiversity density and distribution within the project area.

Basically, the vegetation of the project area can be divided into four types, namely: Mangrove forest along the coast and river estuaries; Fresh water swamp forest, Rainforest proper and secondary vegetation punctuated with farmlands.

Plant pathological Studies
Findings from the study, typical of such similar investigations, indicated that the plants were generally healthy as most leaves were succulent, greenish and luxuriant. Some however had pathological problems like chlorotic and necrotic leaf spots, which were, in some cases, associated with the tropical red ants (*Oecophylla sp*) and native fungus species which have no long term damaging effects. Overall the disease severity indices revealed that the few diseases encountered were of very light to moderate infections. While there was no devastation by insect or animal pests observed in the project area there was evidence of leafs eaten up by biting and chewing insects such as grasshoppers and locusts.
Thus the appearance and the state of health of the plant communities and of the commonest species were quite normal in the rainy season and revealed no cause epidemic infection. There was no evidence of endemic vegetation problems as well. In discussing the type of plant diseases observed, it is pertinent to remark that none of the diseases was unusual either in its nature or severity. The few diseases observed are common and comparable in nature and intensity to those on plant species all over the forest zones of the country and elsewhere in the tropics.

Wildlife
The wildlife of the study area was rich and diverse, comprising Mammalia, Aves, Reptile,s Amphibians, Arthropods, Molluscs and Annelids.

Endangered Species
Most species reported in this study ranged from not evaluated to least concerned. However, there were reports of sightings of the White Throated Guenon (*Cercopithecus erythrogaster)* which is characterized by IUCN as threatened.
Although most species observed do not fall in IUCN threatened species red list, the observed local rarity of many species may be due to perennial habitat destruction and disturbance, emanating from deliberate hunting, vegetation clearance and other developmental activities.

Aquatic Studies
Surface Water Physico-chemistry

pH values from the survey ranged from 7.92 to 9.82 in the wet season and 7.64 – 11.80 in the dry season for the Inland Waters. In the shallow Atlantic Ocean, it ranged from 8.84 to 9.86 in the wet season and 8.11 – 10.35 in the dry season which is expected for saline waters. Wet and dry season respective mean of 8.95 and 9.29 for inland waters is consistent 8.80 and 9.37 mean values obtained in the control stations. Wet and dry season respective mean 9.48 and 9.19 for shallow Atlantic Ocean is also consistent with their control station values of 9.24 and 9.42.

Temperature
Measured mean temperature during the wet season in the Inland Waters was 29.34^{o}C from a range of 27.65 to 30.31^{o}C. In the shallow Atlantic, it was 27.81 ^{o}C from a range of 27.30 – 28.29 ^{o}C. A slightly higher mean of 30.57^{o}C from a range of 26.31 to 32.74^{o}C for Inland Waters and

30.90ºC from a range of 28.19 to 37.86ºC for the shallow Atlantic was recorded in the dry season. Similar values were obtained in the control stations in both seasons. The temperature of a surface water body is not expected to exceed ambient temperature based on WHO recommendation.

***Electrical Conductivity (EC)*:** EC Inland Waters ranged from 1713 to 43490 µS/cm (Mean = 29786.29µS/cm) in the wet season and 11000 to 46481 µS/cm (Mean = 41220 µS/cm) in the dry season. Shallow Atlantic ranged from 22230 to 32350 µS/cm (Mean = 31131.54 µS/cm) in the wet season and 30840 to 46250 µS/cm (Mean = 39487.21 µS/cm) in the dry season.

Total Dissolved Solids (TDS

TDS average concentration in Inland Waters was 14853.85 mg/l in the wet season and 20498.76 mg/l in the dry season with similar values obtained in the control stations. The observed increase in the dry season may be attributed to decreased dilution of the water body due to increased evaporation of water associated with the dry season. Given the correlation between EC and TDS, a high TDS value is expected. Similarly, in the shallow Atlantic, it was 15909.04 mg/l in the wet season and 19735.07 mg/l in the dry season.

Salinity

Measured salinity value of the surface waters was very high as expected for the Inland Waters and the shallow Atlantic Ocean with respective mean values of 18.60 psu and 19.72 psu in the wet season, and 25.93 psu and 24.74 psu in the dry season.

Oxidation-Reduction Potential (Redox)

The potential for oxidation and reduction across the sampling stations in the Inland Waters was averagely 20.6mV in the wet season and higher in the dry season (46.27 mV) indicating a net potential for oxidation in the Inland Waters. In the shallow Atlantic, reduction potential was prevalent in the wet season compared to dry season where increased oxidation potential was observed (Wet season = -0.75mV; Dry season = 25.98mV). In the shallow Atlantic control station, oxidation potential was prevalent in both seasons.

Turbidity

Mean turbidity value in inland Waters was 5 FNU in the wet season and 6.32 FNU in the dry season. It was 3.5 and 5.5 FNU in the control stations respectively. Similar values were observed in the shallow Atlantic (Wet season = 5.04 FNU; Dry season = 6.32 FNU) as well as the control stations.

DO

DO levels were observed to be enough to support life both in the Inland Waters and the shallow Atlantic with negligible season induced change. A mean value of 3.54 and 3.37 mg/L was obtained in the wet and dry seasons in the Inland Waters respectively while 3.60 and 3.59 mg/L was obtained in the shallow Atlantic. The values observed in the inland waters and shallow Atlantic were consistent with those recorded in the control stations for both seasons.

Total Suspended Solids

The mean TSS of Inland Waters was observed to be higher in the dry season (11.4 mg/l) than in the wet season (7.5 mg/l). It was not the same for the shallow Atlantic (Wet season = 7.55 mg/l; Dry season = 6.77 mg/l).

Anions

Nitrate values recorded were low in both Inland Waters and shallow Atlantic. It fluctuated in the inland Waters between 1.50 – 12.50mg/L (Mean = 5.2 mg/l) in the wet season and 1.5 – 9.8mg/L (Mean = 4.96 mg/l) in the dry season while in the shallow Atlantic it varied between 1.8 – 8.2mg/L (Mean = 4.76 mg/l) in the wet season and 2 – 7.6 mg/L (Mean = 3.72 mg/l) in the dry season. Their respective mean values are well below FMEnv/DPR limit of 10mg/l. Similarly, ammonia recorded wet and dry season respective mean of 3.21 and 3.46 mg/L for Inland Waters and 2.43 and 2.54 mg/L for the shallow Atlantic. Chloride was very high as expected for both water bodies with wet and dry season average values of 8160.77 and 10958.36 mg/l for Inland Waters and 12164.73 and 10056 mg/l for shallow Atlantic respectively.

The phosphate values recorded in Inland Waters ranged from 0 - 0.07 mg/l in the wet season and 0 to 0.06 mg/l in the dry season. In the control stations, they were mostly not detected but record maximum values of 0.01 and 0.02 in the wet and dry seasons respectively. Similar trend was observed in the shallow Atlantic with 0.02mg/l and 0.03mg/l being the maximum values recorded in the wet and dry seasons respectively. Phosphate was only detected in the control station during the dry season posting a value of 0.01mg/l. Elevated levels of phosphorus in some waters are usually due to soil leaching from surrounding fertile soil, livestock activities and human faeces.

Sulphate values recorded were quite high. Wet and dry season mean values were 457.74 mg/l and 447.60 mg/l for Inland Waters while it was 292.43 and 362.07 mg/L respectively. These values exceeded the DPR set limit of 200mg/l but are within FMEnv limit for surface water which is set at 500 mg/l.

Biological Oxygen Demand

BOD in the Inland Waters ranged from 5.26 to 210.19 mg/l with an average of 63.52 mg/l in the wet season and 19.97 to 199.68 mg/l with an average of 68.00 mg/l in the dry season. In the shallow Atlantic wet and dry season mean were 48.79 mg/l and 119.09 mg/l respectively.

Chemical Oxygen Demand

COD values obtained for Inland Waters ranged from 9.98 to 399.36 mg/l, with an average of 120.69 mg/l in the wet season and 10.51 to 199.68 mg/l, with an average of 68 mg/l in the dry season. In the shallow Atlantic, it ranged from 9.98 to 399.36 mg/l, with an average of 92.71 mg/l in the wet season and 10.51 to 126.11 mg/l, with an average of 62.68 mg/l in the dry season. Generally, COD of the waterbodies were high and mostly exceeded the 20mg/l FMEnv recommended limit.

Exchangeable Cations in Surface Waters

Mean sodium concentration in the wet and dry season was observed to be 10.20 and 9.83 mg/l in the Inland Waters respectively while it was 9.93 and 9.94 mg/l in the shallow Atlantic. Mean magnesium concentrations was 6.35 and 5.37 mg/l in the Inland Waters during the wet and dry seasons respectively and 6.75 and 4.77 mg/l in the shallow Atlantic.

Heavy Metals

The results of the heavy metals analyzed shows that Arsenic was below equipment detection limit of 0.001mg/l in Inland Waters and shallow Atlantic samples in both seasons. While the respective wet and dry season mean concentrations recorded in Inland Waters were 0.17 and 0.33 mg/l for Cu, 0.06 and 0.04 mg/l for Cr, 0.22 and 0.04 mg/l for Cd, 1.23 and 1.06 mg/l for Ni, 2.37 and 1.74 mg/l for Fe, 1.80 and 1.20 mg/l for Hg, 0.64 and 0.33 mg/l for Pb, 0.32 and 0.13 mg/l for Zn, 0.30 and 0.25 mg/l for Mn, the respective wet and dry season mean concentrations recorded in shallow Atlantic were 0.12 and 0.14 mg/l for Cu, 0.06 and 0.05 mg/l for Cr, 0.26 and

0.16 mg/l for Cd, 1.23 and 1.03 mg/l for Ni, 2.37 and 0.99 mg/l for Fe, 2.39 and 0.98 mg/l for Hg, 1.17 and 0.84 mg/l for Pb, 0.26 and 0.11 mg/l for Zn, 0.24 and 0.23 mg/l for Mn.

The mean concentrations of Copper, Cadmium, Iron, Mercury, Lead and Manganese in the Inland Waters exceeded their FMEnv set limits in both seasons.

Organics in Surface Water

Of the organics analyzed PAH and BTEX were not detected in Inland Waters and shallow Atlantic in both seasons. TPH was scarcely detected in the Inland Waters but was not detected in the shallow Atlantic. Maximum THC concentrations in the wet and dry seasons were 0.002 mg/l and 0.06 mg/l respectively in the Inland Waters. It was undetected in the shallow Atlantic during the wet season but recorded maximum concentration of 0.03 mg/l in the dry season. The wet and dry season mean concentration of oil and grease were 0.002 mg/l and 0.12 mg/l in the Inland Waters and 0.001 mg/l and 0.02 mg/l in the shallow Atlantic respectively.

Surface Water Microbiology

The total heterotrophic bacteria in the Inland Waters during the wet season ranged from (0.09 to 1.58) x 10^5 cfu/ml which is consistent with the range recorded in the control stations (0.68 to 1.03) x10^5 cfu/ml. In the dry season, a range of (0.13 – 9.4) x 10^5 cfu/ml was obtained while in the control stations it was 5.3 to 8.6 x10^4 cfu/ml. An increase was observed in the dry season which may have been season induced.
Similarly, in the shallow Atlantic total heterotrophic bacteria during the wet season ranged from (0.15 to 1.64) x 10^5 cfu/ml while in the dry season, a range of (0.15 – 9.7) x 10^5 cfu/ml was recorded.
Total heterotrophic fungi in Inland Waters ranged from 0.0 to 1.8 x 10^4 cfu/ml in the wet season and were heavier in density compared to the 0.0 to 2.0 x10^3 cfu/ml observed in the control stations. In the shallow Atlantic it ranged from 0.0 to 7.0 x 10^3cfu/ml. A range of 0.0 to 1.5 x 10^4cfu/ml was recorded in the Inland Waters during the dry season while in the shallow Atlantic it ranged from 0.0 to 7.0 x 10^3cfu/ml. A decline in total heterotrophic fungi density was observed in the dry season which may have been season induced.

Faecal coliform was scarcely present in the Inland Waters with a range of 0 to 20 and 0 to 21 MPN/100ml in the wet and dry seasons respectively. Faecal coliform was not present in the control stations in both seasons. Similar trend was observed in the shallow Atlantic. Total Coliform count ranged from 0.0 – 150 and 0.0 – 160 MPN/100ml in the wet season for Inland Waters and shallow Atlantic respectively whereas in the control stations, it was averagely 10.5 and 4 MPN/100ml respectively. In the dry season, a range of 0 – 111 MPN/100ml and 0.0 – 75.0 MPN/100ml was recorded in the Inland Waters and shallow Atlantic respectively indicating season induced decline in Coliform density.

Sediment Quality

Sediment Physico-chemical Characteristics

Particle Size Distribution

Silt particles were dominant across the sample locations in the Inland Waters during the wet and dry seasons with respective mean for silt – 54.15 and 54.82%, clay – 23.23 and 23.03% and sand 22.62 and 22.15%. However, sand sized particles were dominant and closely trailed by silt particles in the control points during the wet and dry seasons.

In the shallow Atlantic, sand sized particles were evidently dominant in both seasons. Wet and dry season mean values were 76.05 and 76.63% respectively. Silt grade particles followed with respective wet and dry season mean of 14.73 and 13.43% while Clay particles recorded 9.21 and 9.95% respectively (

pH

The pH of the sediment samples during the wet and dry seasons in the Inland Waters was observed to be strongly acidic. pH range of 4.11 – 5.47 was recorded in the wet season and was consistent with control stations range of 4.29 – 4.93. Dry season sediment pH in the Inland Waters ranged from 4.88 – 8.59 with average of 6.01 (acidic sediments). Upon comparison, Sediments pH remained mostly acidic in the Inland Waters but a slight increase in pH was observed in the dry season which may be season induced.

In the shallow Atlantic, pH range was between 4.12 – 5.31 in the wet season and 4.28 – 6.79 (mean = 5.68) in the dry season which puts the sediment in acidic class. These values were consistent with control station pH of 5.01 and 6.11 obtained in the wet and dry seasons respectively. Season induced increase was evident in the shallow Atlantic Sediments in the dry season.

Electrical Conductivity (EC)

Sediment EC in the Inland Waters during the wet season was low ranging from 51 -193 µS/cm while significant increase was noted in the dry season with a range of 68 – 6923 µS/cm. In the control stations, EC was consistent with values obtained in the sampling station (wet season range 66 - 72 µS/cm; dry season range = 79 - 6906 µS/cm).

In the shallow Atlantic, the wet and dry season mean were 79.57 and 89.29 µS/cm which is consistent with 55 and 68 µS/cm observed in the control station.

Sediment Anions

Sediment Sulphate contents in Inland Waters and shallow Atlantic ranged from 2.25 – 8.59 mg/kg and 1.20 – 8.24 mg/kg in the wet season, 2.18 - 8.60 mg/kg and 1.25 – 8.19 mg/kg in the dry season respectively. These values were consistent with those obtained in the control stations (wet season: 5.25 – 5.95 mg/kg and 4.19 mg/kg; dry season: 5.16 – 5.84 mg/kg and 4.11 mg/kg). Sulphate is considered adequate when the levels are >8 mg/kg (Baker and Gourley, 2011).

Phosphate content in the Inland Waters and shallow Atlantic sediments ranged from 1.17 – 4.51 mg/kg and 0.18 – 3.89 mg/kg in the wet season and from 1.31 – 5.58 mg/kg and 0.19 – 3.98 mg/kg in the dry season. The wet and dry season concentration of phosphate is consistent with control stations values in both seasons.

Nitrate contents ranged from 2.5 – 13 mg/kg in the Inland Waters and 2.25 -9.75 mg/kg in the shallow Atlantic during the wet season. Their mean values during the dry season (Inland Waters = 7.86 and shallow Atlantic = 7.24 mg/kg) is indicative of season induced increase.

Among the anions in the sediment samples, chloride recorded the highest concentrations. Wet season range was 562.36 – 1537.02 mg/kg in Inland Waters and 712.28 – 1249.61 mg/kg in the shallow Atlantic while dry season range was from 472.33 – 1824.56 mg/kg in Inland waters and 638.07 – 1532.89 mg/kg in the shallow Atlantic. Season induced increased in the dry season was observed.

Sediment Cation Concentrations

Sediment exchangeable cations during the wet and dry seasons were moderate in concentration for Mg^{2+} and Na^{+} but low for K^{+}. Concentrations of cations in the sampling stations were consistent with values recorded in the control stations.

Mean concentrations of Mg, Na and K in Inland Waters during the wet and dry seasons were 5.20 and 5.21 mg/kg, 4.81 and 4.88 mg/kg, 0.75 and 0.76 mg/kg respectively. While in the shallow

Atlantic the mean concentrations of Mg, Na and K in the wet and dry seasons were 5.29 and 5.34 mg/kg, 4.65 and 4.68 mg/kg, 0.80 and 0.82 mg/kg respectively

In general, slight increase was noted in the mean concentrations of the cations in the dry season.

Heavy Metals in Sediments

The respective wet and dry season mean concentrations recorded in the Inland Waters were 0.27 and 0.29 mg/kg for Cu, 0.80 mg/kg each for Cr, 0.37 mg/kg each for Cd, 0.45 mg/kg each for Ni, 97.01 and 101.73 mg/kg for Fe, 1.09 and 1.11 mg/kg for Hg, 1.62 and 1.65 mg/kg for Pb, 0.37 and 0.41 mg/kg for Zn, 0.66 and 0.69 mg/kg for Mn.

The respective wet and dry season mean concentrations recorded in the shallow Atlantic were 0.21 and 0.35 mg/kg for Cu, 0.85 and 0.88 mg/kg for Cr, 0.42 and 0.43 mg/kg for Cd, 0.55 and 0.57 mg/kg for Ni, 105.68 and 110.35 mg/kg for Fe, 1.13 and 1.54 mg/kg for Hg, 1.87 and 1.89 mg/kg for Pb, 0.42 and 0.44 mg/kg for Zn, 0.35 and 0.36 mg/kg for Mn.

Sediment Organics

Total Organic Carbon (TOC) mean concentration in the Inland Waters and shallow Atlantic sediments were 0.89 and 0.92 mg/kg during the wet season and 0.95 and 0.99 mg/kg in the dry season. Similar concentrations of TOC were observed in the control stations in both seasons. Oil & Grease content in Inland Water sediments recorded mean values of 2.05 and 1.97 mg/kg in the wet and dry seasons respectively. In the shallow Atlantic, it was 1.96 and 1.92 mg/kg in the wet and dry seasons respectively.

Total Hydrocarbon (THC) concentration in the sediment samples was not detected in the wet season in both Inland Waters and shallow Atlantic but had mean values of 0.90 and 0.94 mg/kg in Inland Waters and shallow Atlantic in the dry season. In the control stations, THC was only detected in Inland Waters during the dry season (mean = 0.04 mg/kg).

Total Petroleum Hydrocarbon (“TPH), PAH and Benzene-Toluene-Ethylene-Xylene (BTEX) were undetected in the sediment samples of Inland Waters and shallow Atlantic and at the control stations in both wet and dry seasons.

Microbiological Contents of Sediment Samples

The total heterotrophic bacteria in Inland Water sediment samples during the wet season ranged from (0.21 to 1.53) x 10^9 cfu/ml which exceeded the range recorded in the control stations (7.2 to 8.1) x10^8 cfu/ml. In the dry season, a range of (0.19 – 1.37) x 10^9 cfu/ml was obtained while in the control stations it was from 3.2 to 6.3 x10^8 cfu/ml. In the shallow Atlantic, total heterotrophic bacteria ranged from (0.21 to 1.08) x 10^9 cfu/ml during the wet season and 0.18 – 9.7 x 10^9 cfu/ml in the dry season.

Total heterotrophic fungi in Inland Water sediment ranged from (0 to 1.6) x 10^8 cfu/ml during the wet season and (0 to 1.2) x10^8 cfu/ml in the dry season. It was undetected in the control stations during the wet season but recorded a mean of 1.0 x10^7 cfu/ml during the dry season.

A range of (0 to 5.0) x 10^8 cfu/ml and (0 – 9.0) x 10^7 cfu/ml was recorded during the wet and dry season respectively in the shallow Atlantic. In the control stations it was 2.0 x 10^4 cfu/ml each in the wet and dry season. A decline in total heterotrophic fungi density was observed in the dry season which may have been season induced.

Faecal coliform was scarcely present in sediment samples with a range of 0 to 27 MPN/100ml in the wet season and 0 -11MPN/100ml in the dry season in the Inland Water sediment. Faecal coliform was not present in the control stations in both seasons. Faecal coliform was undetected in the shallow Atlantic in both seasons.

Total Coliform count in Inland Water sediments ranged from 0 – 160 MPN/100ml in the wet season whereas in the control stations, it was between 0 and 14 MPN/100ml. In the dry season, a range of 0 – 93 MPN/100ml was recorded which implies season induced decline in Coliform density of the Inland Water sediment samples. In the shallow Atlantic, the same trend was observed (0 – 64 MPN/100ml in the wet season and 0 - 21 MPN/100ml in the dry season).

Hydrobiological Characteristics

Phytoplankton

Five (5) major families of phytoplankton were recorded in both both water bodies; namely Bacillariophyta, Cyanophyta, Chlorophyta, Euglenophyta and Dinophyta and this composition is in conformity with observations made by Nwankwo *et*. *al*. (2008), Akoma and Opute (2010), Dike and Adedolapo (2012). Bacillariophyta were the dominant family and constituted 55.48% and 57.18% for swamp and marine environment respectively). In the swamp, Cyanophyta with a relative abundance of 24.42% was the second dominant division of phytoplankton. The Cyanophyta had a relative abundance of 22.13% was the second dominant group of phytoplankton in the marine environment..

In all the dominance pattern of the various families of phytoplankton in the swamp waters within the study area is Baccillariophyta > Cyanophta > Chlorophyta > Dinophyta > Euglenophyta and was similar to that in the marine environment. These patterns were in conformity with literature reports of the Lagos coasts (Nwankwo 1993 and 2003).

In the swamp (creeks), total phytoplankton count varied between 1678 x 10^3 organisms per litre of water (sample point SW11) to 3103 x 10^3 organisms per litre of water (sample Point SW 8). In the marine environment, phytoplankton population was 1885 x 10^3 organisms per litre in SW 44 and 3183 x 10^3 organisms per litre in SW47.

Zooplankton

The identified zooplankton fauna in the swamp environment were categorized into Rotifera, Crustaceans (Copepoda), Crustacea (Decapods) and Cladocera while that of marine environment were categorized into Rotifera, Crustaceans (Copepoda), Crustacea (Decapods), Cladocera, Molluscan larvae and Euphausiacea. In the marine environment, copepod crustaceans were the dominant zooplankton and contributed 38.56%, followed by the Rotifers (22.25%). Molluscan larvae (6.00%) and Euphausiacea (2.53%) were the least represented of the zooplankton. copepods were the dominant zooplankton with respect to density and constituted 43.26% in the swamp environment.

In marine environment, the lowest zooplankton numbers of 370 x 10^2 organisms/l was recorded in sample point SW 46 and the highest count of 643 x 10^2 organisms/l was recorded in sample point SW 7. In the swamp environment, zooplankton density ranged from 296 – 592 x 10^2 organisms/l. A total of 26 species of zooplankton were recorded in SW 34 while 37 species were recorded in SW 51. In the marine environment, the number of zooplankton taxa was 31 (SW48) and 42 in SW 6. These figures on number of species are considerably comparable to those recorded in literature (Chowdhury, 2008; Davies *et*. *al*. 2009; Dike and Adedolapo, 2012).

Benthos

Benthos Population and Abundance

A total of twenty-six (26) benthic organisms were recorded in the swamp environment and thirty-two (32) were recorded in shallow marine water. In both water environments, benthic fauna encountered in the study belong to four (4) major taxonomic groupings namely Annelida, Crustaceans, Gastropods Molluscs, Bivalve Molluscs, and Polychaetes. In the swamp, Polychaetes with relative abundance of 53.15% were the dominant benthos. Similarly, in the shallow marine, Polychaetes constituted 44.41% of the total benthos, followed by the

Crustaceans (24.68% in swamp) and (29.72% in the shallow marine). The Gastropods (19.19%) and Bivalve (6.68%) were the least represented.

The number of benthos was stable at 13 (SW22) – 62 (SW56) organisms per m^2 across the sampled points in the swamp waters and fluctuated between 26 in sample points SW 48 and 68 organisms per m^2 in SW 5 in the shallow marine.

The high abundance of the Bacillariophyceae among the phytoplankton, Copepoda among the zooplankton and Polychaetes among the macro-benthos is a strong indication that the water column and sediment of study area creeks and shallow Atlantic were at the time of sample not under any ecological threat. This also indicates that the water was clean and unpolluted.

Fish and Fisheries

Fisheries Species Assessment

The result of the fisheries assessment indicated the presence of variety of fishes of various taxa in the creeks and shallow atlantics. Specifically, 10 species representing 6 Orders and 9 families were observed during the rainy season sampling period. Extensive sampling was impossible due to the security concerns in the water body. The represented taxa include Order Suliriformes, Mugiliformes, Beloniformes, Perciformes, Clupeiformes, Plueronectiformes and Elopiformes. The sighted species abundance varied because of the euryhaline nature of the water. Thus species ranged from fresh water to marine forms. Catfishes (*Clarias gariepinus*) are commonly harvested at the near shore/ flood plain areas of the river, while more salt tolerant forms such as *Cynoglossus senegalensis* is inhabit the seaward areas.

Fishing gears

The fishermen operate different types of gears in the study area and the fishing gear used is dependent on the target fish species. Some gears used are mainly rod and line, basket traps, and gill nets (Plate 4.13). Women fish mainly using basket traps but sometimes they use long lines, set gill nets and lift nets. The men operate different types of gears such as gill nets, long lines and encircling nets in near and distant waters.

Geology and Hydrogeology

Regional Geology

The geology of the Field area consists of sedimentary deposits of the Cenozoic age (about 160 million years) namely Benin, Agbada, and Akata formations. The area is characterized by fairly uniform geomorphology and lacks geological features like mountains, and rock outcrops. The area is characterised by fairly uniform geomorphology. Plains and sand beaches are the dominant features of the landscape with some silt and mud in the southern flank.

Hydrogeology

Two stratigraphic units form the main aquifer systems in the Niger Delta region. These are:

1. **The Alluvium**
   The aquifer systems within the alluvial deposits, especially the near surface beds close to the shore are often saline bearing.
2. **The Benin Formation**
   This chrono-stratigrahic unit forms the aquifer system. Its lithologic composition is mainly 90% sands and sandstones and 10% clay and lignitic beds (MPL, 2014). Recharge to this system is mainly from rainfall, while discharge sources include run-offs from the basin and abstraction through boreholes (Offodile, 1992).

Lithology and Aquifer
The monitoring boreholes drilled within Utapate Field revealed varied lithologies from top to bottom. The lithologies conform to alluvial deposits of Quaternary age in the Niger Delta basin. The water table aquifer was encountered from 3-8m (bgl). The static water level (SWL) measured during the wet and dry seasons ranged from 0.30m in GW4 to 2.59m in GW1 and from 0.50m in GW4 to 2.63m in GW1 respectively.

Groundwater Quality

pH

Groundwater pH ranged from 6.92 to 9.22 in the wet season and 8.18 – 10.22 in the dry season. Wet and dry season respective mean of 7.86±0.71 and 9.02±0.70 falls within the range of 7.44 – 9.67 obtained in the control stations across both seasons.

The computed dry season mean clearly puts the groundwater above 6.5 – 8.5 pH recommended standard.

Temperature
Measured mean temperature during the wet season was 28.47±1.11^oC from a range of 26.55 to 29.81^oC. A slightly higher mean of 30.75±0.98^oC from a range of 29.81 to 32.47^oC was recorded in the dry season.

Organics in Groundwater
All organic parameters analyzed (THC, oil and grease, TPH, PAH and BTEX) were not detected in both seasons.

Groundwater Palatability
Results of most of the parameters analyzed did not reveal any serious concern with regards to the palatability of groundwater in the study area except for certain heavy metals which exceeded their set limit. Consequently, for the purpose of drinking, there will be need for further treatment to meet recommended criteria.

Groundwater Microbiology
The total heterotrophic bacteria in the groundwater samples during the wet season ranged from (1.2 to 9.4) x 10^2 cfu/ml which exceeded the maximum recorded in the control stations (8.4 x10^4 cfu/ml).
In the dry season, a range of (3.1 – 9.9) x 10^2 cfu/ml was obtained while in the control stations it was from 6.4 to 8.3 x10^2 cfu/ml.

Social Profile
Project influences and receptor exposure are felt by the human population. This section of the EIA focuses on the baseline Socio-Economic parameters such as settlement history, population characteristics, educational status, occupation, employment, income, expenditure, land and, water resource ownership, housing, infrastructure, social structure, religion, customs, belief, power and governance, conflicts, conflict resolution and inhabitants perception of the proposed Utapate Field of OML13 re-entry project.

Study Communities
The study communities are those that are within 5km radius of the Utapate Field. The project affected communities are Atabrikang I, Okorombokho, Okoroiti, Okoroete, Iko, Elile, Amadaka, Kwampa, Edowink, Elekpo-Okoroete, Emerioke I & II, Okwanaobolo, Otuenene, Emeriemen,

Akpabom, Bethlehem, Isotoyo, Amanglass, Okoromeobolo, Ayama, Okorobilom, Amangbuiji, Ozoubo, Amauka, Okoroinyang, Iwofe, Nkonta, Obianga, and Engwewe in Eastern Obolo LGA of Akwa-Ibom State. The communities are predominantly inhabited by the Obolo ethnic group of Akwa Ibom State. Though autonomous in terms of traditional leadership, the communities have historical links. Eastern Obolo LGA whose Local Government headquarters is in Okoroete town has an area of 120km², a Density of 702.5/km² and a population of 59,970 based on the 2006 National Population Census figures, projected at 84,300 in 2016 and currently in 2020 projected at 95620 using 3.2% annual growth rate. However, the male-female population ratio in 2006 was 30,229(50.4%) and 29,741(49.6%) respectively.

Educational Status and Characteristics

Education is a key determinant of lifestyle and social status among individuals. Studies have consistently shown that educational attainment is highly correlated with socio economic wellbeing, health behaviours and attitudes. A large proportion of the sampled population has formal education indicating a literate society. The common classes of educational attainment among the sampled population are the tertiary, post primary and primary education. On the average, 8.3% of the respondents had tertiary education training. Those with post primary (secondary) and primary education accounted for 44.3% and 27.3% respectively. The possession of vocational/technical education among the sampled population is quite high (14.8%) and this is good on occupational skill needed for prospective employment positions that may be offered to members of the communities. Those of NFE constitute 3.9% and 1.4% others.

Livelihood and Micro-economy

Occupation, Employment and Income Generating Activities

The economic livelihood activities in Utapate Field communities depend much on the natural resource-base and traditional occupations like farming, fishing, hunting and lumbering. Farming and Fishing are the major activity of the people and majorly on rice farming, vegetable, maize, pepper etc. Artisanal fishing and processing of sea products, essentially drying, are part of economic livelihood activities in the study communities. Fishing is done in the rivers like, and other water bodies around the communities as well as in the Atlantic Ocean. Fishing nets, hooks, fish traps and machetes are used. Fishing activities in the communities are most lucrative in the dry season months from about October to April. The catch is generally reduced and, therefore, expeditions are less during the rainy season. High water levels from floods hamper fishing in the rivers and residents fish mostly in the wetlands and swamps in their communities. The usual catch includes tilapia, catfish, mudfish, electric fish, sardines, shrimps and craw fish, among others.

Infrastructure

Functional Status of Available Infrastructure

The infrastructural framework in the Utapate Field study communities is made up of a few physical and social amenities. Some of the available amenities are not functional. Most of the amenities have been provided by governments and development agencies. The physical amenities include paved access roads, internal roads, community halls and telecommunication services. Social amenities consist mainly of education, health, water supply and electrification facilities.

Community Expectations and Suggestions to Mitigate & Enhance Socioeconomic Impacts

The primary concerns of the people focused on negative activities during the project development period as well as potential negative impacts on livelihood, health and environment as the project proponent embark on construction and its operational activities. They made suggestions on how best to improve their socio-economic conditions and lessen the negative impacts on their livelihoods. Community members want the project to bring about improvements in employment, education facilities and services, provide good health centres and improve access to health care, and access to potable water in line with their infrastructure needs. The communities are eagerly expecting some benefits; they expect to enter into a GMoU agreement with the company and total adherence with the terms of the contract. Social issues, including employment opportunities for skilled, semi-skilled and unskilled indigenes at various levels as company's operations commence are expected. They also want economic empowerment of youths and women groups through skills training/acquisition and micro-credit programs; vendor services/minor supplies (contractor), compensation for resource losses, scholarships and provision of infrastructures, e.g., educational, health, electricity, water, among others are expectations of the communities. Pooled responses of these positive expectations put employment opportunities ahead of all expected benefits while a boost in education through awards of scholarships to children and wards, and the provision of primary healthcare facilities were recognized equally by respondents.

Community Health Profile

Health system

The resident population in the Utapate Field study communities have access to functional primary health care services. Functional and effective public (government health care facilities) primary healthcare (PHC) facilities and services are available at Okorote, the local government headquarter, Okorombokho, Iko, Amadaka, Akpabom and Amauka. There are also private clinics/maternities in the bigger communities like Okorote which have public (government) health establishments including a general hospital and a maternity health centre and 1 private clinics.

Preliminary observations

The health condition of the host communities of the OML 13 facilities is similar to those of the other oil-bearing communities in Akwa Ibom State, and the lowland rainforest ecological zone of the Niger delta region.

Members of the communities are mostly fisher men and subsistent farmers of cassava, plantain, yam and cocoyam etc.

Prevalence of non-communicable diseases:

A closer interaction with the community leaders and community health workers revealed that Diarrhoea, Malaria and Typhoid were the commonest ailments in the area. The people attributed the prevalence of these diseases to lack of portable drinking water, absence of serine environment and lack of zero medical facilities and care. Also, the people are aware of HIV/AIDs and its main mode of transmission (sexual intercourse). However, they deny the prevalence of such dreaded disease in their area. Near zero prevalence of Tuberculosis (TB) was also noted in area. Public health services and national program on immunization (NPI) are sparingly conducted in the area.

ES 0.12 Associated Potential Environmental Impacts

There are a number of approaches for the prediction and evaluation of impacts. The ISO 14001 method is simple to apply and provides a high level of detail and also relies on limited data, unlike the other methods that require the availability of large historical data. The ISO 14001 method, therefore, is selected for the identification and evaluation of impacts for the proposed Utapate Field Development Project.

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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 platform, commissioning operations and maintenance, demobilization, decommissioning and abandonment. The potential positive impacts of the project include opportunities for business and employment, increased oil production and revenue generation. Significant potential negative impacts of the project include:

- Risk of accident
- Interference with water transport
- Increase in noise vibration/levels
- Risk of piracy & kidnapping
- Interference with fishing activities
- Increase in noise and vibration
- Impacts of wastes
- Loss of biodiversity
- 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 etc.

ES 0.13 Mitigation Measures

Mitigation measures were proposed for the predicted medium and high-ranking impacts. The risk of accident shall be mitigated via compliance with NPDC journey management policy for land and marine transport marine and training for boat/ vehicle drivers and public awareness. The Risk of Piracy and kidnapping shall be mitigated via making adequate security arrangements at the project site, sensitized on the peculiarity of the project environment and engagement of the youths from the host/neighbouring communities on worthwhile ventures e. g. skills acquisition. The impact of air quality and noise shall be mitigated by the use of equipment and machineries (boats and vehicles) that are pre-mobbed and meet regulatory emission standards and also ensure that there is controlled use of all vessels and that their engines are turned off when not in use. Compliance with NPDC 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 0.14 Environmental Management Plan

NPDC 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 the monitoring plan. The EMP team shall liaise with all contractors, engineers, quality assurance officers, supervisors and all relevant NPDC 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 should be updated from time to time throughout the project lifespan, to incorporate innovations, and changes in policy and in regulations.

ES 0.15 Conclusion

This EIA report was prepared to assess the potential impacts of the Utapate Field Development Project on the environment. The need to identify and predict the adverse and beneficial impacts of the proposed Utapate Field Development Project on the biophysical environment and the socio-economic and health status of the people and thus provide necessary data/evidence that will form the Environmental Impact Statement (EIS) of the project necessitated NPDC to carry out an EIA of the proposed project. This study was carried out in accordance with relevant local and international regulations. The methodology applied for the study involved desktop studies, reviews of existing data and fieldwork including community consultations.

To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various ecological components of the project area using extensive literature, two season field sampling, measurements/testing as well as quantitative and qualitative analysis. Consultations with the project communities were also carried out and these would continue throughout the project life cycle. These consequently established the environmental characteristics of the proposed project area with respect to climate, air quality, soil, surface water, groundwater, socio-economic and health environment, among others.

The EIA of the project shows that it would have a significant beneficial impact on both regional and national economy. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the mitigation recommended measures are adhered to.

Further, an Environmental Management Plan has been developed to ensure effective implementation of prescribed mitigation measures and for proactive environmental management throughout the drilling, flowline construction and operational life of the project facilities. The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components.

It can be concluded that the project will not cause serious damage to the environment if executed in accordance with plans and programmes in this EIA. The approval of this EIA report for the execution of the proposed project is hereby recommended in accordance with the contents of this EIA to enhance project and environmental sustainability.

ACKNOWLEDGEMENT

The Nigeria Petroleum Development Company acknowledges the opportunity granted by the Government of the Federal Republic of Nigeria through its regulatory Agencies, to conduct this Environmental Impact Assessment of Utapate Field Development Project. We recognized the national regulatory requirements and standards, the Akwa-Ibom State Ministry of Environment edicts and International specifications. We have enjoyed cordial working relationships with the regulators, community leaders, individuals, corporate bodies and groups.

The contributions of Osten Laboratory Ltd, commissioned to execute this EIA are also recognized. We acknowledge with thanks the opportunity to provide useful information toward effective environmental management.

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CHAPTER

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Nigerian Petroleum Development Company (NPDC) is the sole operator of OML 13 in Akwa Ibom State, Nigeria. OML 13, hitherto operated by Shell Petroleum Development Company (SPDC). SPDC divested from the field in 2011 and the block was handed over by Department of Petroleum Resources (DPR) to NPDC in February 2017 in a bid to drive and actualize Government's projections of increasing crude oil and gas output.

To have baseline information on the state of the Utapate Field that is planned for re - entry, NPDC conducted an Environmental Impact Assessment (EIA) study of the OML 13 proposed Utapate Field EPF, New Flow station, a short-term Fixed Platform Transhipment Point (FPTP), drilling sites (Locations 1A, 1B; 2A,2B; 3A, 3B & Alt-1; UTA-A,B,C,D, UTA-9, UTA-13), tank farm and FLB etc.), pipelines from wells to common manifold, pipelines from common manifold to EPF/MFS; pipeline from EPF/MFS to Tank Farm . OML 13 is situated in the south east onshore of the prolific Niger Delta hydrocarbon belt in Akwa Ibom state. This field which transverses dry land in the north to mangrove swamps, beaches and shallow marine (Atlantic Ocean) to the south, covers a total area of 1,987km2.

This report presents the environmental baseline description and impact assessment of Utapate Field. The baseline was produced using a two-season field data gathering. Fieldwork was conducted between Thursday 19th September to 2nd October 2019 for the wet season and January 26th to 31st, 2020.

1.2 Study Objectives

The main objective of this EIA is to predict possible changes on the ecosystem that may result from the proposed project. The general objectives of the study include the following:

- Determine the current status of baseline and ambient conditions of the environment (biophysical, socio-economic and health).

- Determine and evaluate the additional “pollution load” and potential impacts of the new proposed project activities on the biophysical, social and health environment of the area.

- Identify and evaluate the potential socio-economic effects of the project on communities including impacts on cultural properties, social infrastructures, natural resources and lifestyles / values.

- Develop an appropriate and cost effective mitigation measures and Environmental Management Plan (EMP) for sustainable development.

1.3 Benefits of this EIA

The benefits of this EIA will include the following:

- Obtaining a permit or authorization. Prior to the commencement of the execution of any development such as the drilling of wells, a regulatory approval or permit must be secured. This is dependent on the completion of an EIA study.
- Proper accounting and inclusion of environmental issues and concerns into project designs and implementation.
- Serving as a meeting ground for all stakeholders to address problems, impacts and mitigating measures of a proposed project through its consultation processes; and
- Cost saving approach or effort through the achievement of long term management objectives and elimination of financial and environmental risks that are associated with project development.

1.4 Scope of this Study

The proposed project shall be executed in conformity with NPDC’s policy on the preservation of the environment. In order to fully protect the environment during the project execution, an Environmental Impact Assessment (EIA) was commissioned.

The general scope of the EIA covered all the activities that constitute the project. It outlined the techniques and methodologies used in data generation and gathering, including the description of the data sources and impact identification, prediction, evaluation and management. The following categories were covered:

- Baseline Data Acquisition
  - ✓ Literature Review
  - ✓ Field Work
  - ✓ Laboratory Analysis
  - ✓ Data Analysis and interpretation
- Consultation/Stakeholder Engagement
- Evaluation and Prediction of Potential Impacts
- Determination of Appropriate Mitigation Measures
- Development of an Environmental Management Plan
- Report Preparation

1.5 Administrative and Legal Framework

In Nigeria, it is a regulatory requirement that the proponent of a major project submit an EIA study report for approval before project execution. This section presents a review of some of the relevant statutory requirements for the proposed project. The information contained in this section is derived from The Federal Ministry of Environment, Housing and Urban Development, the Government of Nigeria Laws and regulations, Akwa Ibom State Ministry of Environment edicts, International conventions and agreements to which Nigeria is a signatory and OEPL's HSE policies.

1.5.1 Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, 1991 (Revised Edition 2002)

The DPR Environmental Guidelines and Standards of 1991 (revised in 2002/2018), stipulate in part VIII (A), the manner of preparing EIA. Section 6 provides guidelines for preliminary EIA Report. The content of detailed EIA Reports is outlined in Section 5 of Part VIII (A).

1.5.2 Federal Ministry of Environment, Housing and Urban Development (FMEH&UD)

The FMEH&UD is now the apex institution in Nigeria charged with the overall responsibility for the protection and development of the environment, biodiversity conservation and sustainable development of Nigeria's natural resources. The Ministry grants permits for environmental and laboratory consultancies and must approve an EIA study of a major development activity such as this one before the proponent can implement the project. The FMEH&UD has taken over the functions of the Federal Environmental Protection Agency.

1.5.3 Federal Environmental Protection Agency, FEPA, 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 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.

1.5.4 Environmental Impact Assessment Act No. 86, 1992

This Act, which became operational on 10th December 1992, provides guidelines for activities for which EIA is mandatory in Nigeria. Such developments include the following:

- Coastal reclamation involving an area of 50 hectares or more;
- Conversion of mangrove swamps for industrial use covering an area of 50 hectares or more
- Hydrocarbon processing facilities such as flow station or gas plant.

This process involves the undertaking of mandatory study/meditation or assessment by a review panel and the preparation of a mandatory EIA report.

1.5.5 EIA Sectoral Guidelines (Oil & Gas Industry Projects)

These guidelines are to assist project proponents to conform to the requirements of the EIA Act No. 86 of 1992 to obtain certification from the Federal Government of Nigeria through the Federal Ministry of Environment, Housing and Urban Development.

1.5.6 Other FMEH&UD Regulations

The Federal Ministry of Environment through former FEPA also has the following regulations, policies and guidelines:

(a) The National Policy on Environment, Federal Government of Nigeria 1989

(b) National Guidelines and Standards for Environmental Pollution Control in Nigeria

(c) National Effluent Limitations Regulations S.1.8, 1991, lists the parameters in industrial effluents and gaseous emissions and their limitations and standards of discharges into the environment.

(d) National Pollution Abatement in Industries and Facilities General Wastes Regulations S.1.9 1991 requires every industry to install anti-pollution abatement equipment to treat effluent discharges and gaseous emissions to the standards and limits prescribed in Regulations S.1.8

(e) Waste Management and Hazardous Wastes Regulations S.1.15

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

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

1.5.8 National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEH&UD)

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 labelling 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.

Other Nigerian Environmental regulations are presented in Table 1.1

Table 1.1: Relevant National Regulations Relating to Environmental Protection (by the Oil and Gas Industry) in Nigeria

S/N	(f) Regulation	Year Adopted
1	Environmental Guidelines & Standards for the Petroleum Industry in Nigeria 1991, Revised 1999, 2002 and 2018	1991
2	Petroleum (Drilling and Production) Act 1969 (Cap 350 Vol. XIX)	1969
3	Mineral Oils (Safety) Regulations. 1963 (Cap 350 Vol. XX P.112667)	1963
4	Oil Pipelines Act, 1956, (Cap 338, Vol. XIX P.12363)	1956
5	The Mineral Oils (Safety) Regulations (Revised 1995)	1995
6	Oil Terminal Dues Act 1969, (Cap 339, Vol. XIX, P.12385.)	1969
7	Oil and Pipelines Regulations 1995	1995.
8	Petroleum Refining Regulations 1974	1974
9	Nigerian National Petroleum Corporation Decree 1977	1977
10	Associated Gas Re-injection Act 1979, (Cap 26 Vol.XIX.I.P.519)	1979
11	Explosives Regulations, Cap 117, LFN	
12	Federal Environmental Protection Agency Act 1988, Cap.131, Vol. IX P.6303	1988
13	National Environmental Protection (Effluent Limitation) Regulations 1991	1991
14	National Environmental Protection (Pollution and Abatement in Industries in Facilities Producing Waste) Regulations. 1991:	1991
15	National Environmental Protection (Management of Solid Hazardous Wastes) Regulations. 1991	1991
16	Environmental Impact Assessment Act (Decree No. 86) 1992	1992
17	National Inland Waterways Authority Decree, 1997	1997
18	Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991	1991
19	Guidelines and Standards for Environmental Pollution Control in Nigeria, 2002 Edition	2002

1.5.9 State Legislations

The Nigerian Constitution permits states to make legislations, laws, and edicts on the environment. The EIA Decree (Act of Parliament) No. 86 of 1992 also recommended the setting up of State Environmental Agencies to participate in regulating the consequences of project development on their environment. In accordance with the foregoing, the laws and edicts of the Akwa Ibom State Ministry of Environment (AKMENV) shall also apply in this project (Table 1.2). AKMENV was empowered by the Act setting up FEPA (Act 58 of 1988, as amended by Act 59 of 1992), which encourages State governments to set up their own Environmental Protection Agencies.

Table 1.2: Relevant legislation relating to environmental protection in Akwa Ibom state

S/N	Legislations
1	Akwa-Ibom Environmental Protection and Waste Management Agency Law No.8 of 2000
2	Forest Law Cap 52 Laws Of Akwa-Ibom State 2002
3	Forest Regulation
4	Public Health Rules
5	Public Health Law: Cap 103 Laws of Akwa-Ibom state 2002
6	Rural water Supply and sanitation Agency Cap 116 Law of Akwa-Ibom
7	State Land (Allocation of plot) Regulation
8	State Land (Temporary Occupation) Regulation
9	State Land (Leaders) Regulation
10	State Land Law Cap 126 Laws of Akwa-Ibom State 2002
11	The Town and Country Planning Law Cap.133 Laws of Akwa-Ibom state 2002
12	Wild Life Preservation Law Cap.142 Laws of Akwa-Ibom state 2002
13	Water Transport Agency Law Cap 141 Laws of Akwa-Ibom State 2002
14	Uyo capital City Development Authority Cap 136 Laws of Akwa-Ibom State 2002
15	Akwa-Ibom state water corporation (repeal) law 2002

1.5.10 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. 1 – III of 1991. Potential issues considered for EA in the energy projects include the following:

- Biological Diversity
- Coastal and Marine Resources Management
- Cultural properties
- Hazardous and Toxic Materials

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

The world Conservation Union was founded in October 1948 as the International Union for the Protection of Nature (IUPN). Following an international conference in Fontainebleau, France, the organization changed its name to the International Union for Conservation of Nature and Natural Resources in 1956.

In conjunction with the Oil Industry International Exploration and Production Forum the IUCN 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 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.

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

The convention was adopted on 22 March 1989 by the conference of plenipotentiaries, which was convened at Basel from 20 to 22 March 1989. 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. Other international regulations are presented in Table 1.3.

Table 1.3: International Regulations and Conventions Relating to Environmental Protection in Nigeria

S/No.	Regulation/Convention	Year Adopted
1	Convention on the Continental Shelf (CSC)	1958
2	African Convention on the Conservation of nature and Natural Resources	1968
3	International Convention on Civil Liability for Oil Pollution Damage	1969
4	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND)	1971
5	Convention Concerning the Protection of the World Cultural and National Heritage (World Heritage Convention)	1972
6	Protocol Concerning Co-operation in Combating Pollution in Cases of Emergency in the West and Central African Region	1981
7	Convention for the Protection of the Ozone Layer	1985
8	Protocol on Substances that deplete the Ozone Layer. Note: The protocol was amended for the first time on 29 June 1990 in London. A second set of amendments was adopted in Copenhagen in November 1992; these entered into force on 1994	1987
9	Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal of 1989 (Basel Convention)	1989
10	International Convention on Oil Pollution Preparedness, Response and Co-operation	1990
11	United Nations Framework Convention on Climate Change	1992
12	Convention on Biological Diversity	1994
13	World Bank Environmental Assessment Source Books	1998

1.5.13 Land-use Act 1978

The Land-use Act was promulgated in 1978 with commencement date of March 29, 1978. It vests all land in each State of the Federation (except land already vested in the Federal Government of Nigeria or its agencies) to the Governor of the State. It makes the State Government the authority for allocating land in all urban areas for residential, agricultural, commercial and other purposes, while it confers similar powers regarding non-urban areas on the local governments in such cases. The governor of a State can revoke a right of occupancy for overriding public interest (e.g. petroleum mining and pipelines purposes)

The following surface rights are permitted under Section 51 of the Land use Act:

- Fishing rights
- Buildings and other structures, juju shrines, objects of worship
- Farms, cultivated crops, economic trees, roads
- Loss of use of the land

1.5.14 Petroleum Act – Cap 350 1990 and Exclusive Legislative List, (Constitution of Federal Republic of Nigeria)

This legal provision vests the entire ownership and control of all petroleum (natural gas included) in, under, or upon any lands and anywhere in Nigeria, its territorial waters, continental shelf areas as well as the exclusive economic zone areas in the Federal Government.

In the course of land acquisition oil companies are enjoined to pay adequately for any damage caused to the land surface, including the surface rights.

1.5.15 The Mineral Oil (Safety) Regulations, 1963

Section 37 and 40 require provision of personal protective equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

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

The oil pipelines ordinance (CAP 1945), 1956, as amended by the Oil Pipelines Act 1965 provides under section 4(2) for a permit to survey (PTS) the 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 such 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. Such a survey should include the approximate route or alternative routes proposed, in order to determine the suitability of the land for laying and construction of the pipelines and ancillary installations. Section 15(1) of the Oil Pipelines Ordinance (CAP) 145 prohibits the holder of an OPL to enter upon, take possession of or use any of the following land unless the occupiers or persons in charge thereof have given their assent.

(a) Any land occupied by a burial ground or cemetery;
(b) Any land containing any grave, grotto and trees or things to be held sacred or the object of veneration;
(c) Any land under actual cultivation.

Further, the Federal republic of Nigeria Official Gazette on 2nd October 1995 Vol. 82 No: 26 on Oil Pipelines Acts provides in details all the regulations on pipelines, proposed routes, construction activities and the associated protection measures. Consideration for public safety shall be in accordance with the provision of API/RP 1102 or any other recognized equivalent standards. The overall implication is that pipelines are constructed, in conformity with ASME B31.8 standards.

1.5.17 National Inland Waterways Authority (NIWA) Act 13 of 1997

NIWA is a statutory body established by the Federal Government of Nigeria with the power to regulate the use and utilization of declared Inland waterways and the Right of way (ROW) of declared waterways, creeks and lagoons.

The following permits must be granted by NIWA for the execution of any pipe-laying project:

i) Permit to survey (PTS) pipeline route that falls within the ROW and declared waterway.
ii) License to lay pipe (OPL) for the approved pipeline routes stated in (i) above.
iii) Permit for dredging activities within the declared waterways and ROW.
iv) Any other relevant requirement as contained in Act No. 13 of 1997 and its operating Tariff thereof.

1.5.18 Forestry Law CAP 52, 1994

The Forestry Law CAP 51 of Lagos is the only substantive legislation applicable to all parts of the federation. The law prohibits any act that may lead to the destruction of or cause injuries to any forest produce, forest growth or forest property. The law prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria. This law is applicable to the mangrove forest of the Niger Delta.

1.5.19 Urban and Regional Planning Law Act 88 of 1992

Urban and Regional Planning Law Act 88 of 1992 states that:

(1) A developer (whether private or government) shall apply for a development permit in such manner using such forms and providing such information, including plans, designs drawings and any other information as may be prescribed by regulation made pursuant to this section.

(2) Any Government or its agencies shall commence no development without obtaining an approval from the relevant Development Control Department.

(3) A developer shall at the time of submitting his application for development, submit to an appropriate control Department a detailed environmental impact statement for an application for –

(a) A residential land in excess of 2 hectares; or

(b) Permission to build or expand a factory or for the construction of an office building in excess of floors or 5,000 square meters of a let table space.

1.5.20 NPDC Health, Safety & Environmental Policy

NPDC shall, during the course of carrying out Environmental Impact Assessments in relation to all aspect of the natural and social environments that may affect or be affected by its activities:

- Identify all factors that will affect the ecosystem
- Identify any such interface for the complete lifecycle of facilities and operations.
- Enhance positive effects and prevent intolerable impacts from occurring.
- Limit the nature and extent of any residual negative impacts, however caused, such that they are as low as practicable.
- Consult relevant stakeholders.
- Leave the environment at the end of the useful life of any operation in a condition suitable for future use.
- Routinely monitor the environmental status of each operation and take corrective action as necessary.
- Observe all precautionary safety procedures during its operation.

1.6 Terms of Reference for the EIA

In compliance with the EIA Procedural Guidelines of 1995, the Project Proposal and Terms of Reference (ToR) were submitted by NPDC to the regulatory bodies for approval.

The ToR for the EIA of the OML 13 Utapete Development Project was developed through extensive stakeholder consultation at the initial stages of project conception, and approved by FMEnv/DPR. The consultation was organized in order to identify and define the project activities and aspects that may have significant environmental effects as well as scope the environmental baseline data needed as basis for impact assessment.

The EIA is expected to establish the environmental issues associated with the project; predict their impacts and magnitude; suggest and evaluate project alternatives; and recommend mitigation measures and Environmental Management Plans (EMP) to ensure environmental friendliness and sustainable development.

The summary of the scope of the EIA as contained in the TOR is as follows;

- Literature Review
- Detailed Description of the Project
- Baseline Data Collection
- Field Work and Laboratory Analysis
- Impact Identification, Prediction and Assessment
- Determination of Appropriate Mitigation
- Development of an Environmental Management Plan (EMP) and Monitoring Measures
- Decommissioning /Abandonment Plan

1.7 Declaration

Nigerian Petroleum Development Company (NPDC), in her capacity as the technical operator of the field, proposes to embark on OML 13 Utapate Field Development Project and hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the project.

This EIA has been prepared in accordance with the NPDC corporate policy on the environment; the DPR Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, 2018 and the FMENV Act No. 86 of 1992.

The management of NPDC is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report and avows that it has prepared this EIA report using the best available expertise in personnel, equipment, national and internationally acceptable methods.

1.8 Structure of the Report

This report is divided into chapters as follows:

Chapter One introduces the study and gives background information.

The Project Justification and Project Description are detailed in Chapters Two and Three, respectively.

The baseline bio-physical, socio-economic and health conditions are discussed in Chapter Four.

The identified potential and associated impacts of the projects are discussed in Chapter Five.

Chapter Six contains the mitigation measures proffered for the identified potential impacts.

The environmental management plan is detailed in Chapter Seven; while

The conclusions are presented in Chapter Eight.

2 CHAPTER

CHAPTER TWO
PROJECT JUSTIFICATION

2.1 Project Background

Utapate Field has fifteen (15) existing wells (exploratory and production wells), 30,000 BPD Capacity decommissioned Flow Station, approximately 12.7 kms of 12" crude oil evacuation pipeline and flowlines that have been fully vandalized with remnant heavily corroded. The field has not been under production since it was shut-in by SPDC over twenty- five years ago (1995).

Nigerian Petroleum Development Company (NPDC) is the sole operator of OML 13 in Akwa Ibom State, Nigeria. OML 13, hitherto operated by Shell Petroleum Development Company (SPDC). SPDC divested from the field in 2011and the block was handed over by Department of Petroleum Resources (DPR) to NPDC in February 2017 in a bid to drive and actualize Government's projections of increasing crude oil and gas output.

OML 13 is situated in the south east onshore of the prolific Niger Delta hydrocarbon belt in Akwa Ibom state. This field which transverses dry land in the north to mangrove swamps, beaches and shallow marine (Atlantic Ocean) to the south, covers a total area of 1,987km^2.

2.2 Project Objectives

The Nigerian Petroleum Development Company Limited, NPDC a subsidiary of Nigerian National Petroleum Corporation, NNPC is committed to the sustenance of the Nigerian economy by ensuring constant energy generation. OML 13 is one of the assets recently divested to NPDC by the Federal Government of Nigeria. The asset was formally operated by SPDC. However, Operatorship has now been transferred to NPDC. NPDC's key growth objectives are to:

• Develop NPDC to become a major player like any of the International Oil Companies (IOCs) in the Nigerian E&P sector.

• Sustain production and ensure 95% continuity in production chain,

• Commercialize Associated and Non-Associated Gas (NAG),

• Fully utilize associated gas and stop flaring,

• Support Government aspirations in the Power Sector,

• Support Government aspiration in making Nigeria a hub for Gas Based Industry.

2.3 Need for the Project

Nigeria is rich in mineral resources, of which the most exploited at present is crude oil. The country is among the world's largest exporter of crude petroleum. The Nigerian economy is largely dependent on its oil sector, which accounts for more than 80% of government revenue, over 95% of total exports, and over 90% of the country's foreign exchange earnings.

Nigeria's proven oil reserves are estimated at 37 billion barrels, which are found mainly in relatively simple geological structures along the country's coastal Niger Delta basin ("Niger Delta"), thus making the area one of the world's richest oil and gas provinces.

The Nigerian government is desirous to increase oil production capacity to 4 million barrels per day (640×10^3 m^3/day) in the next few years.

Block OML-13 was partially covered with 3D seismic data. The results of interpretation of the available seismic data of Utapate Field (OML 13) indicates presence of potential hydrocarbon bearing structures, some of which were earlier explored by the earlier operator and some of them are planned to be taken up for exploration / appraisal / development by NPDC. Besides, NPDC also has the plans to acquire new 3D seismic data over the entire Block OML-13 by deploying the latest state-of-the-art technology to delineate deep seated geological structures which could be potentially hydrocarbon bearing. Thus, a systematic and methodical approach of exploration / appraisal and development of OML-13 is likely to support the envisaged daily production goal of the Federal Government of Nigeria. The operator's intention to embark on early field production will verify available data and hence achieve optimal exploitation of the proven discoveries and production potentials of the Field. Ultimately, this will add to Nigeria's proven reserves as well as daily production in the coming years.

The implementation of Utapate FDP will contribute other numerous benefits including those listed below will accrue to Nigeria because of the project:

- Employment opportunities
- Transfer of Technical know-how and capacity building
- Contribution to macro-economic progress of Akwa Ibom State and Nigeria

2.4 Envisaged sustainability

The envisaged sustainability of the Utapate field oil reserve is categorized as follows:

2.4.1 Economic Sustainability

The OML 13 Field development project is economically sustainable due to the adequate oil and gas reserves in the block and the favourable gas policy implementation in Nigeria further drives the economic sustainability of this project. Also under the proposed development strategy, the project is expected to deliver a 57.1% in equity returns and achieve accounting payback by 2023 (economic payback at 15% discount is achieved in 2025). The project will therefore contribute substantially to the revenue accruable to the Federal Government of Nigeria, NPDC, its financial partners and the host communities

2.4.2 Technical sustainability

The Utapate field development project is technically sustainable because, innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project

2.4.3 Environmental sustainability

For all its activities, it is NPDC's policy to carry out environmental assessments with the view to identifying all significant impacts of the project and putting measures in place to limit the nature and extent of any negative impacts to as low as reasonably practicable.

This proposed field development is envisaged to be environmentally sustainable as it is expected to be implemented in accordance with this policy and in particular with the recommendations of this EIA. The incorporation of the findings and recommendations of this EIA at the various stages of the project development and strict adherence to the environmental management plan (EMP) will ensure environmental sustainability.

2. 5 Project Alternatives

The operator is a well-experienced and efficient oil and gas operator and as such restricts its designs to optimal practicable designs. In this regard, two concepts have been identified for the proposed field development project:

Option 1: Implement proposed Utapate field development project and undertake evacuation of stabilized crude via single point mooring system.

Option 2: Implement proposed Utapate field development project and evacuate stabilized crude oil via land pipeline.

The above scenarios only differ in terms of crude oil evacuation route as both options have the same design concepts and entails similar project activities.

The selected concept for this project is Option-1:

It is the intention of the operator to harness a single point mooring (SPM) anchored offshore for the evacuation of stabilized crude oil from the field to tanker barge/ships. This presents an advantage over land pipeline given that the field is near shore and SPM in this case would present both economic and environmental benefits compared to crude oil export via land pipeline. Crude oil export via land pipeline usually span several kilometers crossing various communities and consequently leaving significant biophysical and social environmental footprint before tie-in to nearby trunk line. SPM on the other hand is mainly used in areas proximate to the shore and would require relatively small pipeline stringing on land which implies smaller biophysical and social impacts.

Single point mooring system (SPM)

Single Point mooring system delivers the flexibility that in turn delivers significant time and cost benefits with high reliability factor.

Single Point Mooring system has benefits to them and can be useful when anchoring is not an option as well as when it is not conducive to going all the way back to shore. Single Point Mooring system allow tanker to:

1. Moor and Weathervane while loading and discharging.
2. Reduced Mooring forces
3. Suitable for mild to severe environment

Cost and Time Effective

Without a mooring, a vessel would have to go all the way back to shore when it requires fuel, to drop off crude oil barrels. The vessels are not known for speed and therefore it can slow a project down considerably. It is always best for business to finish projects on or before deadline and therefore utilizing moorings is good. It can be the needed halfway point to save days or even weeks of travel and thus making it cost and time effective.

Extra Large Vessels Can Use the Moorings

Single point moorings are capable of handling extra-large vessels in a better capacity than certain loading docks and even certain anchor systems. This will allow the vessel to pull up to the mooring for a fuel fill up or to load/unload materials. A ship can simply be connected to the buoy using a series of lines and connectors – and the mooring will have sufficient space in most instances to make the connections easy to establish.

High Draft Ships Can Be Moored

Single point moorings are capable of working with shifts that catch a high draft because the mooring can be accessed from any side, thus making it convenient for the ship to come up on the side that works best for them based upon the direction of the wind.

Large Amounts of Cargo Can Be Handled

Single point moorings can be built to handle a significant amount of weight.

Offshore Platform

- High availability of Crude and Uninterruptable Crude Supply.
- Reliability on the Operating System.
- Minimization of community interference with barge movement.
- Less dependency on high tide and low tide
- Less grounding of vessels – Pick up point from the sea instead sea mouth.
- No constraints of shallow patches.
- Less security constraints by avoiding River movement.
- Turning radius constraints while Barge movements in River is minimized
- Loss/ pilferage is high in long chain movement (Jetty- River- Sea mouth- Sea Going Vessels) comparatively with platform.
- Optimization of cost involvement.
- Increase in carrying capacity of Sea Going Vessel.

CHAPTER 3

CHAPTER THREE
PROJECT DESCRIPTION

3.1 Project Overview

Historically, the previous operator (SPDC) modified the development and operations of Utapate field from land to marine-based. This was likely done to improve field access at a time when road access was restricted. NPDC's objectives and development philosophy includes conversion from marine to land operations; cluster drilling to reduce footprint; and an accelerated development that achieves first oil in Q1 2020.

From facilities perspective, Utapate field development has been split into two distinct phases, which both comply with the zero-flare policy set out by the operator:

Utapate field development Phase-1

Phase-1 is a short-term plan which comprises leasing of Early Production Facility ("EPF") of 2 x 30 M bpd capacity. The produced fluid will be stabilized, stored and pumped to an offshore platform, via above ground and sub-sea pipeline, from where the crude is evacuated through vessels to the FSO. Gas will be separated and compressed for use through 8 inch flowlines into injection well(s) and the remaining used as fuel gas. The EPF's will be manned for operations that consist of hydrocarbon separation, gas compression and injection, crude pumping, water treatment and disposal and metering. Phase-I development is expected to cover, approximately, the first two (2) years of the field development, during which the following activities are anticipated to be completed and brought on stream: re-entry of six (6) existing wells (i.e. UTAS-1,3,4; UTAS-5; UTAS-6;and UTAS-11); drilling of 10 oil development wells, 2 gas injection wells and 2 water disposal wells. The gas injection would require compression for the associated gas.

Utapate field development Phase-2

Phase-2 development is planned for an integrated field development concept for the overall OML 13 block. It involves construction of a new main flow station(MFS) with capacity of 2x50 Mbpd and central processing facilities (CPF) as an onshore operational facility with a nominal crude storage capacity of 2 million barrels ~~floating~~ storage tanks with pumps, metered and exported crude via single point mooring(SPM) offloading into VLCC tanker located in Imo River Estuary. Operational metering on the tanker export line from onshore terminal will be provided. The facilities will be designed to handle up to 200 MMscfd (AG+NAG) raw gas to be monetized through a Special Vehicle Purpose contract (SPV) and water injection system design for up to 100,000 stb/d. Produced water is to be processed for re-injection and for buffer, routed to treated water tanks post processing, should injection system be offline.

Total of 46 new wells have been proposed for full redevelopment of Utapate field. These comprise 20 oil producers, 6 re-entry/sidetrack, 2 gas injector, 11 water injectors, 2 water disposal, and 5 NAG producers. The drilling activities are planned to span from Q3-2020 to Q2-2022. The OML 13 Utapate facilities, flowline and wells will be decommissioned at the end of economic life as proposed under the decommissioning strategy and will meet the requirements of the applicable regulations.

Table 0-2: Summary of Re-entry & New Wells for Utapate Field Development

Category	Well Designation	Total
Re-entry	Oil Producers	6
New Drilling	Oil Producers	20
	Gas Producers	5
	Water Injectors	11
	Water Disposal[2]	2
	Gas Injectors	2
Total Wells		**46**

3.2 Project Location

The Utapate field is located within OML 13 in Eastern Obolo Local Government Area, of Akwa-Ibom State. This field transverses dry land in the north to mangrove swamps, beaches and shallow marine (Atlantic Ocean) to the south, covers a total area of 1,987km2.

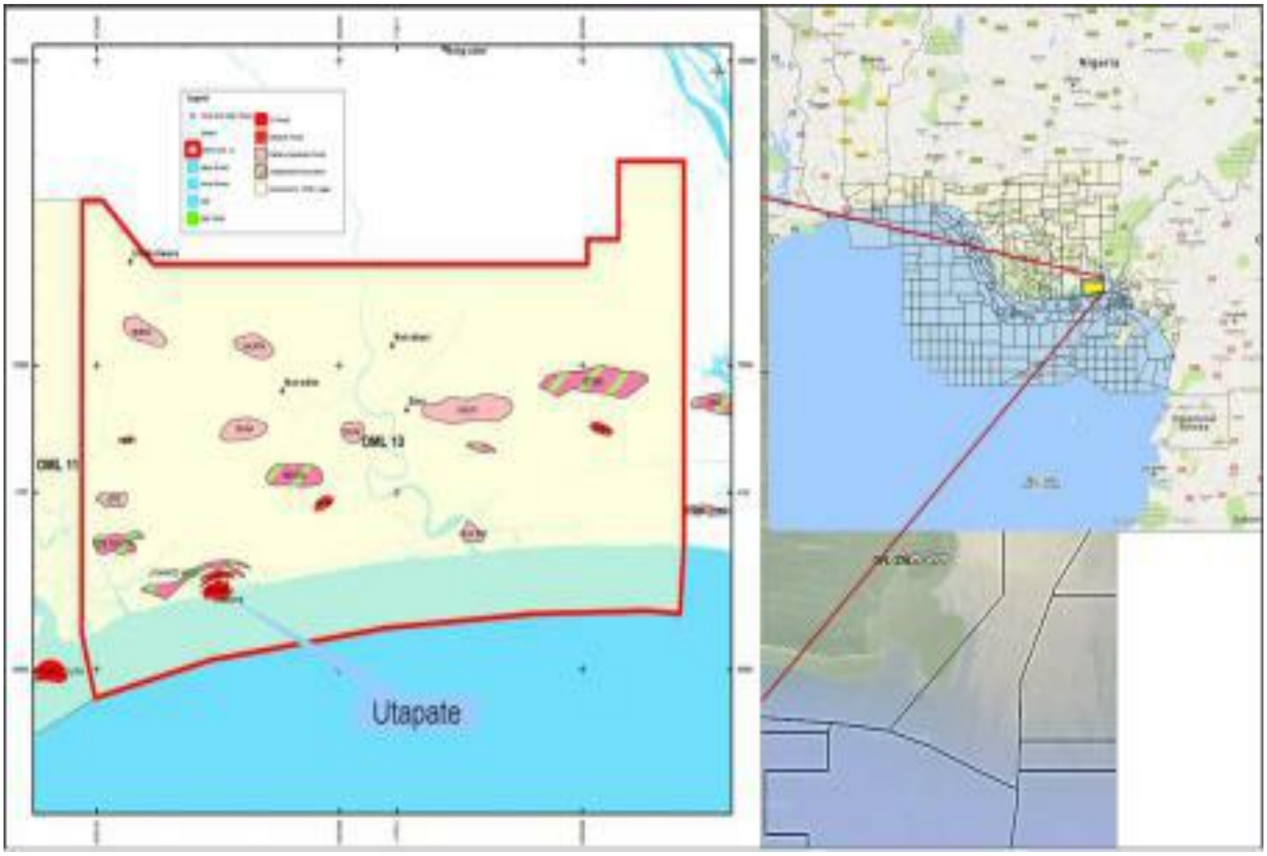


Figure 1.1: Location map of OML 13 in Niger Delta

3.3 Technical Project Description

A. Drilling Activities /Well re-entry

Following the availability of seismic data for the field, it is the intention of the proponent to first focus on re-entry activities of various Wells abandoned by the previous operator and later commence drilling activity in the developed field of Utapate. A total of 31 developmental oil and gas wells, 11 water injector, 2 water disposal, 2 gas injector have been proposed.

Well Planning& Design

Review of Offset Wells Drilling

A total of 15 wells have been drilled in the Utapate field in OML 13 block. These wells date back to as early as 1961 with the most recent, UTAS-13 being in 2000

Drill Bit Durability

Multiple bit runs have been required to complete each of the hole sections except for the 17-1/2" section on the later wells. Many of the reports stated that the bits were balled with clay (see section on drilling fluid issues for further information) but the main reason for the magnitude of failure in bits is the fact that roller cone or tri-cone bits were used in the offset wells.Tri-cone drill bits have bearings with a finite life, this is commonly known as KREVS and is a measure of revolutions completed by the bearings. KREVS is calculated based on revolutions on the drilling string plus any additional revolutions imposed should a mud motor be utilised.Typically, a 121/4" tri-cone bit will only last 700 ft if the string is being rotated at around 120 RPM from surface.In order to mitigate this issue; technologically advanced journal bearing bits will be used to drill 16"/12-1/4" section. Journal bearing Tri Cone bits are designed to yeild higher KREVS, therby increasing the meterage of the bit. For 12-1/4"/8-1/2" production section PDC bits with better cutting efficiency and effective junk cleaning area are planned for drilling. Modern PDC bits can drilling 10,000's ft without requiring being replaced as they have no moving components. PDC drilling bits will also increase the rate of penetration (ROP) and reduce the overall drilling time.

Stuck Pipe and High Over pulls

Five of the offset wells had serious issues with stuck pipe resulting in considerable lost timing freeing the string and, in some instances, having to fish or side-track the wells. Most of the offset wells used a low specification water-based mud. Issues arise with water-based drilling fluids particularly around shale inhibition, this is where the water phase of the of the mud is not controlled and hydrates the surrounding clays causing them to swell. As the clays swell this reduces the hole diameter and hence 'grabs' the drilling assembly resulting in high overpulls and stuck pipe events.Regardless of the base-fluid used, the drilling fluid / shale membrane is the key to inhibiting highly reactive shales. The emulsified phase of non-aqueous drilling fluids (oil, mineral or synthetic-based) provides an ideal membrane. In water-based drilling fluids, the membrane must be built using chemistry. High Performance Water Based Muds (HPWBM) offer enhanced shale inhibition through chemistry at relatively low-cost option with the performance of an emulsified fluid such as oil-based mud. During the detailed planning for the next phase of drilling offset shale samples shouldbe supplied to the preferred drilling fluid supplier to determine the quantities and types of clays present in the shales, the drilling fluid formulation can be fine-tuned and optimised. To combat the above issue of shale inhibition, SOBM/OBM drilling fluid is planned.

QA/QC

Several of the offset wells lost a considerable amount of time due to drill string wash out and tool failures. Drill string washouts normally occurred as a result of damage to the drill pipe either as general wear and tear or more sinister damage, should the damage not be identified through inspection to the required standards the damage due to erosion can result in a hole. If the washout goes undetected, in the worst case, the pipe can part and result in either a fishing job or the requirement to side-track.During the detailed planning phase, the inspection standards expected must be made clear to the drilling rig owner or pipe supplier to ensure that the risk of failures is minimised.

Directional Control

Several of the offset wells have been directionally drilled; these have varied in inclination from 30°to 52°. Build rates of up to 3.5°/100 ft were achieved. Kick off points in the few directional wells varied from 1,200 ft to 6,100 ft so there should be no issues with directional control in the next phase of drilling. Modern drilling tools such as point the bit rotary steerable and mud motors can build inclination at rates of 1-4°/100 ft, this will provide a better wellbore condition.

Anti-Collision

Directional records for the original wells exist and an anti-collision scan has been performed, although no issues has been identified with the survey tools used in the directional software it is recommended that once a directional drilling provider is identified the well plans and hence anti-collision scan is performed as their tools may carry different error models.

Losses during Cementing of Casing Strings

Several of the casing strings in the offset wells have suffered losses, although these do not appear to have a detrimental effect on the wells, this is not good practice from a well integrity perspective. Ideally cement slurries should isolate casing strings from sources of formation water. During the detailed planning for the next phase of drilling, a detailed review of the previous cementing procedures along with the design of the slurries should be undertaken with the preferred supplier of the service. The cement slurry design and the pumping pressure simulations are done using CemCade software to ensure an effective placement and good cement bond behind the production casing.

Well Functional Requirements

The following are the functional specifications for the OML 13 wells:

- Maximize well deliverability within the constraints of drawdown.
- Design robust wells with a lifecycle long enough to optimally deplete reservoir and ensure minimum or no well intervention.
- Ensure effective lifecycle management that will minimize OPEX.
- Install gauges and equipment for continuous data collection and transmission to the office location.
- Surface-controlled subsurface safety valve (ScSSV) shall be installed in all the wells.

Surface Location

The field design has been optimized to have 3 main clusters from which the wells will be drilled. The cluster approach minimizes rig moves allowing for an efficient drilling campaign. The cluster locations are shown in Table 3.1.

Table 3.1: Cluster Surface Locations (To be verified by Subsurface)

Cluster 1	Cluster 2	Cluster 3
X: 587,922.15 Y: 57,196.46	X: 585,194.36 Y: 56,552.21	X: 582,633.50 Y: 55,820.35

Well Trajectory

To ensure that all the wells planned can be drilled successfully, dogleg severity was restricted to a maximum of 3 deg /100 ft during the design stage. Generally, one continuous build wherever possible and deeper kick-off points (KOP) have been considered permitting build-up and turn rate of between 2-5 deg/100 ft. From the reviewed offset data, KOP ranging between 1,000 - 4,000 ft MD has been selected, this ensures that should the required build rates not be achieved there is enough vertical depth to 'catch up'. Figure 3.2 shows full plan view of the well trajectories from the three cluster locations.

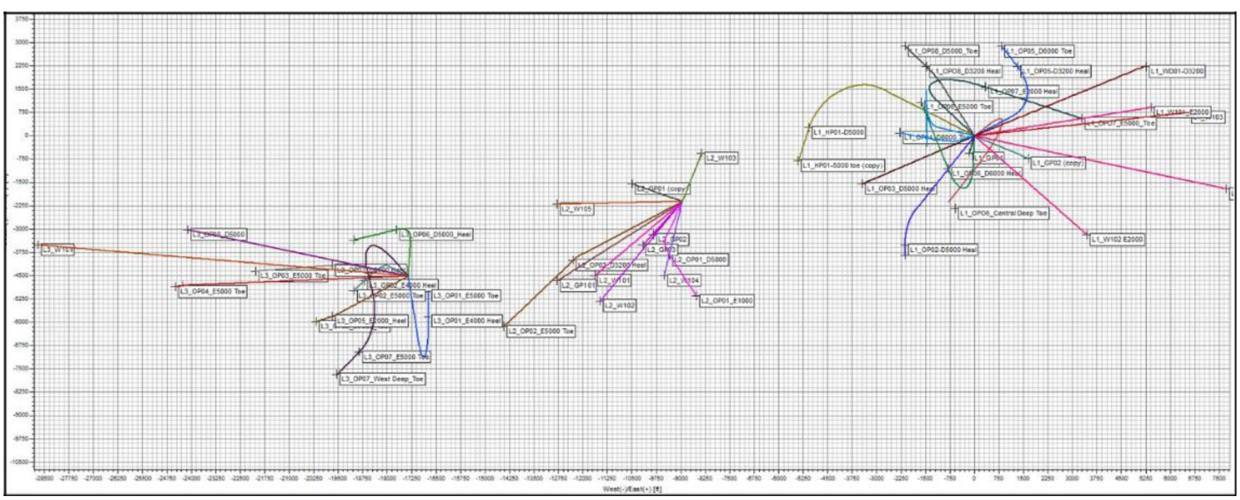


Figure 3.2: Full Plan view of Proposed Development Wells from all three clusters

Wellhead Design

The wellheads and production trees for the development wells have been designed to suit the planned casing and tubular strings programmed expected sub surface geo-hazards and reservoir fluids. Consideration also needs to be given to sub surface monitoring and if there is a requirement to monitor downhole conditions. The selection of wellhead was based on the following considerations:

- Maximum allowable surface pressure (MASP) not exceeding 5,000 psi;
- Casing programme;
- 3 1/2” tubing for single zone oil producers;
- 3 1/2” tubing for injectors and NAG producers;
- Dual completion for dual zone producers, with combination of, 2-3/8” x 2-3/8” or 2-7/8” x 3-1/2” for the short and long tubing strings respectively;
- Fluid properties;
- Reservoir characterization and
- Pad optimization.

Trees and wellheads should be qualified to the following API specs: API 11AX-0035, API 11B-0034, API 6A-0327, API 16A and API Q1 as a minimum.

Casing Programme

The casing strings are designed and planned to be set at depths that full control of the well can always be maintained. Casing setting depth was selected based on anticipated pore pressures, hydrocarbon interval, formation strengths, kick tolerance, regulatory requirements, offset lessons learned and directional well plan consideration.

The foundation or stove pipe, typically 20”/16” will be driven to refusal, based on offset wells this has been to a depth of between 150 ft and 210 ft. The surface hole, 16”/12-1/4” will be drilled to around 6,000 ft before running and cementing 13-3/8”/9-5/8” surface casing. The production hole section, 12-1/4”/8-1/2” will then be drilled to well TD before running and cementing 9-5/8”/7” casing. The proposed casing programmes are shown in Figure 3.3 and Figure 3.4.

Deep Appraisal horizons have been identified in this study at depths similar / deeper than that reached in UTAS-01, where an influx was taken resulting in the mud weight being increased to 1.68 SG. For wells selected to target the deep appraisal horizons, it is recommended that 95/8”/7” casing is set below the primary target before drilling into the pressure ramp. This will provide a strong casing shoe and permit the mud weight to be increased should an influx be taken.

Contingency Casing Design

Should hole stability issues be apparent in the shallow sections, the proposed contingency casing design (Figure 3.5) allows for a contingent casing string to be utilized, for example 13-3/8” surface casing could be run and cemented at 2,000 ft. The proposed casing design offers a further contingency should wellbore stability issues be experienced whilst drilling the $12^{1}/4$”/8-1/2” section below the $13^{3}/8$” casing, the ability to deploy an $11^{3}/4$” drilling liner would allow for unstable formations to be cased off after enlarging the hole to 12-1/4”

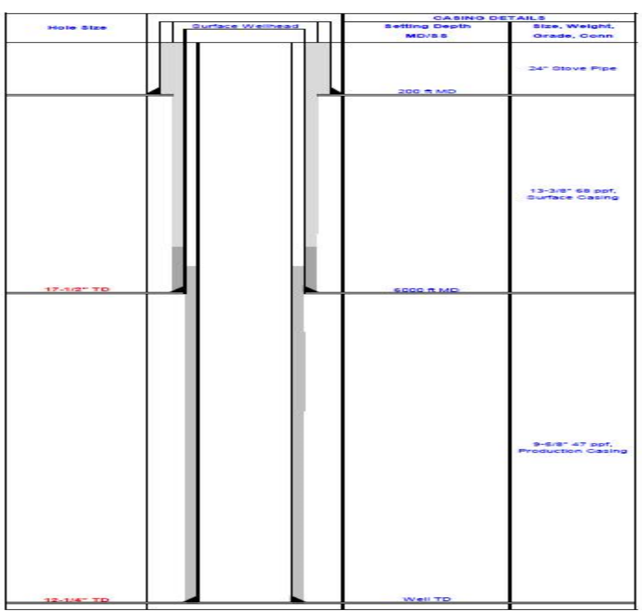


Figure 3.3: Conventional Casing Design

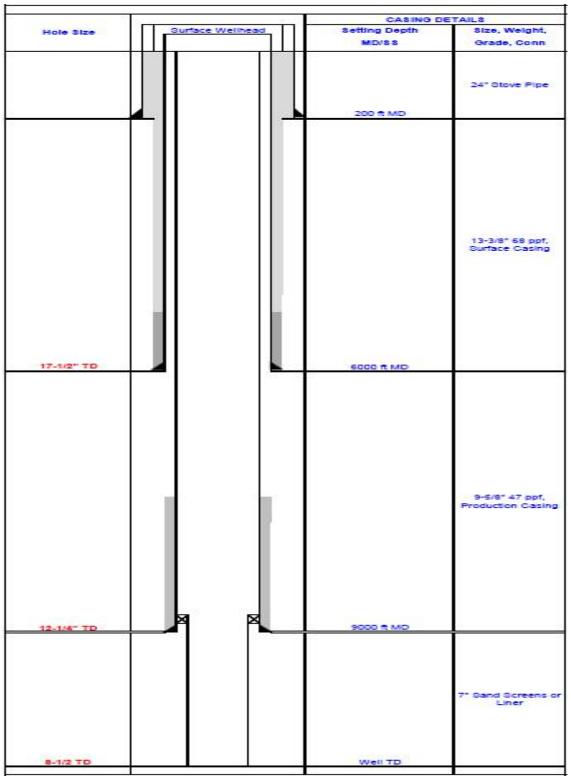


Figure 3.4: Horizontal Casing Design

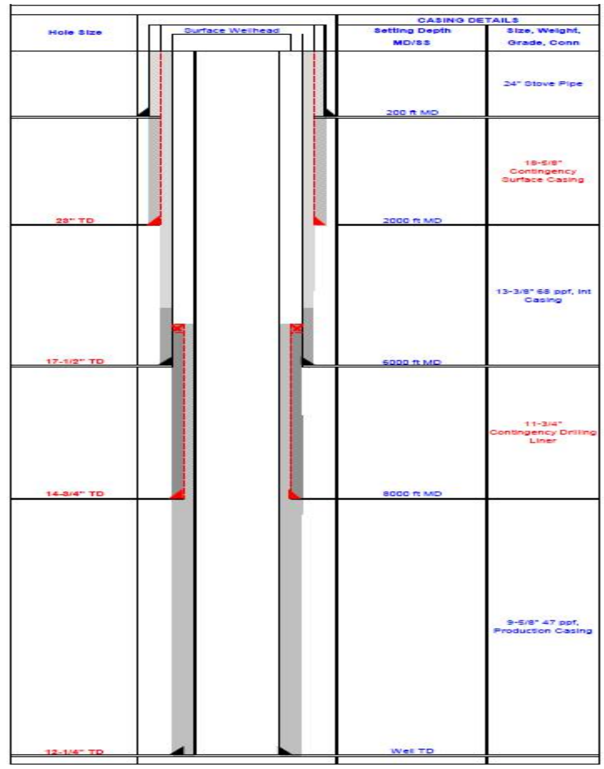


Figure 3.5: Contingent Casing Design

Drilling Fluid Programme

Water-base mud (WBM) i.e. KCl /polymer, will be used to drill surface holes. However, below the surface casing shoe, synthetic oil-base mud (SOBM) will be applied as it gives better drilling performance through improved mud lubricity and better borehole stability. Hence, SOBM will be used to drill build-up sections and production holes.

Experiences using WBM to drill deeper section, as shown in offset wells, have resulted in enormous hole problems, especially borehole instability, loss circulation, poor shale/clay inhibition and differential sticking. SOBM of appropriate mud weight will be used to enhance borehole stability.

All drilling operations will be conducted with an overbalance on the formation pore pressure. Mud weight selection to total depth (TD) was also based on the following considerations.

• Trip margin

• A minimum of 200 psi is normally recommended. This over-balance allows for swabbing effects while pulling drill strings.

• Hole stability

• Lessons from offset wells were applied.

• Recommendations from preliminary geo-mechanical analysis described in the previous section.

The recommend drilling fluids for each of the hole sections are listed in Table 3.2.

Table 3.2: Proposed Drilling Fluid Programme

Hole Size	Proposed Mud System	Mud Weight Range	Comments
16"/12-1/4"	KCL Polymer	1.15-1.20 SG	Base Case Well Design
12-1/4"/8-1/2"	Oil Based Mud	1.15-1.20 SG	Contingent Well Design
8$^1/_2$"/6"	Oil Based Mud	1.60-1.80 SG	For deep Appraisal wells

Cementing Programme

The main objectives of the cement designs are to:

- Obtain a strong casing shoe, and isolate all weaker formations drilled in the previous hole section.

- Provide structural support.
- Provide annular isolation of all permeable formations and local aquifers.
- Minimize the risk of inducing losses, due to an excessive hydrostatic column during cement placement.
- Minimize final field abandonment costs.

The recommend cementing programme for each casing string is outlined in Table 3.3.

Table 3.3: Proposed Cementing Programme

Casing String	Lead Slurry (SG)	Tail Slurry (SG)	Planned Top of Cement	Comments
20”/16”	N/A	N/A	N/A	
13-3/8”/9-5/8”	1.49	1.9	Surface	Isolates all shallow aquifers
9 5/8”/7”	1.49	1.9	500 ft inside previous casing String	Isolates all permeable zones
7” Liner	N/A	1.9	150 ft above top of liner	Only required in horizontal wells if cased

Completion Design

Completions Philosophy

The main completions philosophy is to design simple and robust wells with fit-for-purpose proven technology. The wells will be used to maximize production without affecting the well integrity and recovery from the reservoirs, throughout the well's operational life. The wells will be completed with:

- Sand control equipment to mitigate sand production;
- Minimal intervention requirement; and
- Top packers, SCSSV and an appropriate well-head to prevent accidental discharge of hydrocarbons into the environment.

The wells will be completed such that they will have high level of reliability requiring minimum intervention. It will, however, allow through-tubing well intervention using either wireline or coil tubing whenever required, to maximize the lifecycle value of the wells.

Design Consideration

Utapate (OML 13) well design for the proposed field development plan is premised on fit-for-purpose, bottoms-up well completions to enable the following.

- Optimum production by proper sizing the production tubing using nodal analysis and delaying water production.
- Reduce the risks of sand production by installing sand-exclusion and control systems in wells, including pre-pack screens, expandable sand screens (ESS), and slotted liners, as well as wire-wrap screens in the wells – final sand control method to be determined.
- Minimal well intervention in the acquisition of well and reservoir surveillance data, by installing downhole monitoring and control devices in the wells.

- Improve well deliverability by implementing appropriate drill-in fluid system, well clean-up practices, and maximize completion efficiency.

Key Risks, Drilling Hazards and Uncertainties

Wellbore Instability

An analysis of non-productive time (NPT) from the offset wells data revealed that the largest contributor to NPT was wellbore instability. Wellbore instability manifested itself in tight hole, hole collapse, pack-off, overpulls, stuck pipe (with subsequent fishing operations), annulus loading, poor hole cleaning, excessive and hard reaming as well as borehole washouts. This risk will be mitigated with properly engineered mud properties, effective hole cleaning and good drilling practices.

Gas Flow

Gas Flow was experienced in deeper section of well UTAS-01 with an EMW of 1.68 s.g. Same over-pressured formation was encountered while drilling deeper section of the well UTAP-001. However, no major incidents or hazards were identified within the rest of the offset well reports used for this study as they were not drilled deeper below E5/E6 reservoirs.

However, conscientious gas monitoring will be performed, and will be mindful of developing pore pressure trends. Perhaps, the biggest risk associated with high gas peaks is the potential to swab in an influx whilst tripping and back reaming.

TAF Shale

Chemically unstable clay and shale especially in the top hole contributed to extensive NPT hours in all drilled wells. The unstable shale was also present in some deeper formations. Reduced penetration rate and hydrocarbon swabbing in reservoir sections are common risks associated with TAF shales. Drilling mud will be engineered for adequate mud inhibition. Contingent plan to use dispersant in the mud system will be in place. Drill bits and bottom-hole assembly (BHA) will be supplied treated with anti-balling agents.

A. Flowlines and Pipelines

Flowlines and pipelines shall be constructed as part of the re-entry development program. This is to enable the evacuation of hydrocarbon that will be produced from the planned oil and gas wells.

All such new flowlines and pipelines will be buried, with a minimum cover of -1.0m to the top of pipe. Minimum cover will be 1.0m at river crossings. The flowline and pipeline construction works shall include but not be limited to the following:

- Trenching and backfilling works.
- Concrete coating at crossings (swamps, rivers) if applicable.
- 100% Radiography of welded joints.
- Hydrostatic testing
- Flushing
- Tie- in and Hook-up
- Reconditioning of areas damaged as result of the above works

The field shall utilize available single point mooring (SPM) system which shall serve as a link between the shore-facilities and the tankers few kilometers offshore for evacuation of crude oil. Some of the major benefits of using SPM are:

- The tanker ship is moored to the buoy for loading or unloading of liquid/gas products.
- A boat landing space on the buoy deck provides access to the buoy for setting up the connections and securing the barge/ship.
- Fenders are used to protect the buoy from unexpected movement of the ship due to bad weather.
- Lifting and handling equipment on the buoy allows handling of hoses connections and safety tools.

- Once the connections are made, valves are operated from the electrical substation.
- Necessary alarm systems and navigational aids are provided as safety precautions.
- Liquid cargo is transferred from geostatic location (Pipeline End and Manifold (PLEM) to the tanker using product transfer system of the single point mooring system. The Pipeline will be an 18”x 23km Pipeline designed to transport export quality crude from the Flowstation to the platform. The pipeline consists of the following facilities;
  - Pig Launcher
  - Pig Receiver
  - Pipeline
  - Shutdown Systems

Crude Transfer System Process

After pumped onshore, the oil is transported to subsea pipeline and then to Crude Transfer Platform, One floating hose, finally to oil tanker. When oil loading operation is finished each time, there will be a number of crude oil staying in pipeline until the next oil loading. Typical Crude Transfer Facility showed as below:

- The FSO will be anchored 50 Meters away from the Platform Location to avoid the platform from weather wane.
- FSO will be moored by using B1 (Buoy 1) and B2 (Buoy 2).
- The Floating Hose will be connected from the Platform Flange to FSO by using Cam Lock Coupling.
- Tug Boat will be at Boat Landing to support the Operation incase required.
- Once the Operation completed, the floating hose flange will be Blinded and lowered down on the sea surface.

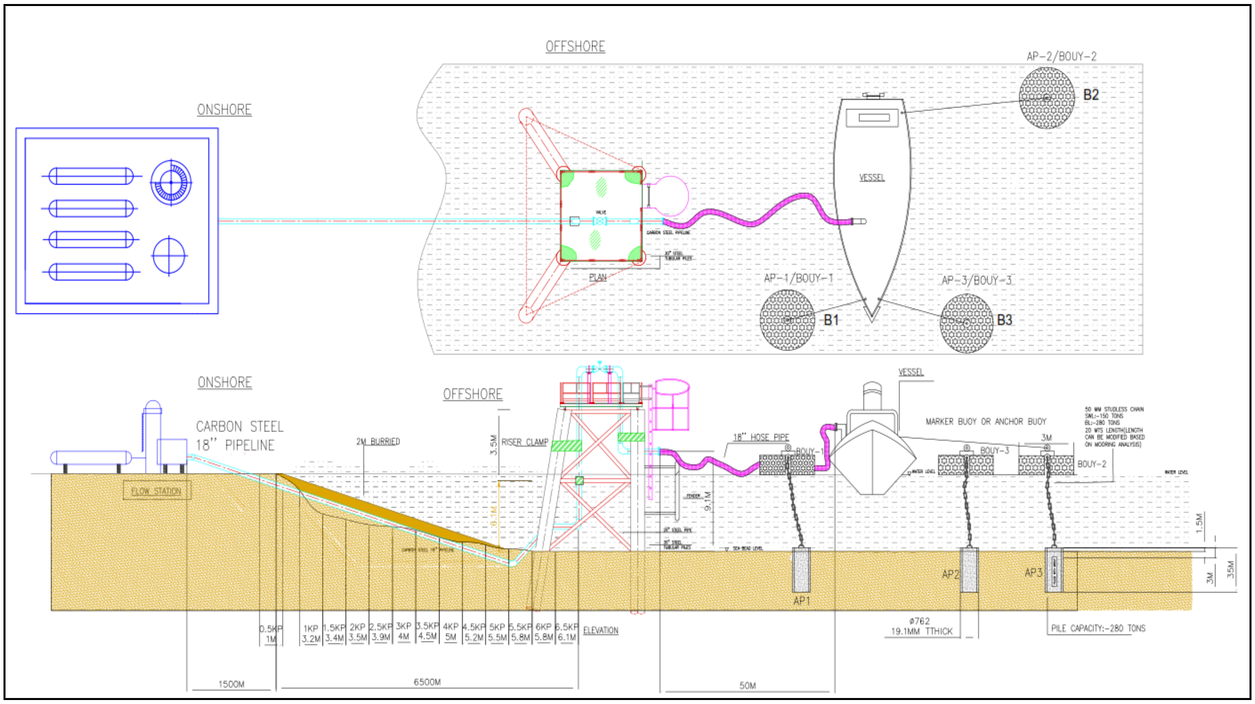


Figure 3.6: Typical Crude Transfer System

Submarine Pipeline System

After pumped onshore, the oil is transported through subsea pipeline and then to SGV moored 50 Meters away from Crude Transfer Platform via Floating hose.

- Tentative Onshore length = 1.5 to 2 Km
- Offshore Length = 8 to 9 Km

Selection of Wall Thickess of Subsea Pipeline

General

The nominal wall thickness of the pipeline and riser shall be verified for adequacy in accordance with the requirement of the applied design codes, standard and specifications.

Design Criteria

The wall thickness selection shall be performed based on DNV 1981 & ASME B31.4. The pipeline and riser shall be checked against the following possible modes of failure:

The nominal wall thickness calculation for rigid pipelines is based on satisfying the following requirements in accordance with DNV 1981

Internal Pressure Containment;
Local Buckling (for rigid pipelines only);
Buckle Initiation (for rigid pipelines only);
Propagation Buckling (for rigid pipelines only);
Propagation Buckling (for rigid pipelines only);
Hydrostatic Collapse.

Selection of CWC Thickness on Bottom Stability

DNV On bottom stability analysis shall be performed to ensure the stability of the pipeline, when exposed to wave and current forces. On bottom stability shall generally obtained by increasing the submerged weight of the pipe by concrete coating.

Subsea pipeline shall be coated with concrete coating. The density of concrete coating is 3040 kg/m3

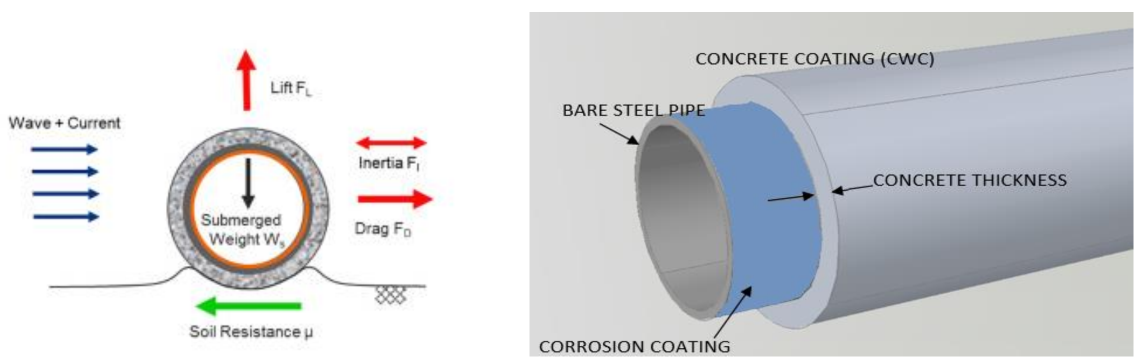


Figure 3.7: Typical protection schemes for subsea pipeline

Based on the above protection schemes, subsea pipeline satisfies the requirement of on bottom stability for all design conditions i.e. both Vertical Stability and Horizontal stability.

Table 3.4: Proposed Subsea Pipeline Design Conditions

Item	Unit	Value
Outside diameter	mm	457.2
Wall thickness	mm	17.5
Material grade	-	API 5L PSL 2 X-60
Fabrication	-	SAWL
Anti-corrosion coating material	-	3LPE
Anti-corrosion coating thickness	mm	3.5
Anti-corrosion coating density	Kg/m3	940
Concrete coating thickness	mm	30 (Tentative)
Concrete coating density	Kg/m3	3040
Maximum flow rate	BPH	10000
Design pressure	N/mm2	8
Hydro test pressure	N/mm2	12
Design temperature	oC	50

Platform Description

The platform is comprised of Jacket, Deck with Piping and safety equipment, Boat landing and 3 Nos Mooring Buoys

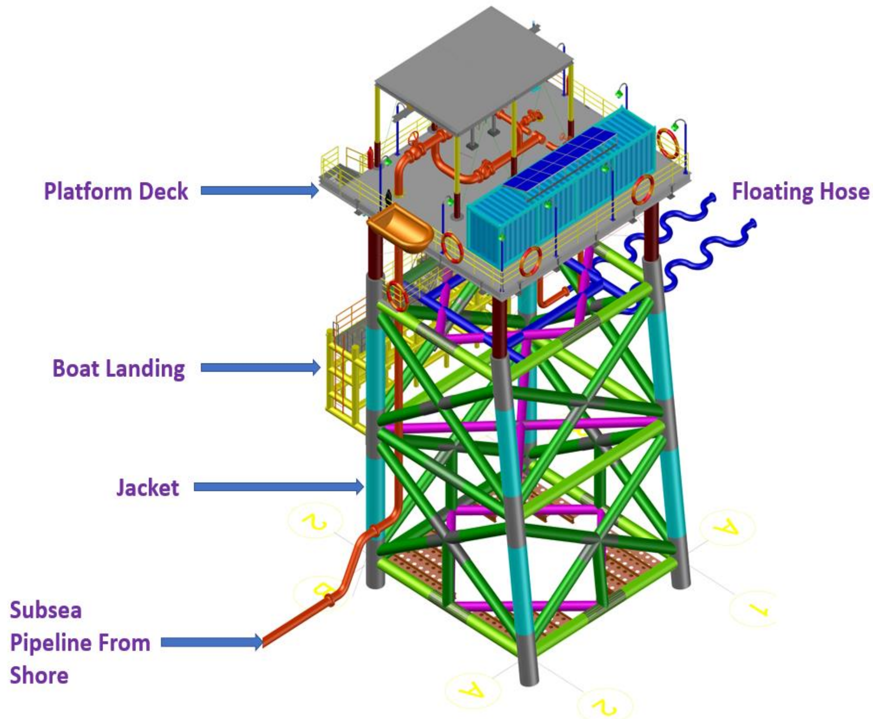


Figure 3.8: Typical Platform

Jacket

Jacket refers to the steel frame supporting the deck and the topsides in a fixed offshore platform.

Platforms are fixed and their deck is supported by a steel tubular structure having its feet on the seabed. This steel tubular structure is called the jacket.

The tubular structure of a jacket is designed to support multiple constraints:

- Weight of the processing equipment (topsides)
- Impact of the waves
- Pressure of the wind on the topsides
- Flow of the sea water streams and tides
- Corrosion
- Fatigue effect
- Life cycle time

Boat Landing

Boat landings on fixed offshore platforms are designed to absorb the impact energy from the boats approaching the platform for crew transfer.

Deck

- Deck refers to the upper half of the structure, above the sea level, outside the splash zone, on which equipment are installed.
- Deck will contain the piping and valve systems to control the flow of Crude oil.
- Air Tugger winch (which can be operated by the Tug boat air Hose) will be installed on the Deck.

Safety

- Safety Equipment like Spider Ladder, Fire Extinguisher, Swing Rope, Life Raft will be available on the Deck.

Mooring Pile

- Each Mooring pile will have the design capacity considering the adverse mooring load under worst weather condition.
- Normal mooring will be done on B1 (Buoy 1), B2 (Buoy 2).
- In addition any unusual change in wind direction will be countered by B3 (Buoy 3).

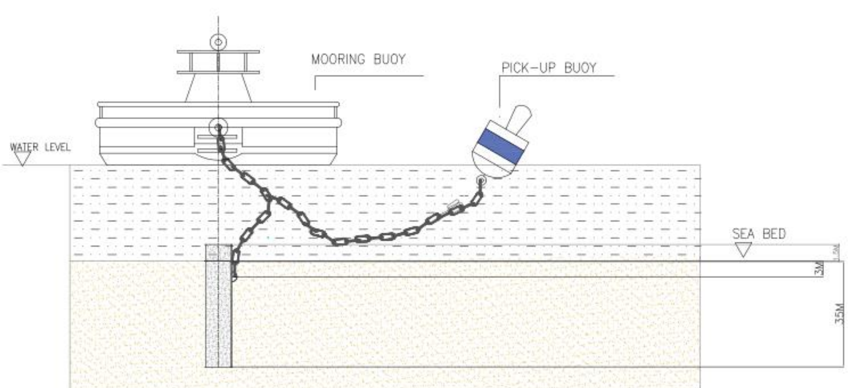


Figure 3.8: Proposed Mooring pile sketch

Floating Hose

- The connection of the FSO with the Platform flange is made by the use of floating hose strings.
- OCIMF GMPHOM 2009, Guide to Manufacturing and Purchasing of Floating Hoses.
- 18 inch Diameter and 60 M length Floating hose will be used.

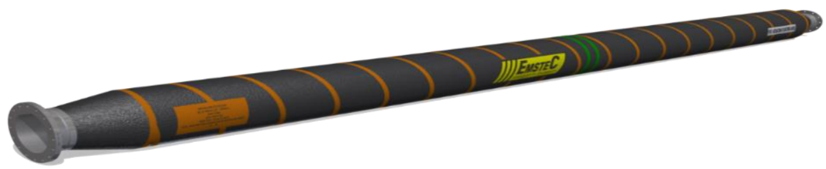


Figure 3.8: Floating Hose

Camlock Coupling:

- Camlock coupling will be used to connect the Floating hose end with FSO.
- Camlock Coupling is a form of hose coupling. This kind of coupling will be used because, it is a simple and reliable means of connecting and disconnecting hoses quickly.

Figure 3.8: Typical Camlock Coupler

B. Early Field Production Facility (EPF)/ Flow Station

Early Production Facility (EPF)

The early production facility (EPF) will be a fully manned facility designed to process 30,000 BLPDof hydrocarbon fluid and 40mmscfd of gas. It is to be located near Iko town with coordinates 4^0 32’11.42” N & $7^0$48’6.21” E. The capacity will be scaled up to 60,000bbls/day of LIQUID and 80mmscfd of gas as operation increases. The overall intent will be to commingle 3 phase hydrocarbon fluid flowing from the various wellheads and direct them in the oil and gas trains for separation.

The commingled hydrocarbon fluid is processed in the Oil and Gas trains to be used for Oil, Gas and produced water separation. by separation into 3 distinct phase of Oil, Water and Gas. The separated gas will be utilised for gas injection, power generation, while negligible amount goes for flare DURING EMERGENCY CASES

The separated produced water is treated in the Water Treatment System and is reinjected into the reservoir via dedicated wells. Two tanks of 30,000 BBL capacity will be dedicated for the produced water storage.

The Crude oil is treated to export quality and is stored in the dedicated tanks with about 400,000 BBLS capacity Storages, from where it is exported via the crude transfer platform

Personnel accommodation has also been provided as part of the facility. The accommodation is located at a suitable distance from the process systems to prevent the escalation of hazardous event and minimize the risk to personnel.

The EPF will consist of the following Process and Utility Equipment;

- Flowlines
- Inlet Manifold
- Test Separator
- HP Separator
- IP Separator
- LP Pre- heater
- LP Separator
- Feed bottom exchanger

- CSU column
- CSU re-boiler
- Run down cooler
- Cooling tower
- Hot Oil package
- Export Pumps
- Booster compressors
- Dew Point unit
- MEG regen unit
- Injection compressors
- Relief and Flare Systems
- Water Treatment Systems
- Water Injection Systems
- Tank farm
- Instrument Air Systems
- Fuel Gas Systems
- Gas Generators
- Utility water system
- Fire and Gas Detection Systems
- Fire Fighting Systems
- Emergency Shutdown Systems
- Metering System
- Drain system

In conceptualizing the facilities development and exploitation of OML 13 Block, the operator took cognizance of the following key issues:

- Acquisition of a suitable location (available) for citing the separation facility. Utmost criteria include that proposed site is plain land with good connectivity and close to existing infrastructure.

- Skid mounted Modular Separation facility of optimum sizing, engineered to the specific application of the field's fluids and profiles, proven standard equipment, cost effective and simple to operate.
- Selection of suitable pipeline route, size and surface flow assurance to meet the design and operational requirements.
- Overall economics.

Concept Selection

The concept was developed to maximize the utilization of the existing infrastructure and also to exploit the crude optimally, so that the CAPEX for facilities contained to minimum. As part of the development philosophy of the Utapate field, the operator intends to put the field into production as soon as possible. Because of the terrain, the facilities will commence with early field production facility (EPF) to achieve the target and to assess the field potential with enough data for further development. Consequently, the facilities and offtake plan include the following;

- EPF of 10-15 bbls/day
- Flowlines/Pipelines – 4"-6", 8", 10", 12", 18"
- Fixed storage system
- Hold platform/ Loading system
- Shuttle barges/vessels/FSO

Hazards and Effects Identification

Risks and effects from the identified hazards will be evaluated against standardized screening criteria considering probabilities of occurrence and severity of consequence for people, assets, the environment and reputation. An HSE Risk Matrix will be used in conjunction with the judgment of experienced personnel to identify those areas of risk that need to be managed.

The essential steps that will be taken in the risk / hazard management are as follows:

- Identify hazards and effects
- Establish screening criteria
- Evaluate hazards and effects

- Document significant hazards and effects and apply legal or other standards
- Set detailed objectives and performance criteria
- Identify and evaluate risk reduction measures
- Implement selected risk reduction measures

Project Schedule

Field development programmes are expected to commence as soon as statutory permits including environmental impact assessment permit are obtained. The operator intends to put the field into production soonest to achieve its target and to assess the field potential with enough data for further development.

Network Modelling – Data Input & Methodology

The data used for the facilities sizing and process equipment requirement are presented as follows.

Production Profiles and Flowing Wellhead Conditions

Based on Utapate field development profiles, the following sizing basis is applied:

- Oil facilities sized for 50 - 60 Mbbl/d (initial EPF for 2 x 30 Mbbl/d EPF for Phase-I),

- Water injection facilities sized for 30,000 stb/d (as per water injection profiles; Initial EPF water processing, injection capacity for 15 – 20 Mbbl/d),

- Gas injection facilities for 60 MMscf/d.

Fluid Compositions

The well fluid compositions[32] vary across the field, and selections are presented in

Table 3.5 Example of varying Fluid Compositions

D8000 Fluid Compositions		
Comp	Mol%	MW (g/mol)
N_2	0.0	28.0
CO_2	1.3	44.0
H_2S	0.0	34.1
C_1	49.6	16.0
C2	2.4	30.1
C3	3.3	44.1
iC_4	4.7	58.1
nC_4	3.6	58.1
iC_5	2.4	72.2
nC_5	1.1	72.2
C_6	1.6	86.2
C_7+	29.9	194.9

E2000 Fluid Compositions		
Comp	Mol%	MW (g/mol)
N_2	0	28
CO_2	2.2	44
H_2S	0	34.1
C_1	52.6	16
C2	2.7	30.1
C3	2.3	44.1
iC_4	5.6	58.1
nC_4	4.6	58.1
iC_5	2.8	72.2
nC_5	1.4	72.2
C_6	2	86.2
C_7+	23.9	176.1

E5000 Fluid Compositions		
Comp	Mol%	MW (g/mol)
N_2	0.0	28.0
CO_2	5.6	44.0
H_2S	0.0	34.1
C_1	55.7	16.0
C2	3.5	30.1
C3	3.9	44.1
iC_4	2.9	58.1
nC_4	4.2	58.1
iC_5	1.7	72.2
nC_5	1.3	72.2
C_6	1.4	86.2
C_7+	19.9	176.1

Arrival Pressure at Terminals

The following arrival pressures are applied for fluid delivery:

- Injection wellhead = 4,000 psia,
- EPF reception pressure = 900 psia
- Offshore Platform for tanker connection = 45 psia,
- Water injection wellhead pressure = 2450 psia.

Modelling Approach (Phase-I)

A fluid gathering network model to is constructed using PIPESIM-Net to determine in-field flowline sizes between wellheads and a central EPF. The model has at its inputs:

- Well flowrates (oil, water and gas),
- Well flowing wellhead pressure and temperature,
- Flowline configuration – id, distance and roughness,
- Arrival pressure at the cpf,
- Gas injection wellhead,
- Arrival pressure at water injection wellhead.

Separate models were constructed for the export pipeline to the SMB and injection wellhead.

Outputs from the models include the following:

- Sizing of Infield flowlines,
- Sizing of gas injection line(s) and compression required to injection well (injection well assumed < 1 km from EPF location),
- Checked the deliverability of the profile flowrates to EPF and terminal,
- In field flowline from EPF to oil storage (or barge),
- Size of water injection flowline (injection well assumed < 1 km from settle tanks)
- Discharge pressure for water injection pumps.

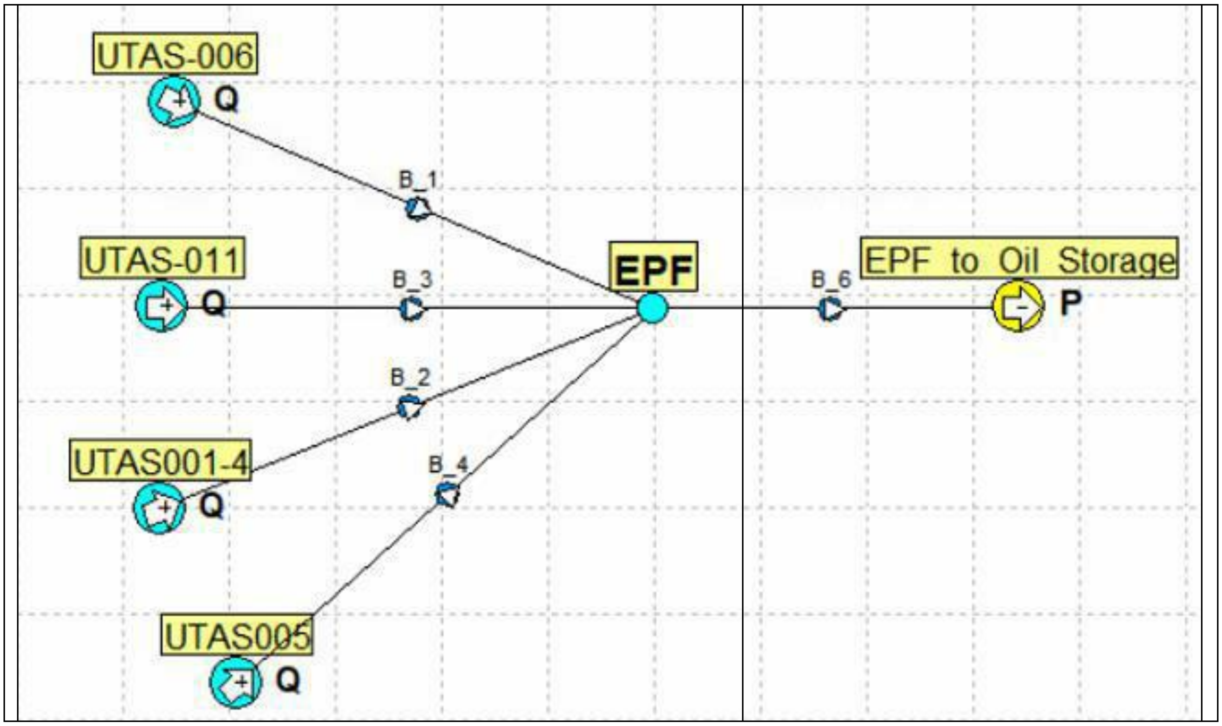


Figure 3.12: Phase-I Network Model with Oil to Storage

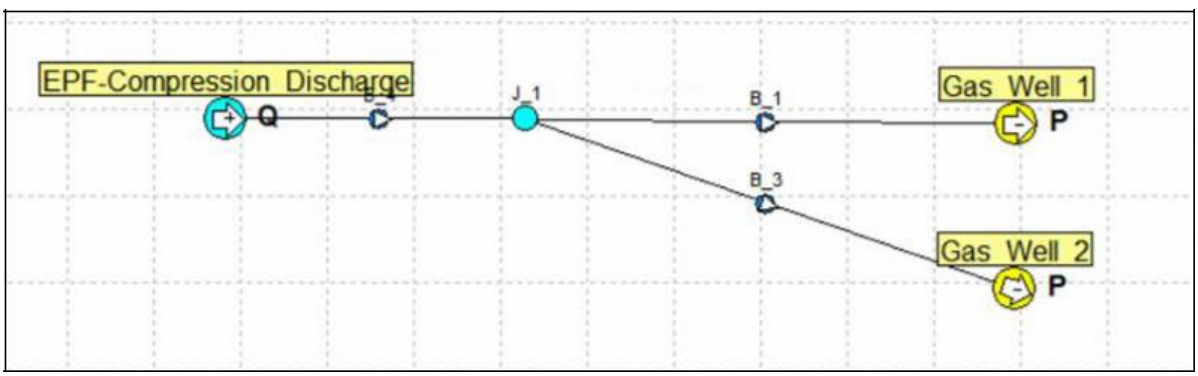


Figure 3.13: Phase-I Network Model with Gas to Injection wells

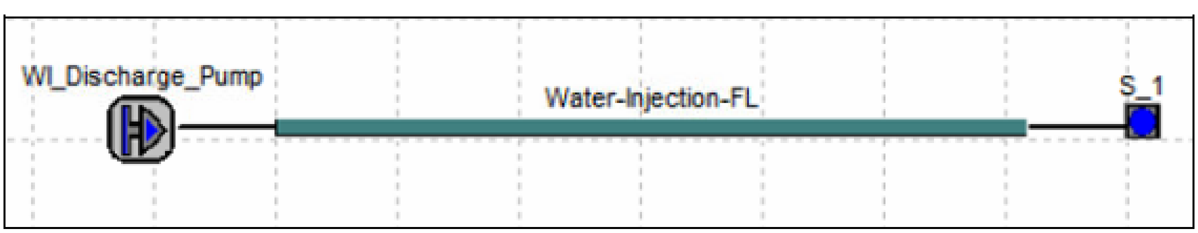


Figure 3.14: Phase-I Water Injection Model

Modelling Approach (Phase-II)

Phase-II model comprises the addition of all producing wells to the Phase-I model and the inclusion of a pipeline export pipeline to an offshore SBM point. The model has at its inputs:

- well flowrates (oil, water and gas),
- well flowing wellhead pressure and temperature,
- flowline configuration – ID, distance and roughness,
- arrival pressure at the flowstation (assumed same as EPF),
- arrival pressure at SMB,
- arrival pressure at water injection wellhead.

The export oil pipeline is sized for 1,000,000 stb/d based on the requirement to load a 1 MMbbl tanker within 1-day. Outputs from the models include the following:

- sizing of additional Infield flowlines,
- sizing of oil export pipeline to offshore SBM,
- checked the deliverability of the profile flowrates to flowstation,
- in field flowline from EPF to oil storage (or onsite oil terminal),
- size of water injection flowline (injection well assumed <1km from settle tanks),

- discharge pressure for water injection pumps.

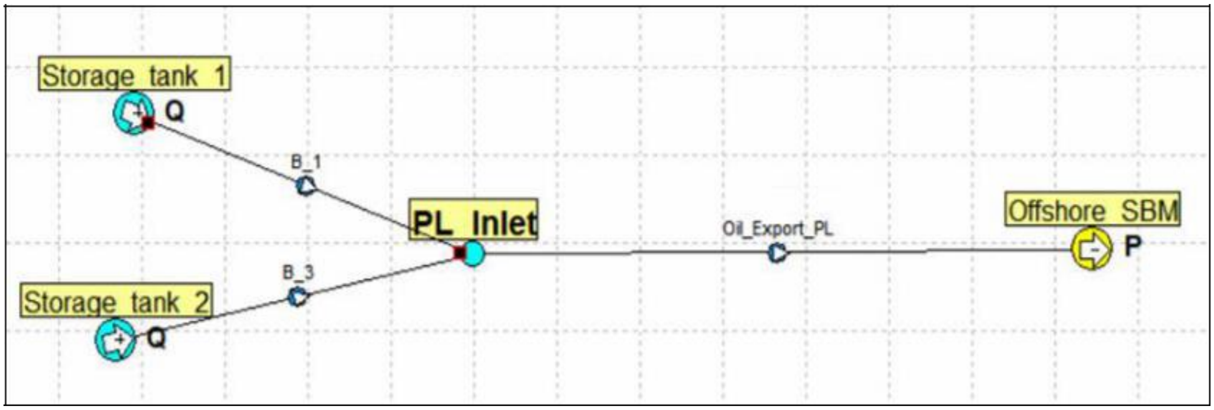


Figure 3.15: Phase-II Network Model for Oil Export to Offshore SBM

Proposed Phase-I Surface Development Description

The proposed Phase-I development option with first oil in January 2020 is selected based on the following guiding premises and objectives:

- Minimize the construction of additional infrastructure (flowlines, processing facilities and roads)

- Minimize the facilities and equipment installation scope.

- No flaring

On the above basis, the following is the decision sequence and outcome:

- An early production facility will be required.
- The selected option should exclude the need for construction and installation of an export pipelines for oil and/or gas evacuation.
- With no oil export pipeline, a storage-and-evacuation strategy will be adopted.

- A tank barge located within proximity of the field will be required for crude storage and avoid the need for immediate construction of storage tanks
- Evacuation will be by shuttle tankers along the Imo River Estuary to an offshore storage. If it is confirmed that commutable road access between the field and terminal exists, shuttle via road tankers could be looked at subject to safety/security, regulatory limitations and ability of nearby terminal to receive road-tanked crude.
- Qua-Iboe River terminal evacuation is dropped due to high tide towards west of Qua-Iboe, Site consideration and the cut-open beach situation.
- Shuttle tanker delivery is to an offshore storage.
- Location of EPF and tank barge to be optimized to be within proximity of selected wells (a well cluster strategy) with selection based on need to minimize flowline installation and flaring.

Gas re-injection into gas wells with compression provided to deliver the required injection pressure.

Proposed Phase-I Oil Evacuation Solution

The strategy of local cluster processing, storage and evacuation of the produced oil via shuttle tanker is proposed strategy for realizing the 1st oil target. The shuttle barge storage capacity, barge loading/offloading rate, shuttle vessel's speed, the size of crude storage and selected well cluster production rate needs to be balanced to avoid an evacuation bottleneck. presents a simple schematic of the operation. Based on typical vessel speed and pump capacity, the crude evacuation rate is determined. The key parameters for evaluating the evacuation rate are as follows:

- Local storage capacity = 25,000 bbl (minimum or equivalent to 3 – 4 days production),
- Shuttle loading/offloading rate = 450 m^3/hr (2,830 bbl/hr),
- Shuttle speed = 11 knots (20.3 km/hr),
- The distance from the Utapate well location to an FSO located offshore is taken as approximately 20 km.

Based on the above parameters the duration of the main evacuation activities is presented in Table 3.6 for a range of shuttle barge storage volume. The table shows that for the smallest shuttle barge storage of 10,000 barrels, the Utapate Phase-I wells will produce at well below the average offloading rate the outflow rate of 6,900 stb/d for each of the Phase-I option. It is recommended that the storage barge has sufficient capacity for 3 days production. summarises the 'pros' and 'cons' associated with this strategy.

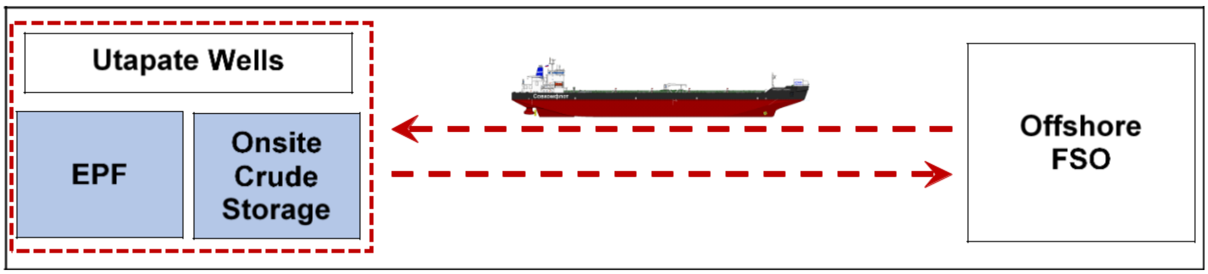


Figure 3.16: Utapate Phase-I oil Evacuation Plan Schematic

Table 3.6: Crude outflow rate for range of Shuttle Barge capacity and pump loading rate

Variable		Value		
		Case-1	**Case-2**	**Case-3**
Shuttle Speed	(km/hr)	20	20	20
Distance	(km)	20	20	20
Shuttle barge Storage	(bbl)	10,000	15,000	20,000
Pump rate	(m^3/hr)	450	450	450

Contingency	(hrs)	24	24	24
Loading/Offloading Time	(hrs)	7.1	10.6	14.1
Travel Time	(hrs)	2.0	2.0	2.0
Time between offloads	(days)	1.4	1.6	1.7
Barrels Outflow Rate	**bbl/d**	7140	9390	11470

Table 3.7: Potential Pros & Cons for Phase-I Evacuation Strategy

Phase-I Option	
PROS	**CONS**
Quick oil production with significant migration of part of CAPEX to OPEX	Evacuation is driven by the reliability and smooth operation of the shuttle barges including both operability and security.
Staged development possible	Oil production directly and intrinsically linked to and limited by gas injection

Proposed Phase-I Gas Evacuation Solution

Gas compression is provided to inject gas into a gas well (or wells) within proximity (< 1 km) from the location of the flowstation. A compression system will be deployed to allow injection of the produced gas with a discharge pressure of 4,000 psia. Fuel gas will also be taken from the discharge of the gas compression allowing a lower separator operating pressure.

Gas Injection Flowline Sizing

For a 4,000 psia discharge pressure from the compressor, it is recommended that ~~6~~ 8 inch flowlines rated for 4,000 x 1.5 psia be used to connect the compressor discharge to the injection wells.

Proposed Phase-I Water Handling Solution

The need for water injection has been identified by the sub-surface analysis. As a result, Utapate water is to be processed for injection into the reservoir. Produced water from the EPF should be routed to settle-out tanks post-processing to allow a buffer for water storage should injection system be offline.

For redundancy and to maintain acceptable uptime it is recommended that multiple discharge pumps be used connecting the settle-out tanks to the injection wells. If one pump is dedicated to a water injection well, the sizing calculations recommend a 4-inch flowline to each wellhead. Each pump should operate with a pressure differential of 70 barg and combined capacity for 50,000 stb/d of water. The water settle tanks should be sized to the water production rate expected over 3 – 4 days. Produced water can also be de-oiled to the regulatory specification for re-injection into the river system of 10ppm oil-in-water. The EPF will need to be equipped for this specification. The possibility for disposal of water to remote location via tanker evacuation also exists however the need for water injection removes this requirement.

Proposed Phase-I Process Equipment Capacities

Oil Processing Capacity

The Oil Processing capacity is to handle an input volumetric flow rate of 50 – 60 MMstb/d.

Gas handling Capacity

The Gas handling capacity is to handle an input volumetric flow rate of 60 MMscfd for re-injection.

Water handling Capacity

The Water processing capacity is to handle an input volumetric flow rate of up to 30,000 stb/d and capacity to inject 50,000 stb/d.

Proposed Phase-II Option Description

Phase-II production facilities are sized for all Utapate wells onstream. For the Phase-II long-term operation of the field, a dedicated flow station, oil storage (or oil terminal for the wider OML 13 producers) and export pipeline will be constructed. The gas will be sold to an SPV.

Proposed Phase-II Oil Evacuation Solution

The internal storage terminal option has been proposed as an option to handle nominal crude storage capacity of 2.0Million barrels comprising of 8 x 250kbbls capacity floating roof tanks. Crude from storage tanks will be pumped, metered and exported via Single Point Mooring (SPM) system designed for mooring ship loading for offloading into a very large crude carrier (VLCC) tanker located at Imo River Estuary.

Oil Export Pipeline Sizing

A 24-inch oil export pipeline is recommended with oil discharge pumps sized for a 90 barg differential pressure and multiple export pumps. shows the designed pipeline pressure profile.

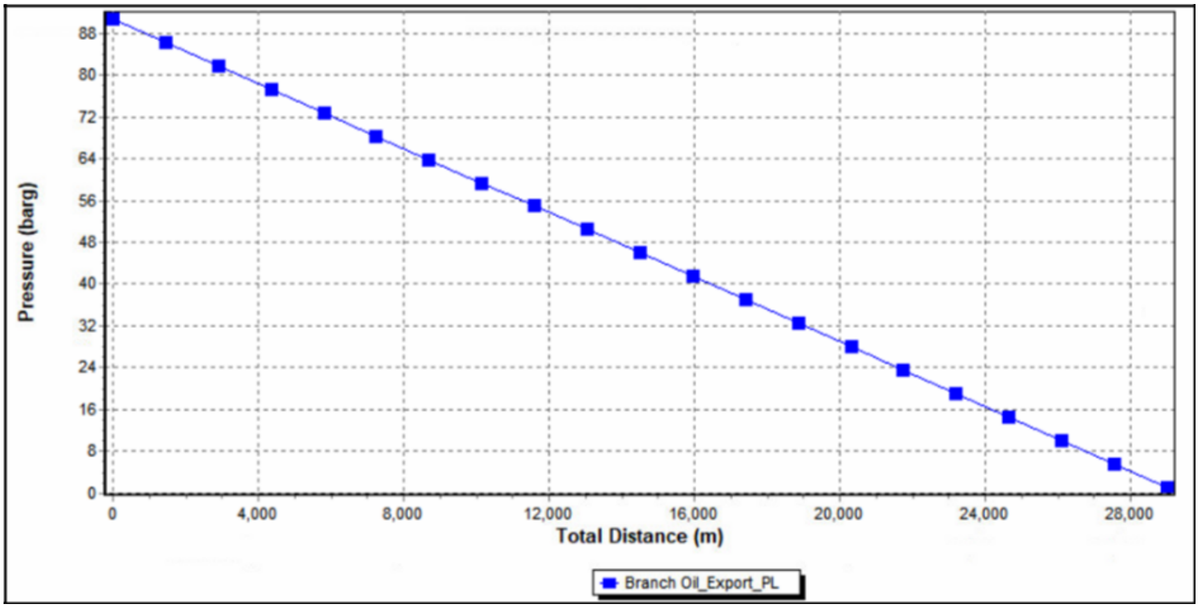


Figure 3.17: Oil Export Pipeline Pressure Profile

Proposed Phase-II Gas Evacuation Solution

Gas monetization and processing will be performed by an SPV.

Proposed Phase-II Process Equipment Capacities

Oil Processing Capacity

The Oil Processing capacity is to handle an input volumetric flow rate of 50 – 60 Mbbl/d.

9.4.4.2 Gas handling Capacity

The Gas handling capacity is to handle an input volumetric flow rate of up to 200 MMscfd (AG+NAG) to SPV as unprocessed raw gas

Water handling Capacity

The Water processing capacity is to handle an input volumetric flow rate 20,000 stb/d and capacity to inject 50,000 stb/d.

Proposed Phase-II Water Handling Solutions

- Treatment and used for water injection into wells for Pressure maintenance as per Phase-I

- Possibility for treatment and disposal through Pipeline to Open Pond and disposal to onshore via tanker evacuation.

- Treatment and disposal via FSO to sea.

Abandonment Strategy

The OML 13 Utapate assets comprising of wells, surface facilities, flowlines, trunk lines etc., which have reached the end of their economic life, shall be abandoned in conformity with statutory requirements (DPR, Federal Ministry of Environment). Field site shall be restored to environmentally safe and clean condition prior to returning to their original owners/ communities. The ultimate intent is to restore the host environment as close as possible to what existed before emplacement of the facilities. The process shall ensure that no residual risk to life and the environment is left behind after the abandonment. At the end of the fields' life the wells will be properly abandoned to eliminate any possibility migration from normally pressured zones (water or hydrocarbon) to depleted reservoirs or to the surface. Prior to abandonment, pipings and equipment shall be positively isolated from sources of hydrocarbon and cleared of their hydrocarbon inventories using environmentally friendly substances (water, nitrogen, non-toxic foam, etc.) for the flushing / purging. Effluents shall be received at locations where they can be safely managed and where they can do the least damage to the environment.

The operator plans to set up a decommissioning team to plan and implement decommissioning activities, which include but not limited to:

- Wells Decommissioning

- Facilities Decommissioning

- Demolition and site clean-up
- Disposal of wastes
- Rehabilitation of site

Production Facilities Abandonment

The Production facilities will be decommissioned when it is no longer economical to continue production or when they are no longer required.

The facilities design will incorporate abandonment considerations where applicable. All vessels shall be removed intact with their skids where applicable. The abandonment scope will involve total removal of the host. The Process system will be purged of all hydrocarbons. The facilities will be disconnected and disposed in one of the several ways

- refurbished and reused
- sold for reuse
- scrapped onshore

Production and Injection Wells Abandonment

The Utapate field is planned for re-development with an extended field life. License expiry is currently 2037 and many of the wells are expected to be operational at that date. There are no immediate plans to abandon any of the wells. However, as the wells reach their economical limit, they will be abandoned in line with NPDC/DPR/NAPIMS Field asset abandonment regulations. Wells will be abandoned at the end of their respective fields' life to eliminate any migration of water or hydrocarbon from pressurized zone to depleted reservoirs or surface. As a standard, completion string and accessories will be retrieved, all perforations squeezed or plugged off with a back-up mechanical barrier for well or formation isolation. Casing will be cut and retrieved as much as possible. Cement plug will be set in the well from depth of 100 ft to surface. All wellhead equipment will be removed. The surface casing will be cut and a ½" plate (complete with ¼" needle valve) welded on top of the casing for observation. At the end of observation period, all the dredge surface locations should be rehabilitated throughout appropriate fill backs and re-vegetation.

Production Flowlines Abandonment

At the end of field life, the flowline system will be depressurized and flushed to remove traces of oil and ensure a safe and pollution free end to production. Where underground flowlines are to be left in place. It shall not be mothballed except it is determined that it has useful life left and there is a possible future use for it.

CHAPTER FOUR

DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1: General

Environmental Impact Assessment procedure involves the use of adequately planned and well structured analyses to establish the environmental condition of the proposed project area. This environmental status will provide the basis for identification of potential impacts of the project activities on ecological system and the resource use of the area. In addition, information on the existing environmental status of the proposed project area shall serve as a reference data for further studies and environmental monitoring. This chapter presents the environmental baseline description of the proposed Utapete Field Development Project (FDP) Area. The details of the methodologies adopted for data acquisition for each of the environmental components and the Impact indicators are described in Appendix 2.

4.2: Data Acquisition

The ecological, social and health data was produced using a two-season field data gathering exercise carried out between Thursday 19th to 2nd October 2019 for the wet season and January 26th to 31st, 2020 for the dry season. Data was acquired on vegetation, soil, air quality/noise, sediment, surface and ground water, socio-economics and health. A multi-disciplinary approach was employed in the acquisition of baseline data of the proposed project area. Desktop research was carried out to augment information obtained from the field data gathering. Relevant textbooks, articles, research publications, previous study reports were adequately searched to generate the desktop information. The data generated from these processes include maps, demographic data, and meteorological data of the study area.

4.3: Baseline Environmental Conditions

4.3.1 Climate and Meteorology

The study area is in south-south parts of Nigeria sharing the same climatic condition with Uyo, the Akwa Ibom State capital. Using the 30-year climatic data (1985 – 2014) of Uyo obtained from the Nigerian Meteorological Agency (NIMET, 2016), the proposed project location has climate characterized with both the dry and wet seasons associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. Its annual rainfall varies from 3200 to 5100 mm with monthly levels of 19.0 – 349.9 mm (Figure 4.1) coming in every month of the year.

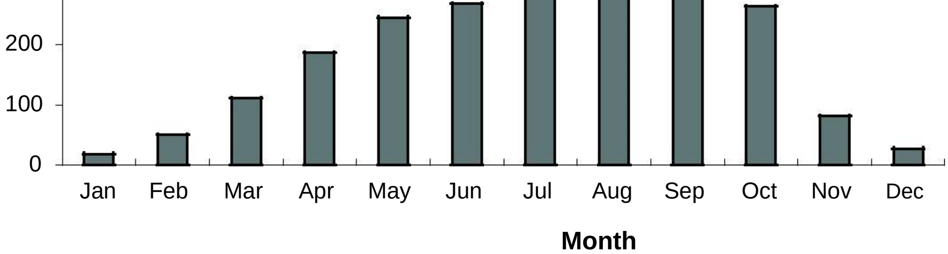


Fig. 4.1: Thirty Years (1985 – 2014) Rainfall in the Study Area (NIMET, 2016)

Relative Humidity

The mean relative humidity of the study area ranges between 75 and 90% using the 30-year climatic data from NIMET (Figure 4.2) with the mean monthly level indicating June through September as wettest and December through March as driest. The relative humidity range of 62.9 – 84.3% with an average of 73.6% obtained during the fieldwork (Table 4.1) agrees with the climatic data.

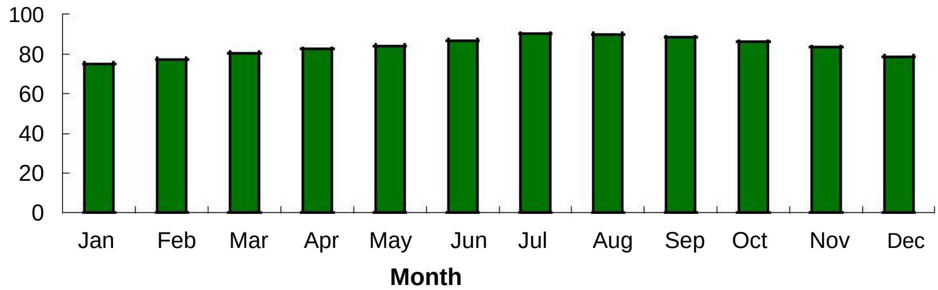


Fig. 4.2: Thirty Years (1985 – 2014) Relative Humidity in the Area (NIMET, 2016)

Table 4.1a: Field Measured Meteorological Parameters in the Study Area (Wet season)

Parameter	Study influence Area			Control 1	Control 2
	Min	Max	Mean	Mean	Mean
Temp (˚C)	26.3	34.9	31.5	33	32.4
Wind speed (m/s)	0.2	3.6	1.7	3.3	0.4
Humidity (%)	62.9	84.3	73.6	59	85.1
Wind Direction	NE	SW		SW	SW

Source: Osten Laboratory Limited (wet Season (September 2019))

Table 4.1b: Field Measured Meteorological Parameters in the Study Area (Dry season)

Parameter	Study influence Area			Control 1	Control 2
	Min	Max	Mean	Mean	Mean
Temp (˚C)	30.4	36.8	32.9	31.8	32.4
Wind speed (m/s)	0.4	3.3	1.5	0.9	0.6
Humidity (%)	48.3	89.2	68.5	63	73
Wind Direction	NE	SW		SW	SW

Air Temperature

The minimum air temperatures in the proposed project area are 22.2 – 24.0 °C with a mean of 23.1 °C while its maximum levels are 28.3 – 31.6 °C with an average of 31.6 °C (Figure 4.3). The highest air temperature occurs between January and March while the lowest is between June and August. The period of the highest air temperature falls in the dry season of the area and the lowest air temperature are observed to be in the wet season of the year. The lowest temperature during the wet season is attributed to the depletion of incoming solar radiation by greater cloud cover. During the field study, the measured air temperature was 26.3 – 34.9°C with an average of 31.5°C (Table 4.1) which agrees with the temperature variation of the study area.

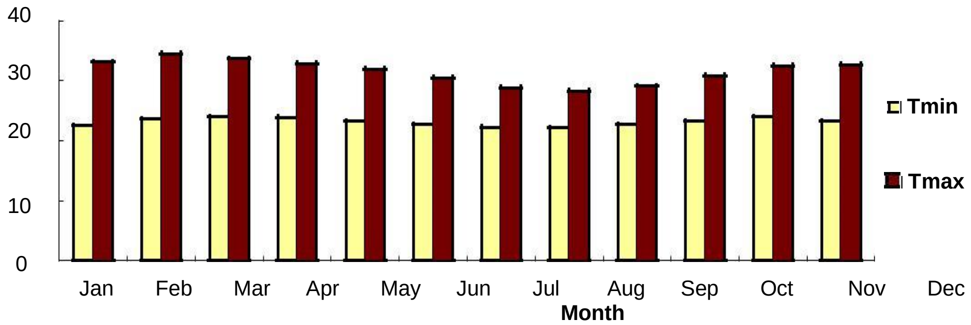


Fig. 4.3: Thirty Years (1985 – 2014) Air Temperature in the Study Area (NIMET, 2016)

Sunshine

As presented in Figure 4.4 the proposed project area experiences sunshine of about 2.7 – 6.3 hours per day with daily average of 4.8 hours. While the minimum sunshine period is in August, the peak of the wet season, the maximum period comes in November which is the dry season.

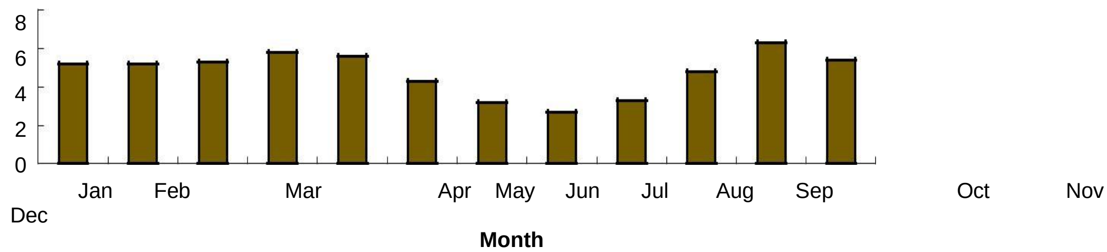


Fig. 4.4: Thirty Years (1985 – 2014) Sunshine Period in the Study Area (NIMET, 2016)

Wind Pattern

Surface wind speed in the area is characterized by small diurnal variation influenced by both land and sea breezes resulting from the alternate warming of the land and sea. It reaches maximum level during the night due to radiation cooling leading to instability in the surface layer. Its two major wind regimes are the northeast and the southwest Trade Winds as earlier indicated and these are similar to the predominant wind pattern observed during the field study (Table 4.1). As presented in Figure 4.5, the mean monthly wind speed of the area can be described as light air (0.1 – 2.0 m/sec) followed by light breeze (2.1 – 3.0 m/sec), gentle breeze (3.1 – 6.0 m/sec), moderate breeze (6.1 – 8.0 m/s), and fresh breeze (8.0 – 11.0 m/s). Winds above 11 m/sec called the strong gale also occur but only during thunderstorms. During this study, the wind speed ranged between 0.2 and 3.6 m/s with an average of 1.7 m/s with southwest and northwest prevailing directions (Table 4.1).These fall within the climatic wind data of the area.

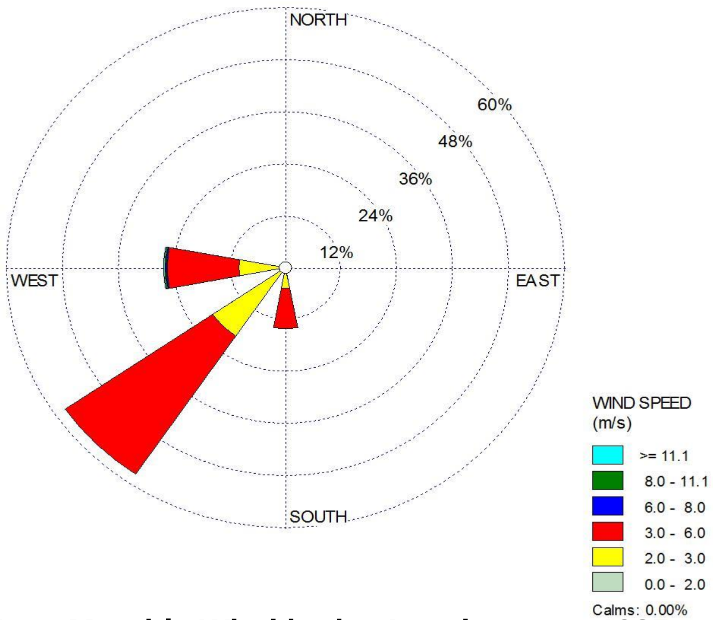


Fig. 4.5: Mean Monthly Wind in the Area between 1985 and 20014 (NIMET, 2016)

4.3.2: Air Quality

In this aspect of the study, some air pollutants were monitored, including Suspended Particulate Matter (SPM), Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), Methane (CH_4), hydrogen sulphide (H_2S) and VOC to evaluate the state of air quality in the project area. Air pollutants concentration observed during the field work at the selected sites are presented in Table 4.2a and Appendix II.

Air Quality Assessment

A summary of the measured concentrations of gaseous pollutants obtained during the study is presented in Table 4.2a and b while the detailed results are presented in Appendix 3. The regulatory limits for these parameters are presented in Table 4.2c for FMEnv and Tables 4.2d and 4.2e for DPR and WHO respectively. In this study, CH_4, SO2, VOC and H_2S were not detected (<0.01 ppm). Carbon monoxide concentrations were low, Mean CO concentration was 0.02±0.14 ppm and 0.074±0.255 ppm in wet and dry season respectively. In all the sampling locations, the daily CO concentrations were within the 10 ppm limit of both the Federal Ministry of Environment (FMEnv) and that of the Department of Petroleum Resources (DPR). The daily SO2 equivalents of the measured concentrations were within its 0.01 ppm FMEnv limit and within the 100 – 150 µg/m^3 (0.04 – 0.06 ppm) DPR limit. Similarly the daily NO2 in the study area were within its 75 – 113 µg/m^3 (0.04 – 0.06 ppm) FMEnv limit and its 150 µg/m^3 (0.08 ppm).

Mean NOx concentration was below 0.001 ppm in the wet season but was 0.002±0.003 ppm in the dry season. NOx was mostly undetected in the control stations except in the wet season (AQN C1 – 0.005 ppm).

Table 4.2a: Measured Air Pollutants Concentrations in and around the Study Area (Wet season)

Parameter	Study influence Area			Control 1	Control 2
	Min	Max	Mean	Mean	Mean
$SPM_{2.5µm}$(µg/m³)	4.10	28.20	8.91±4.92	4.3	5.0
$SPM_{10µm}$(µg/m³)	12.90	76.60	36.76±25.30	18.9	33.7
Methane (ppm)	<0.001	<0.001	ND	<0.001	<0.001
NO_2 (ppm)	<0.001	0.02	<0.001	0.005	<0.001
H_2S (ppm)	<0.001	<0.001	ND	<0.001	<0.001
SO_2 (ppm)	<0.001	<0.001	ND	<0.001	<0.001
CO (ppm)	<0.001	1.00	0.02±0.14	<0.001	<0.001
VOC (ppm)	<0.001	0.01	<0.001	<0.001	<0.001
Noise (dB(A))	35.60	80.60	56.42±12.10	39.7	76.0

Table 4.2b: Measured Air Pollutants Concentrations in and around the Study Area (Dry season)

Parameter	Study influence Area			Control 1	Control 2
	Min	**Max**	**Mean**	**Mean**	**Mean**
$SPM_{2.5µm}$(µg/m³)	5.5	39.0	14.23±7.36	9.0	13.1
$SPM_{10µm}$(µg/m³)	19.2	145	59.84±26.08	52.0	59.0
Methane (ppm)	<0.001	0.02	0.001±0.003	<0.001	<0.001
NO_2 (ppm)	<0.001	0.012	0.002±0.003	<0.001	0.001
H_2S (ppm)	<0.001	0.004	<0.001	<0.001	<0.001
SO_2 (ppm)	<0.001	0.006	0.001±0.002	<0.001	<0.001
CO (ppm)	<0.001	1.1	0.074±0.255	<0.001	<0.001
VOC (ppm)	<0.001	0.003	<0.001	<0.001	<0.001
Noise (dB(A))	33.5	88.6	54.85±10.18	48.5	93.1

Particulates Pollutants

Suspended particulate matter (SPM) was detected in all the sampling locations during the study (Tables 4.2a and b). In the project site, the measured SPM concentrations mean in the wet and dry seasons were 8.91µg/m³ and 14.23µg/m³ for $SPM_{2.5}$, and 36.76µg/m³ and 59.84µg/m³ for SPM_{10} respectively. Their 24-hour extrapolated mean concentrations are 2.67 and 4.27 µg/m³ for $SPM_{2.5}$, and 11.03 and 17.95 µg/m³ for SPM_{10} respectively. Both particulate fractions are within WHO 25 and 50 µg/m³ daily limits for $SPM_{2.5}$ and SPM_{10} grade particles respectively. Though the measured particulates concentrations were slightly higher in the proposed project site than at the Control sites, the 600 µg/m³ TSP 1-hour limit of the Federal Ministry of Environment was not breached in any of the sampling locations.

The measured gaseous pollutants concentrations at the proposed project area were similar to what were obtained at the control sites. Since, VOCs CO and SPM could also be the products of combustion in the atmospheric environment, their detection in the proposed site and at the control points could be attributed to vehicular emissions and electric power generators, domestic cooking activities and domestic waste burning were additional sources identified during the study. Other source includes dust resuspension.

Investigated Air shed Classification

Since all the monitored air pollutants were within their set limits, the study area airshed can be classified as un-degraded airshed using the World Bank classification. It can also be described as having a high carrying capacity to sustain activities of the proposed project.

Ambient Noise

As presented in Tables 4.2, the measured ambient noise levels during the The range ambient noise levels during the wet season study was 35.60 – 90.40 dB(A) whereas in the dry season it was 33.5 – 88.6 dB(A). There corresponding mean values were computed to be 56.42 and 54.85 dB(A) which is within the 90 dB(A) 8-hour limit of the FMEnv.

These measured noise levels at the project and control sites are similar and in none of the sampling locations were above the 90 dB(A) shop floor limit of both the Federal Ministry of Environment and the Department of Petroleum Resources was not exceeded in any location in the two seasons.

Distant vehicles/ boat and domestic activities are the major sources of noise observed in the area during the study in addition to the natural sources including wind and river.

Table 4.2c: Nigerian Ambient Air Quality Standard

Pollutants	***Time of Average***	***Limit***
Particulates	Daily average of hourly values Hourly value	250μg/m^3 600*μg/m^3
SO_x as SO_2	Daily average of hourly values Hourly value	0.01ppm (26μg/m^3) 0.1ppm (260μg/m^3)
NO_x as NO_2	Daily average of hourly values (range)	0.04 – 0.06ppm (75-113μg/m^3)
Carbon Monoxide	Daily average of hourly values 8 - hourly range	10ppm (11.4mg/m^3) 20ppm (22.8mg/m^3)
Petrochemical Oxidants	Hourly value	0.66ppm
Non-Methane Hydrocarbon	Daily average of 3-hourly values	160μg/m^3

*Note: Concentration not to be exceeded for more than once a year,
Source: FEPA 1991 (Guideline and Standards for Environmental Pollution Control in Nigeria)

Table 4.2d: DPR National Air Quality Guidelines for Maximum Exposure

POLLUTANT	**1-Hour Mean (μgm^{-3})**	**8-Hour Mean (μgm^{-3})**	**Daily Average/ Mean (μgm^{-3})**	**Annual (μgm^{-3})**
Total SPM	150-230		60-90	
Carbon Monoxide*	30		10	
Sulphur Dioxide	350		100-150	40-60
Nitrogen Dioxide*	400		150	
Lead				0.5 – 1.0

(1)Not to be exceeded more than once per year.
(2)Final rule signed October 15, 2008.
(3)Not to be exceeded more than once per year on average over 3 years.

Table 4.2e: WHO Air Quality Guidelines

Pollutants	Time- Weighted Average [a]	Averaging time
SO_2	500	10min

	300	1h
	100 - 150[b]	24h
	40 - 60[b]	1yr
CO	30	1h
	10	8h
NO_2	400	1h
	150	24h
Total suspended particulates	150 - 230[b]	24hr
	60 - 90[b]	1yr

Source: WHO Air Quality Guidelines

Table 4.2f: Noise Exposure Limits for Nigeria

Duration Per day, hour	Permissible Exposure Limited dB(A)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: FEPA (1991)

4.3.3 Soil and Land Use

Soil Mechanical/Physical Characteristics

Soil physical properties are strongly link to its plasticity, permeability, ease of tillage, fertility, water holding capacity and general soil productivity. As shown in Table 4.3, there is no significant difference between the top (0-15cm) and sub-surface (15-30cm) soil moisture content (SMC). Respective range values for the top and subsurface SMC are 6.42-38.50% and 6.25-39.50%. Furthermore, there is also no significant variation in the mean sampled top and sub-surface soils and the controls. The soil moisture content values are typical of what is obtainable in wetland/swampy area. As expected, the values are higher in first season study (17.72%) compared to the second season study (9.38%), Appendix x1. This difference is strongly linked to seasonal change in rainfall regimes. The mean top and subsurface soil porosity (degree water of permeability) vary between 26.9% and 27.02%. This variation is less significant. However, sampled locations mean porosity values are higher than the control locations.
The dominant particle size was sand which ranged from 25.7 to 95.64% in the surface soils and 24.33 to 97.47% in subsurface. Again, there is no significant variation in the mean values of sand for both the sampled and controls (Table 4.3). Due to the high

sand particle sizes, the study area is prone leaching. Soils with separate high sand and low clay content have high pollutant leaching potentials (Nyles and Ray (1999); silt ranged from 0.65 to 84.05% with means of 38.42% and 0.31 to 47.28% in surface and subsurface soils respectively. the clay range 1.23-100% and 1.05 to 100% with means of 17.6% and 20.69% for surface and subsurface soils respectively in all the samples. The particle distribution shows that there is no significant depth variation in the textural classes in the prescribed study area. This variation was consistent across the stations in the area.
Predominant texture of the soils sampled in the area sandy loam, sandy clay loam and loam in both surface and subsurface soils depending on the processes of soil development and local edaphic conditions. Based on the textural characteristics of high sand and low clay content both at the surface and subsurface, the study area and environs is prone pollutant leaching potentials (Nyles and Ray, 1999). This layer (0-30cm) is the significant zone for microbial activity and major location of essential nutrient elements for plant growth and development, its pollution will adversely affect life forms that thrive within this soil layer.

Table 4.3: Soil Mechanical/Physical Characteristics

Parameter	Range (0-15cm)	Mean (0-15cm)	Range (15-30cm)	Mean (15-30cm)	CM (0-15cm)	CM (15-30cm)
Moisture Content (%)	6.42-38.50	13.55	6.25-39.50	13.59	16.13	14.38
Porosity (%)	12.1-72.11	26.9	13.51-78.80	27.02	24.55	21.74
Clay (%)	1.23-100	17.6	1.05-100	20.69	15.99	16.52
Silt (%)	0.65-84.05	38.42	0.31-47.28	18.45	18.83	23.98
Sand (%)	25.71-95.64	64.3	24.33-97.47	63.15	65.17	59.67
Texture	sl, scl, l	-	sl ,ls,cl	-	Sl, l	Sl,scl

Source: Osten Lab Field Work- OML13, 2019/2020
CM: Control Mean; sl: Sandy Loam, Scl: Sandy clay loam, l: Loam; cl: Clay loam: ls: loamy sand

Physicochemical Characteristics of study area Soils

Summary of results of the physicochemical properties for the study is shown Table 4.4.

Soil pH
pH is a measure of the free H+ and OH- concentration of soil solutions. Significance of soil reaction lies in the fact that it provides a variety of useful information such as extent of H+ formation by hydrolysis of aluminum and degree of dissociation of H+ from cation exchange sites. As shown in Table 3, the pH value range from 3.79-8.18 at the surface and 3.84-8.77 at the subsurface. The mean values therefore are 5.64 and 5.65 at the surface and subsurface respectively. This shows that there is no significant variation in pH values at the two layers of the soil

around the study area. Again, the mean control values are 5.61(surface) and 5.51(subsurface). Therefore, based on soil pH general range and classification as shown in Table 4.4, the soil of the study area and its environs is distinctly acidic in nature. This has implication in supporting soil organisms and availability of macro/ micro nutrients which are the building blocks of sugars and proteins for plants. Such pH condition was linked to high rainfall area exceeding 2200mm per anum and leaching of basic cations from the soil *solum* (Bulktrade, 1989; Schoeneberge et al., 2002). There is no DPR (2002) permissible limit for pH concentration in the soil, however, the mean values are

Table 4.4: General Soil pH Classification

Range	Class
4.5-5.5	Very Acidic
5.5-6.0	Distinctly Acidic
6.0-7.0	Acidic
7.0	Neutral
7.0-7.5	Faintly Alkaline
7.5-8.0	Alkaline
8.0-8.5	Strongly Alkaline
8.5-9.0	Extremely Alkaline

Electric Conductivity (EC)

Conductivity is a measure of the capability of soil to pass an electric current. It is an indication of the concentration of dissolved electrolytes ions. In other words, it is the most common measure of soil salinity and an indicative of the ability of an aqueous solution to carry an electric current. Significant values of EC could be attributed to pollution discharges in the soil. For the study, the EC range from 15 to 371µS/cm at the surface and 19 to 350µS/cm at the subsurface (Table 4.6). Average sampled mean are 123µS/cm and 120µS/cm at the surface and subsurface respectively. However, a slight lower mean EC was observed at the controls. The mean control values at surface and subsurface are 112µS/cm and 109µS/cm respectively. Overall, it was observed that the EC values tend to decree downward the soil both for the study area and controls. All EC values recorded are below critical values of 2000 µS/cm for sensitive crop species (FAO, 1974).

Soil Anions

Nitrogen; is perhaps one of the most important nutrients required by plants and other organisms for growth and development. As shown in Table 5, the nitrate (NO_3) concentrations in soil samples within the project area range from 2.50 to 110mg/kg at the surface and 2.93-110mg/kg at the subsurface. The average values for NO_3 at the surface and subsurface were 20.89 mg/kg and 20.47 mg/kg respectively. On the controls, respective surface and subsurface means are 14.67 mg/kg and 12.4 mg/kg. The mean values within the proposed project area are higher than the controls. In addition, it was also observed that NO_3 decreases with depth for both sampled and controls. Nitrate is a more readily available form of Nitrogen for plant uptake and expresses a fraction of the total Nitrogen present in soil.

Phosphate concentrations ranged from 0.03 to 4.87mg/kg at the surface and from 0.03 to 4.66 mg/kg at the subsurface in soil sampled from the project site; mean values of the surface and subsurface however are 1.01 mg/kg and 0.96mg/kg respectively. The

surface and subsurface mean Phosphate in sampled soils are higher than the controls (Table 4.6). Phosphorus as Phosphate controls a lot of plant physiological processes.
Ammonia (NH^3) values in surface and subsurface range from 0.06 to 51 mg/kg and 0.06 to 4.57 mg/kg respectively. The mean values for the two soil layers within the study area extent however are 0.61 mg/kg and 0.37mg/kg; these values are higher than the controls. The difference could be link to anthropogenic activities within study area extent compared to the remote/control samples.
Sulphate (SO_4^{2-}) mean values for surface soil and subsurface soils are 8.48 mg/kg and 8.12 mg/kg while their ranges are 0.42 mg/kg to 29.61 mg/kg and 0.22 mg/kg to 27.52 mg/kg respectively. Sulphate mean values observed at the two layers of the sampled soil within the study area are lower than the controls mean of 11.77 mg/kg (control surface) and 9.01 mg/kg (control subsurface).
Furthermore, Chloride is known to combine with other prevalent cations to degrade concrete structures and as such negatively impacting on integrity of such structures. Chloride (Cl-) values range from 137.46 mg/kg to 4361.15 mg/kg at the subsoil while their mean values are 325.89 mg/kg and 432.04 mg/kg respectively. As shown in Table 5, the mean Chloride values for the surface and subsurface were higher than the sampled soil of the study (project) area extent. An important observation in the results shows that Chlorine content in soil increases with depth for both the study area and controls.

Exchangeable Cations

The exchangeable cations/bases are important components of soil nutrients that determine soil fertility. Summary of the observations of exchangeable cations (Potassium, Magnesium, and Sodium) is shown in Table 5 while the results was compared with classification by Sobulo and Adepetu (1987) as shown in Table 4.5 since there is no target value standard by DPR. Potassium (K) in the soil samples of the project area range from 0.35 to 1.92 mg/kg and 0.36 to 1.67 mg/kg at surface and subsurface respectively. In addition, their respective means are 0.61 mg/kg and 0.62 mg/kg. Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. It also helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. Similarly, the same mean values were observed for Sodium (Na) at the two layers of the soils. Magnesium values range from 7.24 to 17.03 mg/kg (surface soil) and 7.2 to 15.87 mg/kg (subsurface soil). Each of the observed exchangeable bases (macronutrients) analyzed for the study are higher than at the controls both at the surface and subsurface. As shown in Table 4, the exchangeable cations within the study area are high; hence, farming activities is practicable. Pockets of cultivated lands were also observed during the field data gathering. In other words, the soils are suitable for agriculture.

Table 4.5: Classification of Exchangeable Cations

Class	**Cations**		
	Potassium(K)	Magnesium(Mg)	Sodium(Na)
Low	<0.15	< 0.5	< 0.3
Medium	0.2-0.3	0.5 – 3.0	0.3 – 0.7
High	>0.3	>3.0	>3.0

Source: Solubo and Adepetu, 1987

Hydrocarbon

Summary of hydrocarbon concentration for the soils of the study area is presented in Table 4.6.

Oil & Grease

Oil and grease observed ranged from 0.01 to 7.62 mg/kg at the surface and 0.03 to 12.00 mg/kg in the subsurface soils while their corresponding means are 1.2 mg/kg and 1.13 mg/kg. O& G was observed in almost all the samples including the controls. This could be as result of previous hydrocarbon activities within and or around the project environment.

Total Hydrocarbon Content (THC)

In the study area THC was not observed in great number of samples; it was not observed in 71 samples in surface and 98 samples in subsurface. However, the observed THC in the surface soils range 0.01 to 2.15 mg/kg and 0.02 to 2.11 mg/kg in subsurface with corresponding of 0.59 mg/kg and 0.55 mg/kg. Controls means are 0.73(surface) and 0.33mg/kg (subsurface).

Total petroleum hydrocarbon (TPH)

TPH was not observed in 86 surface and 72 in subsurface soil samples. In the observed samples however, TPH range are 0.01 to 0.85 mg/kg and 0.01 to 0.33 mg/kg at the surface and subsurface respectively. Corresponding means are 0.12 mg/kg and 0.11 while control surface and subsurface means are 0.16 mg/kg and 0.06 mg/kg

Polycyclic aromatic hydrocarbon (PAH)

PAH observed in sampled collected and analysed are very few. As shown in Appendix x3, in wet season PAH was observed in 23 surface samples and eleven (11) in subsurface soils while it was only observed in 32 surface samples and 24 subsurface samples in the dry season study. However, overall surface and surface PAH mean was 0.04. It was noted that PAH concentrations vary greatly between top and sub soils. In addition, controls mean PAH was 0.02 and was not detected in the control subsoils.

Traces of Benzene, Toluene, Ethybenzene and Xylene (BTEX) observed in the samples of the study area soils are within the target value (0.05mg/kg) of the DPR (Table 4.6). Of the 176 samples locations, BTEX was only observed in twelve (12) surface and five (5) in subsurface soil samples (Appendix x3) while no BTEX was observed in the control soils. BTEX observed however range from 0.01 to 0.03 mg/kg and 0.01 to 0.02 mg/kg at the surface and subsurface soils respectively. The corresponding means are 0.02 mg/kg and 0.01 mg/kg.

Heavy Metals

Heavy metals are metals having a mass number greater than 20 and a specific gravity greater than 5.0 g/cm3. They occur naturally in the environment at low concentrations. However, heavy metal pollution may occur when anthropogenic activities cause the discharge of heavy metal laden waste into the environment. When this occurs, plant and animals may absorb these toxic elements which can impair proper growth and physiological development. Heavy metals in soils, particularly cadmium, arsenic, lead, chromium, nickel and mercury, are of concern due to their toxicity and efficacy to harm soil organisms, plants and humans (Adelekan and Abegunde, 2011).

Summary (first and second seasons mean) of analyzed heavy metals for the study is shown in Table 4.6. As shown in the table, analyzed metals (micro nutrients) are Arsenic (As), Chromium (Cr), Copper (Cu), Mercury (Hg), Lead (Pb), Nickel (Ni), Zinc (Zn), Iron (Fe), and Manganese (Mn). In order to establish status of the soil environment of the project area, results of the soil heavy metals were compared with the DPR target and intervention values. Arsenic (As) was not detected in all the sampled soils of the proposed project area of influence as well as the control points. Cadmium (Cd) in surface and subsurface soil samples has mean concentrations 0.33 mg/kg each. In other words, there is no difference in the observed Cd at the surface and subsurface. However, their range differs. Cd range at surface was 0.18 mg/kg to 0.54 mg/kg while 0.03 mg/kg to 0.68 mg/kg was observed at the subsurface. Further, the observed mean Cd at controls is slightly higher than the project area means.

Chromium (Cr) was observed in all soil samples collected (Appendix 3). Its values at the surface and subsurface ranged from 0.01 mg/kg to 1.24 mg/kg and 0.02 mg/kg to 0.32 mg/kg respectively. Cr means values (0.33 mg/kg) at the surface and subsurface was the same. In other words, there is no variation in Cr mean values at the two soil layers for the study.

Mean concentration of Copper (Cu) in soils of the study area varied from 2.2 mg/kg to 12.15 mg/kg in the surface and subsurface while it ranges from 0.20 to 5.54 mg/kg and 1.05 to 5.43 mg/kg in the respective order. The mean values of Cu of the study area were higher than the mean controls; however, they are both within critical limit of 5-20 $mgkg^{-1}$ (FAO, 1978). Copper can be retained in soils by adsorption via non-specific and specific interactions, as well as precipitation reaction with hydroxides, carbonates, phosphates and silicates (McBride, 1989; McLaren, 2003)

Mercury (Hg) surface value ranged from 0.19 to 3.6 mg/kg and from 0.09 to 97.36 mg/kg at the subsurface. As shown in Table 4.6, the mean Hg values of the study area were slightly higher than the controls both at the surface and subsurface. However, mercury mean values for both the sampled and controls are well above DPR target values of 0.0 3 mg/kg. As shown in Appendix x1, Hg was observed in all the samples including controls.

As obtained in many other parameters for the study, traces of Lead (Pb) were observed in all the samples. It concentrations range from 0.55 to 3.19 mg/kg at the surface and from 0.66 to 2.66 mg/kg at the subsurface while their respective means are 1.62 and 1.59 mg/kg. These mean were slightly lower than Pb controls means of 1.73 mg/kg and 1.66 at surface and subsurface respectively. However, they are found to be within the limit of DPR.

The content of Nickel (Ni) was within DPR target value. At the surface, it ranges from 0.04 to 1.00$mgkg^{-1}$ and mean value of 0.53$mgkg^{-1}$ while subsurface range and mean are 0.05-1.05 $mgkg^{-1}$ and 0.53$mgkg^{-1}$ respectively. The result shows no variation between the surface and subsurface Lead concentration within the project area. Meanwhile, the mean control values were slightly lower to the project area (Table 4.6). Iron (Fe), in the proposed project area, iron contents ranged from 45.74 to 268.42.5$mgkg^{-1}$ with a mean value of 104.19$mgkg^{-1}$ (surface soils) and between 44.08 to 1144.74$mgkg^{-1}$ with a mean of 106.77$mgkg^{-1}$ for the subsurface soils. For both the study area and controls, the results show higher iron contents in subsurface soils compared to surface soils, however, the difference is highly negligible. Mean values of other metals (Zinc and Manganese) analyzed for the study are shown in Table 4.6. Of the heavy metals analyzed except Mercury are within the DPR target values. However, the Mercury observed mean values for Mercury for the study area as well as the controls are below DPR intervention values of 10 mg/kg. Generally, in terms of magnitude of concentrations of metals in surface and subsurface soils, Iron (Fe) ranked the highest followed by Manganese (Mn), Lead (Pb), Mercury (Hg), and Copper (cu) respectively. As discussed above, the concentrations of heavy metals analyzed in soil samples from the study area was compared with the DPR target values. No elevated heavy metal concentration value requires DPR intervention. This implies that the soil environment of the project area is not heavy metal polluted; hence there is no urgent need for intervention.

Table 4.6: Summary of Soil Physicochemical Properties of the Project Area

Physicochemical	Range (0-15cm)	Mean (0-15cm)	Range (15-30cm)	Mean (15-30cm)	CM (015cm)	CM (15-30cm)	CLS	DPRTV(mg/kg)	DPRIV(mg/kg)
pH	3.79-8.18	5.64	3.84-8.77	5.65	5.61	5.51	NA	NS	NS
EC (µS/cm)	15-371	123	19-350	120	112	109	2000	NS	NS
Anions									
NO_3 (mg/kg)	2.50-110	20.89	2.93-110	20.47	14.67	12.4		NS	NS
Ammonia(mg/kg)	0.06-51.00	0.61	0.06-4.57	0.37	0.35	0.36		NS	NS
PO_4^{3-} (mg/kg)	0.03-4.87	1.01	0.03-4.66	0.96	0.88	0.86		NS	NS
SO_4^{2-} (mg/kg)	0.42-29.61	8.48	0.22-27.52	8.12	11.77	9.01		NS	NS
Cl- (mg/kg)	137.46-4361.15	325.89	124.96-4423.63	432.04	485.41	554.34		NS	NS
Cations									
K (mg/kg)	0.35-1.92	0.61	0.36-1.67	0.62	0.39	0.44	2	NS	NS
Na (mg/kg)	1.85-5.93	3.23	1.45-5.85	3.23	2.82	2.94		NS	NS
Mg (mg/kg)	7.24-17.03	12.19	7.2-15.87	12.2	11.02	10.7	1	NS	NS
Hydrocarbon									
O&G (mg/kg)	0.01-7.62	1.2	0.03-12.00	1.13	1.07	0.74		NS	NS
THC(mg/kg)	0.01-2.15	0.59	0.02-2.11	0.55	0.73	0.33		NS	NS
TPH (mg/kg)	0.01-0.85	0.12	0.01-1.33	0.11	0.16	0.06		NS	NS
PAH (mg/kg)	0.01-0.16	0.04	0.01-0.22	0.04	0.02	ND		NS	NS
BTEX (mg/kg)	0.01-0.03	0.02	0.01-0.02	0.01	ND	ND		0.05	NS
Heavy metals									
As (mg/kg)	ND	ND	ND	ND	ND	ND		29	55
Cd (mg/kg)	0.18-0.54	0.33	0.03-0.68	0.33	0.36	0.37		0.8	12
Cr (mg/kg)	0.01-1.24	0.15	0.02-0.32	0.15	0.14	0.15		100	380
Cu(mg/kg)	0.20-5.54	2.2	1.05-5.43	12.15	2.09	1.91	5-20*	36	190
Hg (mg/kg)	0.19-3.6	1.44	0.09-97.36	1.69	1.41	1.41		0.03	10
Pb(mg/kg)	0.55-3.19	1.62	0.66-2.66	1.59	1.73	1.66		85	530
Ni (mg/kg)	0.04-1.00	0.53	0.05-1.05	0.53	0.55	0.56	20-500*	35	210
Zn (mg/kg)	0.03-5.86	0.51	0.02-4.91	0.48	0.4	0.38	10-300*	140	720
Fe (mg/kg)	45.74-	104.19	44.08-	106.77	92.14	92.75	50-	NA	NA

	268.42		1144.74				250**		
Mn (mg/kg)	3.06-9.74	5.48	3.15-8.85	5.49	5.22	5.77	20-300**	NA	NA
Organics									
TOC(%)	0.42-3.68	1.64	0.22-3.28	1.56	1.53	1.27			

Source: Osten Lab Field Work- OML13, 2019/2020
CM: Control Mean; DPRTV: DPR Target Value; DPRIV: DPR Intervention Value
: Bohn et al., 1995; **: Brady and Weil, 1996; *: Allen et al 1974.*

Total Organic Carbon (TOC)

Organic matter plays a significant role in the dynamic of soils as it stores water, provides a living environment for organisms, and promotes structural stability, supplies and stores nutrients. The stored nutrients are slowly released in usable form as the further decomposition of organic matter occurs. Indeed, it determines the form, quantity and quality and hence availability of a few other nutrient elements such as nitrogen and phosphorus. In the study area, organic carbon contents varied from 0.42 to 3.68% with mean values of 1.64% at the surface and varied from 0.22 to 3.28% and mean values of 5.49 in subsurface soils (Table 4.6). Based on Udo, 1986; classification range (Table 4.7), the TOC of the study area is medium while it is low in the controls.

Table 4.7: Organic Matter Classification (Classes)

Organic (%)	Class
< 1.50	Low
1.50-2.50	Medium
>2.50	High

Source: Udo, 1986

Depth-induced Variation

Most of the soils parameters analyze show no significant variation base on depth (0-30cm). Some of the physicochemical concentrations that show significant variation in terms of soil depth (15-30cm) are Chloride (Cl-) and Copper (Cu), Table 4.6. While those that show significant variation from 15-30cm based mechanical/physical properties of soil within the study area are silt and clay (Table 4.3) however, based on spread, results vary geographically as shown in Appendix 3. It could therefore be noted that within the study area extent, there is no significant variation in soil properties based on depth.

Soil Microbiology

Microorganisms are one of the major components of soil. Microbial community in soil makes important contributions to biogeochemical cycling of carbon, nitrogen, sulfur, iron and manganese cycle. Bacteria and fungi also act as agents of degradation, with bacteria assuming the dominant role in marine ecosystem and fungi becoming more important in freshwater and terrestrial environment. The study summary of the population counts of Total Coliform Count (TCC), Faecal Colifom (FC), Total Heterotrophic Bacteria Count (THBC), and Total Heterotrophic Fungi Count (THFC) are shown in Table 4.8.

Total Coliform Count (TCC)

As shown in Appendix 1E, the TCC was observed 99 locations for the surface and 95 subsurface soil samples while it was only observed in one of the three control points.

However, TCC values range from 3 to 1100MPN/100ml and from 0.2 to 1100 MPN/100ml in the surface and subsurface soils respectively. Corresponding means are 6.64 MPN/100ml and 32.16 MPN/100ml. As shown in Table 7, control values range from 21 to 75 MPN/100ml and from 11 to 2011-20 MPN/100ml at the surface and subsurface soils respectively. This shows that TCC in the surface is higher than the surface soils.

Faecal Colifom (FC)

Faecal Clofiform was not identified in a greater number (112 locations) of soil samples. Where it was observed, that surface and subsurface values range from 3 to 1100 MPN/100ml and from 3 to 240 MPN/100ml respectively with corresponding means of 47.61 MPN/100ml and 15.12 MPN/100ml. Again, FC was only detected in one of the control samples; its range is shown in Table 7. It was also noted that FC reduces with soil depth in the proposed project environment.

Total Heterotrophic Bacteria Count (THBC)

The findings from the microbiological examination of the soil samples also indicated the presence of relatively high densities of heterotrophic microbiota in both surface and subsurface soil samples. Specifically, THBC ranged from 3.0 x 10^4 to 1.09 x 10^6 cfu/ml in the surface soil and 1.8 x 10^4 to 2.9 x 10^6cfu/ml in the subsurface soils of the project environment. There is a slight difference in the surface and subsurface THBC. As shown in Appendix 3, THBC was observed in all the study area and control sampled soils.

Total Heterotrophic Fungi Count (THFC)

The total heterotrophic fungi (THFC) assessment indicated some appreciable presence of fungi community in the soil samples across the project associated landscape. Specifically, respective surface and subsurface soil samples of THFC ranged from 1.0 x 10^4 to 4.8 x 10^5cfu/ml and from 1.0 x 10^4 to 9.0 x 10^5cfu/ml while the controls ranged from 4.0 x 10^4 to 3.2 x 10^5 cfu/ml and from 7.0 x10^4 to 4.2 x 10^5 cfu/ml in the surface and subsurface soils respectively. The results show that there is no significant depth difference between Total Heterotrophic Fungi count in the proposed project environment.

Table 4.8: Summary of Microbial Constituents of Top (0-15cm) and Bottom (15-30cm) Soil Samples in the Project Area

Soil Parameters	Range (0-15cm)	Mean (0-15cm)	Range (15-30cm)	Mean (15-30cm)	CR (0-15cm)	CR (15-30cm)
Microbiology						
TCC(MPN/100ml)	3-1100	64.64	0.2-1100	32.16	21-75	11-20
FC(MPN/100ml)	3-1100	47.61	3-240	15.12	0-14	0-7.5
THBC(cfu/ml)	3.0 x 10^4 - 1.09 x 10^6		1.8 x 10^4 - 2.9 x 10^6		8.4 x 10^5 - 2.54 x 10^6	6.9 x 10^5 - 2.16 x 10^6
THFC(cfu/ml)	1.0 x 10^4 - 4.8 x 10^5		1.0 x 10^4 - 9.0 x 10^5		4.0 x 10^4 - 3.2 x 10^5	7.0 x 10^4 - 4.2 x 10^5

Source: Osten Lab Field Work- OML13, 2019/2020

TCC: Total Coliform Count; FC: Faecal Colifom; THBC: Total Heterotrophic Bacteria Count; THFC: Total Heterotrophic Fungi Count; CR: Control Range

Land Use / Cover

Synoptic quantitative and graphic result of the landuse study for the Utapate field is shown in Table 4.9 and Figure 4.6 respectively. As shown in the Table, twelve broad landuse/landcover types were identified within study area.

Table 4.9: Landuse/Landcover for Utapate Field in OML13

Landuse	**Area(Ha)**	**Percent (%) Cover**
Creek	321.482	2.52
Pool	12.714	0.1
Ocean	6047.838	47.32
Sand Bar/Deposit	24.418	0.19
Mangrove/Swamp vegetation	2804.069	21.94
Built-up Area	275.326	2.15
Light Forest Vegetation	2321.908	18.17
Cultivated/Fallow Land	645.607	5.05
Cleared Land	37.684	0.29
Open Space/Bare Surface	243.188	1.9
Mudflat	34	0.27
Abandoned Installation Area	11.775	0.09
Total	**12,780**	**100**

Source: EES Study for Utapate Field in OML13

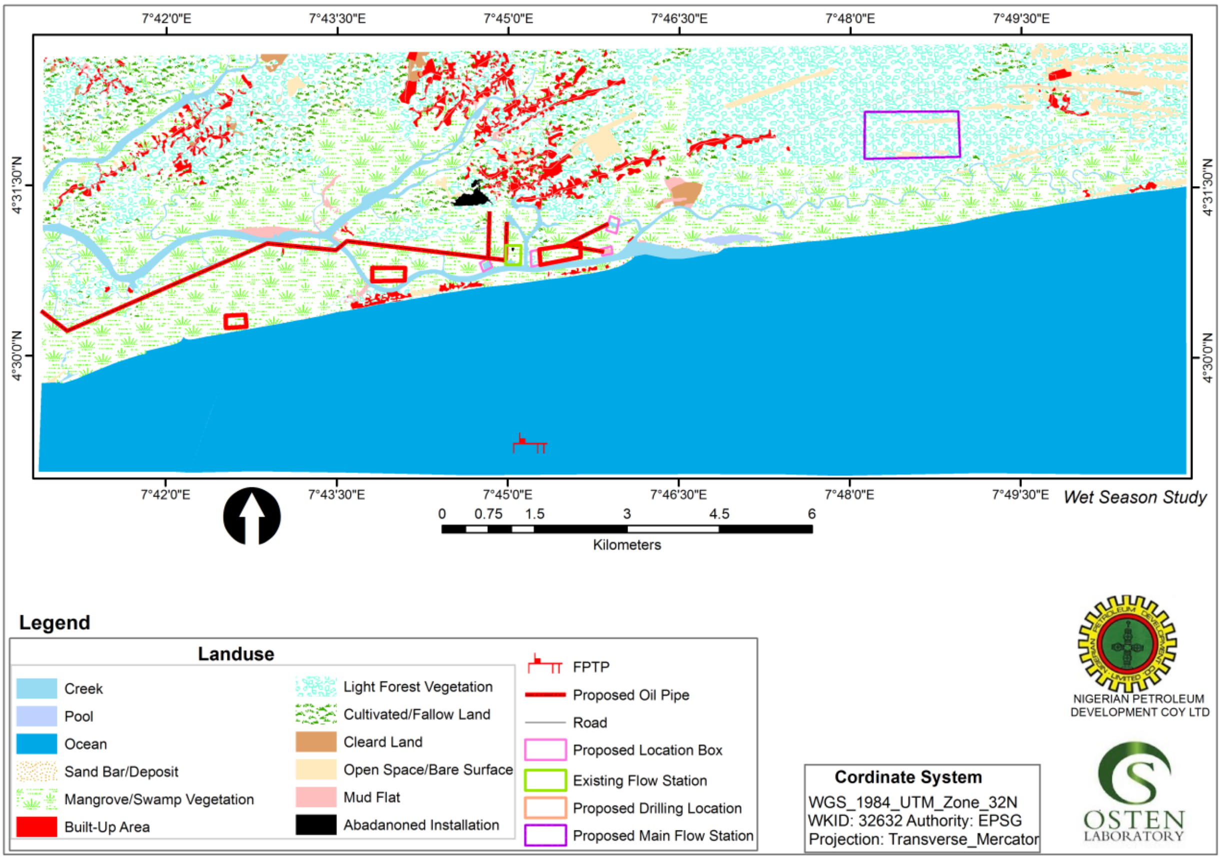


Figure 4.6: Landuse/Landcover for Utapate Field in OML13
Source: EES Study for Utapate Field in OML13

4.3.4 Vegetation Characteristics

General Vegetation Description

The physiognomy of the vegetation cover varied slightly due to the proximity of human settlements, and has influenced the biodiversity density and distribution within the project area.

Basically, the vegetation of the project area can be divided into four types, namely: Mangrove forest along the coast and river estuaries; Fresh water swamp forest, Rainforest proper and secondary vegetation punctuated with farmlands.

The mangrove forest

The Mangrove forest is quite extensive, covering the entire coastal area. The dominant mangrove species, identified in the area, include *Rhizhophora racemosa, Rhizophora mangle, Rhizophora harrisonii, Nypa fruticans, Acrostichum aureum,* Elytrophorus *spicatus, Raphia hookeri, Avicennia germinans*, *Sporobolus pyramidalis*, and *Cyperus articulatus*. It was observed that quite a reasonable portion of the mangrove forest has been taken over by the *Nypa fruticans* (Nipa palm). This palm out-competes the mangrove trees in the brackish environments of the river estuaries.

Plate 4.1: The general overview of the Mangrove vegetation showing its physiognomy

Fresh water vegetation

In the wetland areas, which are removed from the influence of tidal saline waters, fresh water vegetation abounds. This is found along the flood plains of the eastern Obolo. This zone was characterized by presence of marshy wetland plant species like *Triumfetta cordifolia, Laportea aestuans,* Dryopteris *filix-mas, Raphia hookeri, Musanga sp, Elaeis guineensis, Alchornia cordifolia, Bambusa vulgaris, Xanthosoma saggitifolium, Centrosema pubescence, Costus afer,* and *Paspalum vaginatum* among others. Plants found in this zone were mostly herbaceous and a few tree species. Creeping plants like *Momordica charantia, Luffa aegyptiaca,* and *Luffa cylindrical* formed part of the thick undergrowth. Other plants, found in the fresh water swamp forest include: *Alstonia spp., Cleistophollis patens, Lophira alata* and beautifully flowered *Lonchocarpus griffonianus.* Some water-loving plants, like water lotus *(Nymphaea lotus),* water lily *(Pistia striatiotes)* and *Vosia cuspidata* were quite common.

Plate 4.2: The physiognomy of the fresh water swamp ecosystem showing young *Elaeis guineensis, Alchornia cordifolia*, *Raphia hookerii* and a stand of *Anthocleista vogelii* within the fresh water swamp ecosystem

Tropical rain forest

The tropical rain forest is found in the upland areas, where the soil is well drained. The vegetation is complex, but three recognizable layers of heights of trees are observed. The upper layer has trees that reach the height of about 40 metres. These trees are called emergents, and include the most valuable timber trees e.g. *Terminalis spp., (Idigbo), Triplochiton scleroxylon* (Obeche), *Ceiba pentandra* (Silk cotton), *Celtis milbraedii, Lophira alata* (Iron wood). The second layer has trees with smaller crowns, which tend to touch one another. The third layer or, understorey has trees of about 5-10 metres tall, with narrow crowns. Epiphytes and other woody climbers are generally found on the crowns of the understorey. It is important to note that the original rain forest has virtually reduced significantly in terms of size and what is found now is farmland with crops, or, under fallow. The destruction of the forest could be attributed to urban development, lumbering, farming and firewood exploitation. Some forest vegetation was however found in difficult terrain, in areas adjoining the freshwater swamps and beach ridge barrier islands along the coastal fringes.

The most important tree in the rain forest zone is the oil palm, which dots the secondary forest or bush fallow. When the land is cleared for farming, the oil palm trees were usually left undistorted. It was observed that several oil palm and para rubber plantations developed by individuals or the Government Ministry of Agriculture were found in a number of places, particularly along the coastal areas near Iko and Okoroete towns.

Plate 4.3: Sections within the rain forest ecosystem showing thick and sparse growth

Farmland

The main occupation of the community dwellers around the study site is farming; therefore, crop plants and other domesticated plant species like *Capsicum annum*, *Decryodes edulis, Citrus sinensis, Citrus limon, Dioscorea rotundata, Ananas comosus*, *Vernonia amygdalina*, *Telferia occidentalis, Talinum fruticosum, Cucumeropsis mannii*, *Carica papaya, Mangifera indica, Musa sapientum,* and *Musa paradisiaca* were growing as either cultivated plants on farmlands or growing in the fallow portions of the study site.

Some portions of the project area are used land consisting of farmlands, settlements, cottage industries, businesses and palm oil production facilities.

The dominant tree species is the Palm tree (*Elaeis guineensis*), with coconut tree (*Cocos nucifera*) also dotting the landscape while ferns, shrubs and grasses dominate the forest floor.

The forest can be categorized as secondary and successional with long history of agriculture and lumbering. The high annual rainfall characteristic of this area makes it home to luxuriant ever green vegetation; however unsupervised wood harvesting and forest clearance for agriculture has damaged much of its physiognomy. Cassava, *Manihot esculenta* is the most common crop cultivated in the area, followed by maize (*Zea mays*). The general overview of the impacted areas showed that there were dominant species whose densities and distribution were significant; these includes: *Elaeis guineensis* (Oil palm), *Alchornea cordifolia* (Christmas bush), *Chromolaena odorata* (Siam weed), *Calopogonium mucunoides, Sida cordifolia* (Country mallows), *Paspalum vaginatum* (Water grass), *Triumfetta cordifolia*, *Amaranthus spinosus* (Thorny amaranth), *Aspilia africana* (Haemorrhage plant), *Mucuna sloanei, Sida acuta, Panicum maximum,* and *Manihot esculenta*.(Cassava).

Plate 4.4: A farmland of cultivated *Manihot esculenta* /*Musa paradisiaca* within the project area

Economic Plants

More than 70% of the species of economic plants per hectare of land area belongs to the family Palmae especially *Elaeis guineensis*. The economic importance of these plants vary and they include their uses as source of palm wine, oil palm, fuel wood, vegetable, edible fruits and medicinal. The herbs and grasses are particularly important in maintaining soil structure and protecting the soil from errosion resulting from the heavy rainfall typical of this area.

Within the study site are cash crop plantations of *Hevea brasiliensis* (Para rubber), *Cocos nucifera* (Coconut) and *Elaeis guineensis* (Oil Palm) that are actively being tapped for latex, harvested for its juice and palm oil production respectively. Apart from the presence of plantations, cultivated farmlands abound with annual crops like *Manihot esculenta, Zea mays, Dioscorea rotundata, Capsicum annum, Solanum lycopersicum* and *Colocassia esculenta* (cocoyam). As expected of a secondary vegetation, common invasive species found in the arable lands within the project area includes , *Chromolaena odorata* (Siam weed), *Imperata cylindrica* (Spear grass), *Amaranthus spinosus* (Thorny amaranth), *Aspilia africana* (Haemorrhage plant), *Sida cordifolia* (Country mallows), *Ipomea involucrata* (Morning glory), *Mariscus cylindristachyus* (Umbrella sedge), *Cyperus rotundus* (Nut grass), *Elusine indica* (Goose grass), *Ageratum conyzoides* (Goat weed), *Centrosema pubescence* (Butterfly pea), *Panicum maximum* (Guinea grass), *Mimosa pudica* (Touch me not), *Momordica charantia* (Bitter gourd) and *Calopogonium mucunoides* (Calopo).

The wetland area had dominant species like *Raphia hookeri, Dryopteris filix-mas, Nymphea lotus*, *Paspalum vaginatum, Xanthosoma saggitifolium* and *Lemna minor* as dominant species.The study area is punctuated by human settlements that are predominantly farmers, and this development has led to the present of quite a number of economic plants: ornamentals, medicinal, and food crops within the study site. This category of plants includes *Mangifera indica, Theobroma cacao*, *Carica papaya, Manihot esculenta, Talinum fruticosum, Anacardium occidentale, Elaeis guineensis, Cocos nucifera, Decryodes edulis, Gossypium hirsutum, Citrus sinensis, Citrus limon, Azadirachta indica, Ananas comosus, Ocimum gratissimum, Vernonia amygdalina, Chrysophyllum albidum, Colocasia esculenta, Dioscorea rotundata, Zea mays, Musa paradisiaca, Musa sapientum* and *Terminalia catappa*.

Plant pathological Studies

Due to the moist and humid nature of the rainforests of Nigeria, there is a high collection of pest species such as ants, termites, beetles and grasshoppers as well a fungus and parasites which affect the inhabiting plant species. Despite the long years of adaptation and development of inhibitory chemicals, pests still do considerable damage to crops.

Findings from the study, typical of such similar investigations, indicated that the plants were generally healthy as most leaves were succulent, greenish and luxuriant. Some however had pathological problems like chlorotic and necrotic leaf spots, which were, in some cases, associated with the tropical red ants (*Oecophylla sp*) and native fungus species which have no long term damaging effects. Overall the disease severity indices revealed that the few diseases encountered were of very light to moderate infections. While there was no devastation by insect or animal pests observed in the project area there was evidence of leafs eaten up by biting and chewing insects such as grasshoppers and locusts.

Thus the appearance and the state of health of the plant communities and of the commonest species were quite normal in the rainy season and revealed no cause epidemic infection. There was no evidence of endemic vegetation problems as well. In discussing the type of plant diseases observed, it is pertinent to remark that none of the diseases was unusual either in its nature or severity. The few diseases observed are common and comparable in nature and intensity to those on plant species all over the forest zones of the country and elsewhere in the tropics.

Table 4.10: **Checklist of dominant plant species found in the project area**

S/N	PLANT SPECIES	HABIT	DENSITY
1.	*Alchornea cordifolia*	Shrub	Abundant
2.	*Amaranthus spinosus*	Herb	Abundant
3.	*Aspilia africana*	Herb	Abundant
4.	*Avicenia germinans*	Shrub	Abundant
5.	*Calopogonium mucunoides*	Herb	Abundant
6.	*Chromolaena odorata*	Herb	Abundant
7.	*Dryopteris filix-mas*	Herb	Abundant
8.	*Elaeis guineensis*	Palm	Abundant
9.	*Havea brasiliensis*	Tree	Abundant
10.	*Imperata cylindrica*	Grass	Abundant
11.	*Nypa fruticans*	Palm	Abundant
12.	*Panicum maximum*	Grass	Abundant
13.	*Raphia hookeri*	Palm	Abundant
14.	*Rhizophora mangle*	Shrub	Abundant
15.	*Rhizophora racemosa*	Shrub	Abundant
16.	*Rhizophora harrisonii*	Shrub	Abundant
17.	*Sida cordifolia*	Herb	Abundant
18.	*Sporobolus pyramidalis*	Grass	Abundant

Table 4.11: A comprehensive list of Economic plants found in the project area.

S/N	SPECIES	COMMON NAME	USES
1	*Aleo vera*	Aleo vera	Medicinal
2	*Anacardium occidentale*	Cashew	Fruit/Cash
3	*Ananas comosus*	pineapple	Fruit
4	*Azadirachta indica*	Neem plant	Medicinal
5	*Bixa orellana*	Ornatus	Medicinal
6	*Blighia sapida*	Ishin	Fruit/ Medicinal
7	*Capsicum annuum*	pepper	Vegetable
8	*Carica papaya*	Pawpaw	Fruit
9	*Celosia argentea*	Celosia	Vegetable
10	*Chrysophyllum albidum*	Star apple	Fruit
11	*Citrus limon*	Lime orange	Medicinal

12	*Citrus sinensis*	Orange	Fruit
13	*Cocos nucifera*	Coconut	Fruit
14	*Colocasia esculenta*	Cocoyam	Food
15	*Decryodes edulis*	Pear	Fruit
16	*Dioscorea rotundata*	White yam	Food
17	*Elaeis guineensis*	Oil Palm	Cash
18	*Gossypium hirsutum*	Cotton	Cash
19	*Havea brailiensis*	Para rubber	Cash
20	*Solanum lycopersicon*	Tomato	Vegetable
21	*Mangifera indica*	Mango	Fruit
22	*Manihot esculenta*	Cassava	Food/Cash
23	*Morinda lucida*	Brimstone tree	Medicinal
24	*Musa paradisiaca*	Plantain	Food
25	*Musa sapientum*	Banana	Fruit
26	*Occimum gratissimum*	Scent leaf	Medicinal
27	*Raphia hookeri*	Raffia palm	Wine
28	*Saccharum officinarum*	Sugar cane	Fruit
29	*Spondias mombin*	Hog plum	Medicinal
30	*Talinum fruticosum*	Water leaf	Vegetable
31	*Telfaria occidentalis*	Ugwu leaf	Vegetable
32	*Theobroma cacao*	Cocoa	Cash
33	*Terminalia catappa*	Almond	Fruit
34	*Vernonia amygdalina*	Bitter leaf	Vegetable
35	*Zea mays*	Maize	Food

Table 4.12: **Checklist of plant species found in the project area**

S/N	PLANT SPECIES	DENSITY
1.	*Acacia nilotica*	Rare
2.	*Acalypha fimbriata*	Common
3.	*Acalypha wilkesiana*	Rare
4.	*Acrostichum aureum*	Common
5.	*Ageratum conyzoides*	Common
6.	*Alchornea cordifolia*	Abundant
7.	*Alchornea laxiflora*	Common
8.	*Aleo vera*	Rare
9.	*Alstonia boonei*	Rare
10.	*Amaranthus spinosus*	Abundant
11.	*Anacardium occidentale*	Rare
12.	*Ananas comosus*	Rare
13.	*Anchomanes difformis*	Common
14.	*Andropogon tectorum*	Common
15.	*Anthocleista vogelii*	Rare
16.	*Aspilia africana*	Abundant
17.	*Avicenia germinans*	Abundant
18.	*Axonopus compressus*	Common
19.	*Azadirachta indica*	Common
20.	*Bambusa vulgaris*	Common
21.	*Blighia sapida*	Rare
22.	*Bryophyllum pinnatum*	Rare
23.	*Calopogonium mucunoides*	Abundant
24.	*Calotropis procera*	Rare
25.	*Canna indica*	Common
26.	*Canavalia ensiformis*	Common

27.	*Capsicum annuum*	Rare
28.	*Carica papaya*	Rare
29.	*Centrosema pubescence*	Common
30.	*Chloris pilosa*	Common
31.	*Chlorophytum indet*	Common
32.	*Chromolaena odorata*	Abundant
33.	*Chrysophyllum albidum*	Common
34.	*Citrus limon*	Rare
35.	*Citrus sinensis*	Rare
36.	*Cleome ciliata*	Common
37.	*Cnestis ferruginea*	Common
38.	*Cocos nucifera*	Common
39.	*Colocasia esculenta*	Rare
40.	*Combretum hispidum*	Rare
41.	*Commelina diffusa*	Common
42.	*Commelina erecta*	Common
43.	*Crotalaria juncea*	Common
44.	*Cucumeropsis mannii*	Common
45.	*Cynodon dactylon*	Common
46.	*Cyperus articulatus*	Common
47.	*Daniela oliveri*	Rare
48.	*Decryodes edulis*	Common
49.	*Dialium guineense*	Rare
50.	*Dioscorea rotundata*	Common
51.	*Dracaena aborea*	Common
52.	*Drynaria laurentii*	Common
53.	*Dryopteris filix-mas*	Abundant
54.	*Eichhornia crassipes*	Rare
55.	*Elaeis guineensis*	Abundant
56.	*Elusine indica*	Common
57.	*Elytrophorus spicatus*	Common
58.	*Emila sonchifolia*	Common
59.	*Euphorbia hirta*	Common
60.	*Ficus carpensis*	Common
61.	*Ficus elastica*	Rare
62.	*Ficus exasperata*	Rare
63.	*Ficus sur*	Common
64.	*Glyphaea brevis*	Common
65.	*Gossypium hirsutum*	Rare
66.	*Heliotropium indicum*	Common
67.	*Hevea brasiliensis*	Abundant
68.	*Imperata cylindrica*	Abundant
69.	*Khaya ivoriensis*	Rare
70.	*Laportea aestuans*	Common
71.	*Lemna minor*	Common
72.	*Luffa aegyptiaca*	Common
73.	*Luffa cylindrica*	Common
74.	*Macrozamia communis*	Rare
75.	*Mangifera indica*	Common
76.	*Manihot esculenta*	Common
77.	*Mariscus alternifolius*	Common
78.	*Melicia excelsa*	Rare
79.	*Mimosa pudica*	Common
80.	*Mitracarpus scaber*	Common

81.	*Momordica charantia*	Common
82.	*Morinda lucida*	Rare
83.	*Mucuna sloanei*	Common
84.	*Musa paradisiaca*	Common
85.	*Musa sapientum*	Common
86.	*Musanga sp*	Common
87.	*Newbouldia laevis*	Rare
88.	*Nymphea lotus*	Common
89.	*Nypa fruticans*	Abundant
90.	*Occimum gratissimum*	Common
91.	*Opuntia dillenii*	Rare
92.	*Palisota hirsuta*	Rare
93.	*Panicum maximum*	Abundant
94.	*Paspalum vaginatum*	Common
95.	*Pennisetum purpurea*	Common
96.	*Pergularia daemia*	Common
97.	*Phyllanthus amarus*	Common
98.	*Physalis augulata*	Common
99.	*Pupalia lappacea*	Common
100.	*Raphia hookeri*	Abundant
101.	*Rauvolfia vomitoria*	Common
102.	*Rhizophora mangle*	Abundant
103.	*Rhizophora racemosa*	Abundant
104.	*Rhizophora harrisonii*	Abundant
105.	*Saccharum officinarum*	Rare
106.	*Senna obtusifolia*	Common
107.	*Sensevieria liberica*	Rare
108.	*Sida acuta*	Common
109.	*Sida cordifolia*	Abundant
110.	*Sida corymbosa*	Common
111.	*Smilax anceps*	Common
112.	*Solanum lycopersicum*	Rare
113.	*Solanum nigrum*	Common
114.	*Spondias mombin*	Common
115.	*Sporobolus pyramidalis*	Abundant
116.	*Synedrella nodiflora*	Common
117.	*Talinum fruticosum*	Common
118.	*Telfaria occidentalis*	Rare
119.	*Terminalia catappa*	Rare
120.	*Terminalia superba*	Common
121.	*Tremia orientalis*	Common
122.	*Tridax procumbens*	Common
123.	*Triumfetta cordifolia*	Common
124.	*Urena lobata*	Rare
125.	*Vernonia amygdalina*	Rare
126.	*Vitex doniana*	Rare
127.	*Xanthosoma saggitifolium*	Common
128.	*Zea mays*	Rare

4.3.5 Wildlife Species

Annelids

The observed annelids in the soil within the project area were two species of the Order oligochatea, with *Aporrectodea longa* being particularly abundant (Table 4.13)

▪

Table 4.13: **Annelid species observed in the project area**

S/N	Scientific names	Order	IUCN categories	Estimate
1	*Lybiodrilus violaceous*	Oligochaeta	NE	Occasional
2	*Aporrectodea longa*	Oligochaeta	NE	Abundant

NE- Not Evaluated

Molluscs

Three mollusc species including two land dwelling species (*Archachatina marginata and Limnicolaria flammea*) and one amphibious species (*Physa sp.*) were observed during the rainy season field assessment.

Table 4.14: Molluscs found attached to vegetation as well as in ponds around the project area

S/N	Common names	Scientific names	Family	IUCN categories
1	Giant West African Snail/Banana Rasp Snail	*Archachatina marginata*	Achatinidae	NE
2	west African land snail	*Limnicolaria flamm ea*	Achatinidae	NE
	Physa	*Physa sp.*	Planorbidae	NE

NE- Not Evaluated

Arthropods

There was a rich stock of arthropods in project area but their abundance was often low. Generally, they included mostly Insceta and Arachnida. Overall, a total of 35 insect species, 1 centipede species, 1 millipede species and 5 Arachnid species were sighted.The insect taxa include Order Lepidoptera, Orthoptera, Hemiptera, Hymenooptera, Odonata, Isoptera, Coleoptera, Diptera, Dictyoptera and Demaptera. Members of the order Lepidoptera were most abundant insect taxa. Other arthropod taxa observed includes members of the Class Chilopoda, Class Diplopoda and Class Arachnida. There was abundance of insect land marks such as bee hives termiteria and insect tracts. The activities of web spinning spiders were also observed together with damaged leaves which indicated that there was an active biting and chewing community of insects of the order Orthopetera and Coleoptera.

Table 4.15: Checklist of Arthropod species in the project area

S/N	Taxa/Common names	Order	Scientific names
	Class Insecta/Hexapoda		
1	Monarch Butterfly	Lepidoptera	*Danaus plexippus*

2	Black Pansy	Lepidoptera	*Junonia oenone*
3	Charaxas butterfly	Lepidoptera	*Cherasxas sp.*
4	The sailors	Lepidoptera	*Neptis sp.*
5	Cabbage Whaite	Lepidoptera	*Pieris rapae*
6	Chocolate Albertros	Lepidoptera	*Appias sp.*
7	Common Joker	Lepidoptera	*Byblia sp.*
8	House cricket	Orthoptera	*Acheta domestica*
9	Variegated grasshopper	Orthoptera	*Zonocerous varigatus*
10	Mole crickets	Orthoptera	*Gryllotalpa brachyptera*
11	House cricket	Orthoptera	*Acheta domestica*
12	Variegated grasshopper	Orthoptera	*Zonocerus variegatus*
13	Cotton Steiner	Hemiptera	*Dysdercus spp*
14	Water boatman	Hemiptera	*Arctocorisa arguta*
15	Paper Wasp	Hymenotera	*Ropalidia marginata*
16	Fire ant	Hymenooptera	*Componotus herculeanus*
17	Tailor ants	Hymenooptera	*Oecophylla longinoda*
18	Black Ants	Hymenoptera	*Lepisiota sp.*
19	Black garden ant	Hymenoptera	*Lasius niger*
20	Inspector dragon fly	Odonata	*Chalcostephia flavifrons*
21	Damsel fly	Odonata	*Agriocnemis femina femina*
22	Dragon fly	Odonata	*Austroaeschna inermis*
23	Common Orange Damselfly	Odonata	*Ceriagrion glabrum*
24	Yello-viened widow	Odonata	*Palpopleura jucunda*
25	Ear wig	Demaptera	*Forficula auricularia*
26	Termite	Isoptera	*Macrotermis belicosus*
27	Leaf eating beetles	Coleoptera	*Pyrrhalta luteola*
28	Sand fly	Diptera	*Phlebotonus sp.*
29	House fly	Diptera	*Musca domestica*
30	Fruit fly	Diptera	*Drosophilia melanogaster*
31	Praying Mantis	Dictyoptera	*Mantis religiosa*
32	Rhinocerous beetle	Coleoptera	*Pentodon idiota*
33	Common Black Ground Beetle	Coleoptera	*Pterostichus melanarius*
34	Green Metallic scarab	Coleoptera	(*Dicranorrhina micans*
35	Beetle	Coleoptera	*Cryptophagus sp*
	Class Chilopoda		
36	Centipede	Scutigeromorpha	*Scolopendra sp*
	Class Diplopoda		
37	Giant African Millipede	Spirostreptida	*Archispirostreptus gigas*
	Class Arachnida		
38	Crab Spider	Araneae	*Misumena* sp.
39	Mangrove Big-Jawed Spider	Araneae	*Tetragnatha jospephi*
40	Golden silk Orb-weaver spider	Araneae	*Nephilia sp.*
41		Cryopostimata	*Bicrythermannia nigeriana*
42	Oribatid mite	Oripodoidea	*Scheloribates yorubaensis*

Plate 4.5: ***Zonocerus variegatus* resting on a leaf within the project area**

Plate 4.6: **A brown grass hopper caught at the project site using a sweep net**

Amphibians

The amphibian observed were the common African toad, *Amietophrynus regularis*. Sightings were occasional, occurring only near moist patches or as tadpoles in ponds.

Table 4.16: Checklist of Amphibian species in the project area

S/N	Common names	Scientific names	IUCN categories	Estimate
1	Common African Toad	*Amietophrynus regularis*	LC	Occasional

LC-Least Concern; X- Present

Reptiles

The most commonly sighted reptiles are the mangrove skink (*Emoia sp.*) and rainbow lizard (*Agama agama*) belonging to the family Scincidae and Agamidae respectively. No snake species was reported but there were very positive responses from many respondents in the community who stated that they have observed various snakes within the forest path and surrounding areas. All the reptilian species observed were least concerned on the IUCN categorization.

Table 4.17: Checklist of Reptilian species in the project area

S/N	Common names	Scientific names	IUCN categories	Estimate

1	Monitor Lizard	*Varanus niloticus*	LC	Occasional
2	Rainbow lizard	*Agama agama*	LC	Numerous
3	Mangrove Skink	*Emoia sp.*	LC	Numerous
4	*Black-Necked Spitting Cobra (Ibgbo- Ajuala)	*Naja melanoleuca*	LC	Rear
5	*Python (royal)	*Python sebae*	LC	Occasional
6	*Rat snake	*Elaphe obsoleta*	LC	Numerous
7	*Green mamba	*Dendroaspis angusticeps*	LC	Numerous
8	*Serrated Hinge-backed Tortoise	*Kinixys erosa*	DD	Rear

*Reports by community members but not physically sighted; LC- Least Concern; DD- Data Deficient.

Aves

A total of twenty-one Avain species were observed during the rainy season sampling exercise, with sightings occurring on trees, along forest floors, across the skies and by the their nesting sites. The most common species across the sampling sites was the African village weaver bird (*Ploceus cucullatus)* while the least abundant was in terms of sightings was the Sao Tome paradise flycatcher (*Terpsiphone smithii).* The nesting site of the White spotted fluftail (Bush fowl), *Sarothrura pulchra,* was observed within the project area.

Table 4.18: Checklist of Avian species within project area.

S/N	Common names	Scientific names	IUCN Categories
1	Blue- Breasted King Fisher	Halcyon malimbica	LC
2	Pin-Tailed Whydah	*Vidua macroura*	LC
3	Cameroon indigo bird	*Vidua camerunensis*	LC
4	African Village weaver bird	*Ploceus cucullatus*	LC
5	Bob (short)-taild weaver bird	*Brachycope anomala*	LC
6	African Ban fowl	*Tyto alba*	LC
7	Kite (black)	*Muluus migrans*	LC
8	Palm Swift	*Cypsiums pariuus*	LC
9	Senegal Coucal	*Centropus senegalensis*	LC
10	Swallow	*Hirundo sp.*	LC
11	African Harrier Hawk	*Polyboroides typus*	LC
12	Western Black-headed oriole	*Oriolus brachyrhynchus*	LC
13	*Western reef egret	*Egretta gularis*	LC
14	Yellow fronted canary	*Serinus mozambius*	LC
15	Cabanis's bunting	*Emberiza cabanisi*	LC
16	Magpie mannkin	*Spermestes fringilloides*	LC

17	Common Snipe	*Gallinago gallinago*	LC
18	Shelley's (Little) Oliveback	*Nesocharis shelleyi*	LC
19	Squaco heron	*Ardeol ralloides*	LC
20	SaoTome paradise flycatcher	*Terpsiphone smithii*	NE
21	White spotted fluftail (Bush fowl),	*Sarothrura pulchra*	LC
22	Pied crow	*Corvus albus*	LC

LC- Least Concern, NE- Not Evaluated;NA_ Not Applicable *- Water bird

Plate 4.7: **Nesting of the White spotted fluftail (Bush fowl), *Sarothrura pulchra***

Plate 4.8: **Pied crow, C*orvus albus* on trees within the project area**

Plate 4.9: *Ploceus cucullatus* on palm trees in Emere-Oke community

Plate 4.10: A western reef egret (*Egretta gularis*) foraging along Okoroete creek

Plate 4.11: A Common Snipe (*Gallinago gallinago*) sighted along Okoroete creek

Mammalia

Typical of most vegetated areas in Nigeria, there was low abundance and diversity of mammals. This is further enhanced by their often solitary and elusive nature, hiding in thickets and coming out only at night to feed. All of the mammalian species observed or reported in the proposed project site were all least concerned based on the IUCN categorization (Table 9). However, the White throated guenon (*Cercopithecus erythrogaster*) which was sighted once at the control site is categorized as vulnerable. Members of the Order Rodentia - rats and grass cutters were the most abundant and their burrows were also evident. Rodents are the largest mammalian order, often invasive and r- strategist (high reproduction rate), characterized by a single equal ever growing pair of incisors which help them in cutting lush forest vegetation. They are commonly hunted for food in West Africa were bush meat is a delicacy. Habitat destruction due to land conversion and overhunting are the major threats to them but being r- strategist, their populations tend to remain stable.

Table 4.19: Checklist of Mammalian species observed within the project area

S/N	Common names	Scientific names	IUCN Categories	Estimate
1	*Mona monkey	*Cercopithecus mona*	LC	Rear
2	*White throated guenon	*Cercopithecus erythrogaster*	VN	Rear
3	Grass cutter	*Thryonomys (Choeromys) sp*	LC	Numerous

4	African giant rat	*Cricetomys emin*	LC	Numerous
5	Tree squirrel	*Myosciurus pumilio*	LC	Occasional
6	Sierra Leone Collard Fruit Bat	*Myonycteris leptodon*	LC	Rear

*Reports from interviews and focused group discussion with community members

Endangered Species

Most species reported in this study ranged from not evaluated to least concerned. However, there were reports of sightings of the White Throated Guenon (*Cercopithecus erythrogaster)* which is characterized by IUCN as threatened.

Although most species observed do not fall in IUCN threatened species red list, the observed local rarity of many species may be due to perennial habitat destruction and disturbance, emanating from deliberate hunting, vegetation clearance and other developmental activities.

4.3.6: SurfaceWater quality

The results of some physical and chemicalparameters of surface waters of the study area and control are summarized in Tables 4.20 – 4.23. The detailed results for all sampling stations are presented in Appendix 3. The prominent surface water bodies in the project area within the study bounds are the Inland Waters (Estuary) which transverse Utapate Field in several tributaries and the Atlantic Ocean, which lie adjacent to the project area; the estuaries empty into the Atlantic

Surface Water Chemistry

Physical Tests:

Physical test parameters such as Temperature, pH, Turbidity, Conductivity, Dissolved Oxygen (DO), and Total Dissolved Solids (TDS) which are mostly carried-out insitu, are precursor to the quality of water and are very useful tool in water quality measurement. Results obtained during the wet and dry season field survey for surface water measurement insitu are summarized in Tables 4.20 – 4.23

Table 4.20: Summary of Inland Water Physico-Chemistry – Wet Season

Parameter	Wet Season						FMEnv	WHO
	Study Area			Control				
	Min	Max	Mean	Min	Max	Mean		
PHYSICAL TESTS								
pH	7.92	9.82	8.95	8.24	9.35	8.795	6.5-8.5	6.5-8.5
Temp ^oC	27.65	30.31	29.34	27.38	28.12	27.75	30	35
EC (µS/cm)	1713	43490	29786.29	26120	31550	28835	NS	NS
TDS (mg/l)	898	21645	14853.85	13071	15780	14425.5	500	500
Salinity (psu)	0.91	27.60	18.60	14.92	19.6	17.26	NS	NS
ORP (mV)	-127.4	87.5	20.6	6	51.24	28.62	NS	NS
Turbidity (FNU)	2	9	5	3	4	3.5	NS	NS
DO (mg/l)	3.29	3.88	3.54	3.61	3.62	3.615	>3.5	7.5
Colour (Pt.Co)	6	700	82	26	36	31	NS	NS
TSS (mg/l)	3	13.5	7.5	4.5	6	5.25	10	5
ANIONS AND NUTRIENTS								
Nitrate (NO_3) (mg/l)	1.5	12.5	5.2	0.6	3.2	1.9	10	10
Ammonia (mg/l)	0.24	7.34	3.21	0.46	1.42	0.94	NS	NS
Chloride (Cl^-) (mg/l)	402.3	13084.39	8160.78	739.43	1089.66	914.55	250	200
Sulphate (SO_4^{2-})	13.29	1262.29	457.74	37.93	85.43	61.68	500	200

Parameter	Wet Season						FMEnv	WHO
	Study Area			Control				
	Min	Max	Mean	Min	Max	Mean		
(mg/l)								
Phosphate (PO_4^{3-}) (mg/l)	ND	0.07	0.017	ND	0.01	0.005	5	NS
Hardness mg $CaCO_3$/l	1000.71	6004.26	3549.58	3402	3402	3402	200	NS
Alkalinity	30	83	60	46	50	48	NS	NS
BOD (mg/l)	5.25	210.19	63.52	26.27	63.06	44.67	NS	10
COD (mg/l)	9.98	399.36	120.69	49.92	119.81	84.86	20	NS
METALS AND HEAVY METALS								
Magnesium Mg (mg/l)	4.20	7.98	6.35	6.16	6.98	6.57	NS	NS
Sodium Na (mg/l)	8.15	11.64	10.20	9.16	10.07	9.62	200	
Copper Cu (mg/l)	ND	0.384	0.17	ND	0.015	0.007	0.1	0.05
Chromium Cr (mg/l)	0.028	0.091	0.058	0.048	0.091	0.070	0.05	0.05
Cadmium Cd (mg/l)	0.104	0.301	0.224	0.131	0.301	0.216	0.01	NS
Nickel Ni (mg/l)	0.139	2.183	1.227	0.34	0.96	0.65	1.0	0.1
Arsenic As (mg/l)	ND	ND	ND	ND	ND	ND	0.1	0.001
Iron Fe (mg/l)	0.486	7.941	2.366	0.779	4.041	2.41	1	0.1
Mercury Hg (mg/l)	ND	3.684	1.804	0.447	1.955	1.201	0.001	0.001
Lead Pb(mg/l)	ND	1.515	0.639	0.231	0.932	0.582	0.05	0.05
Zinc Zn (mg/l)	ND	1.374	0.318	0.574	0.859	0.717	5	5
Manganese Mn (mg/l)	0.222	0.412	0.295	0.313	0.378	0.346	0.05	NS
ORGANICS								
THC (mg/l)	ND	0.002	ND	ND	ND	ND		
Oil & Grease (mg/l)	ND	0.016	0.002	ND	0.002	0.001		
TPH (mg/l)	ND	0.001	ND	ND	ND	ND		
PAH (mg/l)	ND	ND	ND	ND	ND	ND		
BTEX (mg/l)	ND	ND	ND	ND	ND	ND		

ND: Not detected NS: Not Specified

Table 4.21: Summary of Inland Water Physico-Chemistry – Dry Season

Parameter	Dry Season						FMEnv	WHO
	Study Area			Control Stations				
	Min			Min	Max	Mean		
PHYSICAL TESTS								
pH	7.64	11.8	9.29	8.6	10.13	9.37	6.5-8.5	6.5-8.5
Temp °C	26.31	32.74	30.57	28.94	31.51	30.23	30	35
EC (µS/cm)	11000	46481	41220.62	37480	41960	39720	NS	NS
TDS (mg/l)	5464	22632	20498.76	18760	20990	19875	500	500
Salinity (psu)	6.19	27.63	25.93	23.61	26.83	25.22	NS	NS
ORP (mV)	-4	123.6	46.27	59.3	75.5	67.4	NS	NS
Turbidity (FNU)	4	11	6.32	5	6	5.5	NS	NS
DO (mg/l)	3.19	3.96	3.37	3.31	3.42	3.365	>3.5	7.5
Colour (Pt.Co)	11	301	67.12	19	28	23.5	NS	NS
TSS (mg/l)	3	55	11.4	3	6	4.5	10	5
ANIONS AND NUTRIENTS								
Nitrate (NO_3) (mg/l)	1.5	9.8	4.96	2	3	2.5	10	10
Ammonia (mg/l)	0.941	5.221	3.467	1.605	1.771	1.688	NS	NS
Chloride (Cl^-) (mg/l)	246.71	14485.51	10958.36	8987.21	9986.93	9487.06	250	200
Sulphate (SO_4^{2-}) (mg/l)	37.15	813.52	447.60	46.53	210.75	128.64	500	200

Parameter	Dry Season						FMEnv	WHO
	Study Area			Control Stations				
	Min			Min	Max	Mean		
Phosphate (PO_4^{3-}) (mg/l)	ND	0.06	0.018	ND	0.02	0.01	5	NS
Hardness mg $CaCO_3$/l	984.03	5463.88	4444.43	4102.91	4723.35	4413.13	200	NS
Alkalinity	58.8	88.8	74.28	63.8	77.6	70.7	NS	NS
BOD (mg/l)	19.97	379.39	129.20	89.86	109.82	99.84	NS	10
COD (mg/l)	10.51	199.68	68.00	47.29	57.80	52.55	20	NS
METALS AND HEAVY METALS								
Magnesium Mg (mg/l)	3.184	6.645	5.375	4.181	4.842	4.512	NS	NS
Sodium Na (mg/l)	7.15	11.40	9.833	9.12	9.66	9.389	200	
Copper Cu (mg/l)	ND	1.175	0.328	0.094	0.281	0.188	0.1	0.05
Chromium Cr (mg/l)	ND	0.088	0.041	0.034	0.035	0.035	0.05	0.05
Cadmium Cd (mg/l)	0.091	0.211	0.145	0.096	0.118	0.107	0.01	NS
Nickel Ni (mg/l)	0.264	1.761	1.059	0.515	0.895	0.705	1.0	0.1
Arsenic As (mg/l)	ND	ND	ND	ND	ND	ND	0.1	0.001
Iron Fe (mg/l)	0.976	2.689	1.745	1.055	1.256	1.1555	1	0.1
Mercury Hg (mg/l)	ND	2.093	1.199	0.162	1.76	0.961	0.001	0.001
Lead Pb(mg/l)	ND	0.912	0.332	0.284	0.559	0.4215	0.05	0.05
Zinc Zn (mg/l)	ND	0.268	0.128	0.012	0.143	0.078	5	5
Manganese Mn (mg/l)	0.102	0.445	0.250	0.276	0.284	0.28	0.05	NS
ORGANICS								
THC (mg/l)	ND	0.06	0.004	ND	ND	ND		
Oil & Grease (mg/l)	ND	0.46	0.121	ND	0.13	0.065		
TPH (mg/l)	ND	0.05	0.003	ND	ND	ND		
PAH (mg/l)	ND	ND	ND	ND	ND	ND		
BTEX (mg/l)	ND	ND	ND	ND	ND	ND		

ND: Not detected NS: Not Specified

Table 4.22: Summary of Shallow Atlantic Ocean Physico-Chemistry – Wet Season

Parameters	Wet Season				FMEnv	WHO
	Study Area			Control		
	Min	Max	Mean			
PHYSICAL TEST						
pH	8.84	9.86	9.48	9.24	6.5-8.5	6.5-8.5
Temp oC	27.3	28.29	27.81	28.31	30	35
EC (µS/cm)	22230	32350	31131.54	32310	NS	NS
TDS (mg/l)	15290	16230	15909.04	16130	500	500
Salinity (psu)	18.89	20.21	19.72	13.97	NS	NS
ORP (mV)	-13.6	33.6	-0.75	31.22	NS	NS
Turbidity (FNU)	3	8	5.04	4	NS	NS
DO (mg/l)	3.57	3.65	3.60	3.66	>3.5	7.5
Colour (Pt.Co)	3	26	10.61	10	NS	NS
TSS (mg/l)	4.5	12	7.55	6	10	5
ANIONS AND NUTRIENTS						
Nitrate (NO_3^-) (mg/l)	1.8	8.2	4.76	3.16	10	10
Ammonia (mg/l)	0.22	5.61	2.43	2.01	NS	NS
Chloride (Cl^-) (mg/l)	886.5	93232.8	12164.73	986.59	250	200
Sulphate (SO_4^{2-}) (mg/l)	25.79	861.57	292.43	29.16	500	200
Phosphate (PO_4^{3-}) (mg/l)	ND	0.02	0.005	ND	5	NS
Hardness mg $CaCO_3$/l	3002.13	4603.27	3872.75	3346.52	200	NS
Alkalinity	36	62	50	49	NS	NS
BOD (mg/l)	5.25	210.19	48.79	10.51	NS	10
COD (mg/l)	9.98	399.36	92.71	19.97	20	NS
METALS AND HEAVY METALS						

Parameters	Wet Season				FMEnv	WHO
	Study Area			Control		
	Min	Max	Mean			
Magnesium Mg (mg/l)	4.43	7.68	6.75	6.33	NS	NS
Sodium Na (mg/l)	8.35	12.05	9.93	9.16	200	NS
Copper Cu(mg/l)	ND	0.39	0.119	0.083	0.1	0.05
Chromium Cr (mg/l)	0.028	0.091	0.062	0.064	0.05	0.05
Cadmium Cd (mg/l)	0.164	0.334	0.258	0.311	0.01	NS
Nickel Ni (mg/l)	0.83	1.62	1.194	1.102	1.0	0.1
Arsenic As (mg/l)	ND	ND	ND	ND	0.1	0.001
Iron Fe (mg/l)	0.51	1.95	0.858	0.661	1	0.1
Mercury Hg (mg/l)	0.99	3.96	2.393	4.127	0.001	0.001
Lead Pb(mg/l)	0.65	1.48	1.18	1.51	0.05	0.05
Zinc Zn (mg/l)	ND	0.606	0.258	0.252	5	5
Manganese Mn (mg/l)	0.204	0.316	0.240	0.294	0.05	NS
ORGANICS						
THC	ND	ND	ND	ND		
Oil & Grease(mg/l)	ND	0.011	0.000535714	ND		
TPH (mg/l)	ND	ND	ND	ND		
PAH (mg/l)	ND	ND	ND	ND		
BTEX (mg/l)	ND	ND	ND	ND		

ND: Not detected NS: Not Specified

Table 4.23: Summary of Shallow Atlantic Ocean Physico-Chemistry – Dry Season

Parameters	Dry Season				FMEnv	WHO
	Study Area			Control		
	Min	Max	Mean			
PHYSICAL TEST						
pH	8.11	10.35	9.19	9.42	6.5-8.5	6.5-8.5
Temp oC	28.19	37.86	30.90	30.84	30	35
EC (µS/cm)	30840	46250	39487.21	35270	NS	NS
TDS (mg/l)	15420	23125	19735.07	16130	500	500
Salinity (psu)	20.01	29.97	24.74	20.64	NS	NS
ORP (mV)	-12.4	111	25.98	46.31	NS	NS
Turbidity (FNU)	4	9	6.32	5	NS	NS
DO (mg/l)	3.11	3.99	3.59	3.57	>3.5	7.5
Colour (Pt.Co)	8	33	15.68	16	NS	NS
TSS (mg/l)	2	10.5	6.77	8	10	5
ANIONS AND NUTRIENTS						
Nitrate (NO_3^-) (mg/l)	2	7.6	3.72	3.1	10	10
Ammonia (mg/l)	0.59	5.90	2.54	2.08	NS	NS
Chloride (Cl^-) (mg/l)	1083.66	17834.47	10056	10486.75	250	200
Sulphate (SO_4^{2-}) (mg/l)	79.65	710.25	362.07	186.92	500	200
Phosphate (PO_4^{3-}) (mg/l)	ND	0.03	0.008	0.01	5	NS
Hardness mg $CaCO_3$/l	3402.41	5523.92	4365.24	4202.98	200	NS
Alkalinity	53.2	87.2	66.21	77.2	NS	NS
BOD (mg/l)	19.97	239.62	119.09	99.84	NS	10
COD (mg/l)	10.51	126.11	62.68	52.55	20	NS
METALS						
Magnesium Mg (mg/l)	4.04	6.05	4.77	5.02	NS	NS
Sodium Na (mg/l)	7.76	11.68	9.94	9.16	200	NS
Copper Cu(mg/l)	ND	0.94	0.14	0.18	0.1	0.05
Chromium Cr (mg/l)	ND	0.09	0.05	0.06	0.05	0.05
Cadmium Cd (mg/l)	0.12	0.25	0.16	0.15	0.01	NS
Nickel Ni (mg/l)	0.75	1.56	1.03	0.92	1.0	0.1
Arsenic As (mg/l)	ND	ND	ND	ND	0.1	0.001
Iron Fe (mg/l)	0.58	2.19	1.11	0.98	1	0.1
Mercury Hg (mg/l)	ND	1.84	0.99	1.01	0.001	0.001

Parameters	Dry Season				FMEnv	WHO
	Study Area			Control		
	Min	Max	Mean			
Lead Pb(mg/l)	0.43	1.31	0.84	ND	0.05	0.05
Zinc Zn (mg/l)	ND	0.21	0.11	0.16	5	5
Manganese Mn (mg/l)	0.09	0.35	0.23	0.32	0.05	NS
ORGANICS						
THC	ND	0.03	0.003	ND		
Oil & Grease(mg/l)	ND	0.21	0.023	ND		
TPH (mg/l)	ND	ND	ND	ND		
PAH (mg/l)	ND	ND	ND	ND		
BTEX (mg/l)	ND	ND	ND	ND		

ND: Not detected NS: Not Specified

pH:

pH is one of the water quality parameters which refers to the measure of hydrogen ions, or acidity, in the water. Water has hydrogen ions and hydroxyl ions. When there are equal numbers of both, the water is neutral. As the hydrogen ions increase, the water becomes more acidic; as the hydroxyl ions increase, the water becomes more basic. pH is measured on a logarithmic scale of 0 – 14: 7 is neutral; below 7 is acidic; above 7 is basic.

Most aquatic organisms have a narrow pH tolerance range of 6.5 – 8.5 which also reflects the recommended limit set by FMEnv, DPR and WHO. Acidic waters can cause toxic heavy metals to be released into the water. Acid rain and mining operations can lower the pH of water bodies.

pH values from the survey ranged from 7.92 to 9.82 in the wet season and 7.64 – 11.80 in the dry season for the Inland Waters. The higher bounds of these values were obtained in stations proximate to the Atlantic where mixing due to tide is evident.

In the shallow Atlantic Ocean, it ranged from 8.84 to 9.86 in the wet season and 8.11 – 10.35 in the dry season which is expected for saline waters. Wet and dry season respective mean of 8.95 and 9.29 for inland waters is consistent 8.80 and 9.37 mean values obtained in the control stations. Wet and dry season respective mean 9.48 and 9.19 for shallow Atlantic Ocean is also consistent with their control station values of 9.24 and 9.42. The computed mean in the Inland Waters and shallow Atlantic Ocean clearly puts the water body above 6.5 – 8.5 pH recommended standard. However, the range of values obtained is typical of Estuaries and saline water body such as the Atlantic Ocean.

Temperature

Surface water temperature was influenced by the time of the day and amount of heat absorbed from the Sun. Measured mean temperature during the wet season in the Inland Waters was 29.34^{o}C from a range of 27.65 to 30.31^{o}C. In the shallow Atlantic, it was 27.81 ^{o}C from a range of 27.30 – 28.29 ^{o}C. A slightly higher mean of 30.57^{o}C from a range of 26.31 to 32.74^{o}C for Inland Waters and 30.90^{o}C from a range of 28.19 to 37.86^{o}C for the shallow Atlantic was recorded in the dry season. Similar values were obtained in the control stations in both seasons. The temperature of a surface water body is not expected to exceed ambient temperature based on WHO recommendation.

***Electrical Conductivity (EC)*:** EC is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement.

Solutions of most inorganic compounds are relatively good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly, if at all. Electrical conductivity, which is a measure of the ionic richness of the water body was very high as expected for both Inland Waters and shallow Atlantic Ocean. Inland Waters ranged from 1713 to 43490 µS/cm (Mean = 29786.29µS/cm) in the wet season and 11000 to 46481 µS/cm (Mean = 41220 µS/cm) in the dry season. Shallow Atlantic ranged from 22230 to 32350 µS/cm (Mean = 31131.54 µS/cm) in the wet season and 30840 to 46250 µS/cm (Mean = 39487.21 µS/cm) in the dry season.

Total Dissolved Solids (TDS

TDS average concentration in Inland Waters was 14853.85 mg/l in the wet season and 20498.76 mg/l in the dry season with similar values obtained in the control stations. The observed increase in the dry season may be attributed to decreased dilution of the water body due to increased evaporation of water associated with the dry season. Given the correlation between EC and TDS, a high TDS value is expected. Similarly, in the shallow Atlantic, it was 15909.04 mg/l in the wet season and 19735.07 mg/l in the dry season.

Salinity

Salinity is a measure of the total amount of dissolved salts in a water body. The anions and cations that make up the salinity of a water body include chloride, sodium, sulphate, magnesium, calcium and potassium. Measured salinity value of the surface waters was very high as expected for the Inland Waters and the shallow Atlantic Ocean with respective mean values of 18.60 psu and 19.72 psu in the wet season, and 25.93 psu and 24.74 psu in the dry season.

Oxidation-Reduction Potential (Redox)

The oxidation-reduction potential (redox potential) is a measure of the ratio of oxidized to reduced forms in a solution. This parameter is inextricably linked to oxygen supply and the processes of its consumption thereof by aquatic biota.
Therefore, the redox potential is used as an indicator of the oxygenation status and the content of biogenic forms in the aquatic environment. It is used to determine if oxidizing or reducing conditions are prevalent in the water body. The potential for oxidation and reduction across the sampling stations in the Inland Waters was averagely 20.6mV in the wet season and higher in the dry season (46.27 mV) indicating a net potential for oxidation in the Inland Waters. In the shallow Atlantic, reduction potential was prevalent in the wet season compared to dry season where increased oxidation potential was observed (Wet season = -0.75mV; Dry season = 25.98mV). In the shallow Atlantic control station, oxidation potential was prevalent in both seasons.

Turbidity

Mean turbidity value in inland Waters was 5 FNU in the wet season and 6.32 FNU in the dry season. It was 3.5 and 5.5 FNU in the control stations respectively. Similar values were observed in the shallow Atlantic (Wet season = 5.04 FNU; Dry season = 6.32 FNU) as well as the control stations.

DO

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water - the amount of oxygen available to living aquatic organisms. Concentration of oxygen below 2mg/L (FMEnv) may lead to death of most aquatic organisms. DO levels were observed to be enough to support life both in the Inland Waters and the shallow Atlantic with negligible season induced change. A mean value of 3.54 and 3.37 mg/L was obtained in the wet and dry seasons in the Inland Waters respectively while 3.60 and 3.59 mg/L was obtained in the shallow Atlantic. The values observed in the inland waters and shallow Atlantic were consistent with those recorded in the control stations for both seasons.

Total Suspended Solids

The mean TSS of Inland Waters was observed to be higher in the dry season (11.4 mg/l) than in the wet season (7.5 mg/l). It was not the same for the shallow Atlantic (Wet season = 7.55 mg/l; Dry season = 6.77 mg/l).

Anions

Mono valent and divalent anions were determined and occurred in varying amounts at all sampling stations. These are NO_3-N and NH_3-N (which are different forms of nitrogen in the aquatic ecosystem), phosphates, sulphates and chlorides. Compounds of nitrogen and especially those of phosphorus are major cellular components of organisms. They are highly dynamic in the aquatic ecosystem. Of all forms of nitrogen, the most stable and easily utilised is the nitrate which is derived from the oxidation of nitrite. Aquatic organisms need nitrates as essential nutrient for primary productivity. Nitrate values recorded were low in both Inland Waters and shallow Atlantic. It fluctuated in the inland Waters between 1.50 – 12.50mg/L (Mean = 5.2 mg/l) in the wet season and 1.5 – 9.8mg/L (Mean = 4.96 mg/l) in the dry season while in the shallow Atlantic it varied between 1.8 – 8.2mg/L (Mean = 4.76 mg/l) in the wet season and 2 – 7.6 mg/L (Mean = 3.72 mg/l) in the dry season. Their respective mean values are well below FMEnv/DPR limit of 10mg/l. Similarly, ammonia recorded wet and dry season respective mean of 3.21 and 3.46 mg/L for Inland Waters and 2.43 and 2.54 mg/L for the shallow Atlantic. Chloride was very high as expected for both water bodies with wet and dry season average values of 8160.77 and 10958.36 mg/l for Inland Waters and 12164.73 and 10056 mg/l for shallow Atlantic respectively.
Usually, phosphorus occurs in natural waters and in wastewaters almost majorly as phosphates. These are classified as orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. They occur in solution, in particles or detritus, or in the bodies of aquatic organisms. Orthophosphates applied to agricultural or residential cultivated land as fertilizers are carried into surface waters with storm runoff. Organic phosphates are formed primarily by biological processes. They are contributed to sewage by body wastes and food residues, and also may be formed from orthophosphates in biological treatment processes or by receiving water biota. Phosphorus is essential to the growth of organisms and can be the nutrient that limits the primary productivity of a body of water. In instances where phosphate is a growth-limiting nutrient, the discharge of raw or treated wastewater, agricultural drainage, or certain industrial wastes to that water may stimulate the growth of photosynthetic aquatic micro- and macro-organisms in nuisance quantities.

The phosphate values recorded in Inland Waters ranged from 0 - 0.07 mg/l in the wet season and 0 to 0.06 mg/l in the dry season. In the control stations, they were mostly not detected but record maximum values of 0.01 and 0.02 in the wet and dry seasons respectively. Similar trend was observed in the shallow Atlantic with 0.02mg/l and 0.03mg/l being the maximum values recorded in the wet and dry seasons respectively. Phosphate was only detected in the control station during the dry season posting a value of 0.01mg/l. Elevated levels of phosphorus in some waters are usually due to soil leaching from surrounding fertile soil, livestock activities and human faeces.

Sulphate values recorded were quite high. Wet and dry season mean values were 457.74 mg/l and 447.60 mg/l for Inland Waters while it was 292.43 and 362.07 mg/L respectively. These values exceeded the DPR set limit of 200mg/l but are within FMEnv limit for surface water which is set at 500 mg/l.

Total Hardness

Total hardness in saline water is usually >375 mg/l as $CaCO_3$. Total hardness in the Inland Waters ranged from 1000.71 to 6004.26 mg/l and average of 3549.58 mg/l in the wet season and 984.03 to 5463.88 mg/l and average of 4444.43 mg/l in the dry season. The respective wet and dry season mean in the shallow Atlantic was 3872.75 mg/l and 4365.24 mg/l. In hard water, lathering does not occur until all the hardness ions are precipitated (Howard, 1985).

Biological Oxygen Demand

Biochemical Oxygen Demand (BOD, also called Biological Oxygen Demand) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive. BOD in the Inland Waters ranged from 5.26 to 210.19 mg/l with an average of 63.52 mg/l in the wet season and 19.97 to 199.68 mg/l with an average of 68.00 mg/l in the dry season. In the shallow Atlantic wet and dry season mean were 48.79 mg/l and 119.09 mg/l respectively.

Chemical Oxygen Demand

COD values obtained for Inland Waters ranged from 9.98 to 399.36 mg/l, with an average of 120.69 mg/l in the wet season and 10.51 to 199.68 mg/l, with an average of 68 mg/l in the dry season. In the shallow Atlantic, it ranged from 9.98 to 399.36 mg/l, with an average of 92.71 mg/l in the wet season and 10.51 to 126.11 mg/l, with an average of 62.68 mg/l in the dry season. Generally, COD of the waterbodies were high and mostly exceeded the 20mg/l FMEnv recommended limit.

Exchangeable Cations in Surface Waters

The major cations dissolved in water bodies are calcium, magnesium, sodium and potassium, and of these, calcium and sodium are normally dominant. Calcium and magnesium constitute the major elements responsible for water hardness. The most forms of calcium are calcium carbonate (calcite) and calcium-magnesium carbonate (dolomite). Hardness is based on the concentration of calcium and magnesium salts, and often is used as a measure of potable water quality. Mean sodium concentration in the wet and dry season was observed to be 10.20 and 9.83 mg/l in the Inland Waters respectively while it was 9.93 and 9.94 mg/l in the shallow Atlantic. Mean magnesium concentrations was 6.35 and 5.37 mg/l in the Inland Waters during the wet and dry seasons respectively and 6.75 and 4.77 mg/l in the shallow Atlantic.

Heavy Metals

Metals occur naturally in the earth's crust, and their contents in the environment can vary between different regions resulting in spatial variations of background concentrations. About 92 naturally occurring elements exists and approximately 30 metals and metalloids are potentially toxic to humans including: Be, B, Li, Al, Ti, V, Cr, Mn, Co, Ni, Cu, As, Se, Sr, Mo, Pd, Ag, Cd, Sn, Sb, Te, Cs, Ba, W, Pt, Au, Hg, Pb, and Bi.

Heavy metals enter the environment by natural and anthropogenic means. Such sources include: natural weathering of the earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents, and pest or disease control agents applied to plants, air pollution fallout, and a number of others. Although, toxicity and the resulting threat to human health of any contaminant are, of course, a function of concentration, it is well-known that chronic exposure to heavy metals and metalloids at relatively low levels can cause adverse effects.

The results of the heavy metals analyzed shows that Arsenic was below equipment detection limit of 0.001mg/l in Inland Waters and shallow Atlantic samples in both seasons. While the respective wet and dry season mean concentrations recorded in Inland Waters were 0.17 and 0.33 mg/l for Cu, 0.06 and 0.04 mg/l for Cr, 0.22 and 0.04 mg/l for Cd, 1.23 and 1.06 mg/l for Ni, 2.37 and 1.74 mg/l for Fe, 1.80 and 1.20 mg/l for Hg, 0.64 and 0.33 mg/l for Pb, 0.32 and 0.13 mg/l for Zn, 0.30 and 0.25 mg/l for Mn, the respective wet and dry season mean concentrations recorded in shallow Atlantic were 0.12 and 0.14 mg/l for Cu, 0.06 and 0.05 mg/l for Cr, 0.26 and 0.16 mg/l for Cd, 1.23 and 1.03 mg/l for Ni, 2.37 and 0.99 mg/l for Fe, 2.39 and 0.98 mg/l for Hg, 1.17 and 0.84 mg/l for Pb, 0.26 and 0.11 mg/l for Zn, 0.24 and 0.23 mg/l for Mn.

The mean concentrations of Copper, Cadmium, Iron, Mercury, Lead and Manganese in the Inland Waters exceeded their FMEnv set limits in both seasons.

Organics in Surface Water

Of the organics analyzed PAH and BTEX were not detected in Inland Waters and shallow Atlantic in both seasons. TPH was scarcely detected in the Inland Waters but was not detected in the shallow Atlantic. Maximum THC concentrations in the wet and dry seasons were 0.002 mg/l and 0.06 mg/l respectively in the Inland Waters. It was undetected in the shallow Atlantic during the wet season but recorded maximum concentration of 0.03 mg/l in the dry season. The wet and dry season mean concentration of oil and grease were 0.002 mg/l and 0.12 mg/l in the Inland Waters and 0.001 mg/l and 0.02 mg/l in the shallow Atlantic respectively.

Surface Water Microbiology

As shown in Tables 4.24 and 4.25, the total heterotrophic bacteria in the Inland Waters during the wet season ranged from (0.09 to 1.58) x 10^5 cfu/ml which is consistent with the range recorded in the control stations (0.68 to 1.03) x10^5 cfu/ml. In the dry season, a range of (0.13 – 9.4) x 10^5 cfu/ml was obtained while in the control stations it was 5.3 to 8.6 x10^4 cfu/ml. An increase was observed in the dry season which may have been season induced.
Similarly, in the shallow Atlantic total heterotrophic bacteria during the wet season ranged from (0.15 to 1.64) x 10^5 cfu/ml while in the dry season, a range of (0.15 – 9.7) x 10^5 cfu/ml was recorded (Tables 4.26 and 4.27).

Table 4.24: Inland Water Microbiology - Wet Season

	Wet Season					
	Study Area			Control		
Parameter	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Total Coliform Count (MPN/100ml)	NIL	150	21.5	NIL	21	10.5
Faecal Coliform (MPN/100ml)	NIL	20	2.8	NIL	NIL	NIL
Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	9.0x10^2	1.58x10^4	8.65x10^3	6.8x10^3	1.03x10^4	8.55x10^3
Total Heterotrophic Fungi Count (x10^1 cfu/ml)	NIL	1.8x10^3	5.71x10^2	NIL	2.0x10^2	1.0x10^2

Table 4.25: Inland Water Microbiology – Dry Season

Parameter	Dry Season					
	Study Area			Control		
	Min	Max	Mean	Min	Max	Mean
Total Coliform Count (MPN/100ml)	NIL	111	19	NIL	23	11.5
Faecal Coliform (MPN/100ml)	NIL	21	3	NIL	NIL	NIL
Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	1.3x10^3	9.5x10^4	1.17x10^4	5.3x10^3	8.6x10^3	6.95x10^3
Total Heterotrophic Fungi Count (x10^1 cfu/ml)	NIL	1.5x10^3	5.16x10^2	2x10^2	5 x10^2	3.5x10^2

Table 4.26: Shallow Atlantic Microbiology - Wet Season

Parameters	Wet Season			
	Study Area			Control
	Min	Max	Mean	OML/UTP/SWC3
Total Coliform Count (MPN/100ml)	NIL	160	11	4
Faecal Coliform (MPN/100ml)	NIL	14	1	NIL
Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	1.5x10^3	1.64x10^4	5.568x10^3	3.8 x 10^3
Total Heterotrophic Fungi Count (x10^1 cfu/ml)	NIL	7.0x10^2	2.39x10^2	NIL

Table 4.27: Shallow Atlantic Microbiology - Dry Season

Parameters	Dry Season			
	Study Area			Control
	Min	Max	Mean	OML/UTP/SWC3
Total Coliform Count (MPN/100ml)	NIL	75	10.58214	16
Faecal Coliform (MPN/100ml)	NIL	14	1.1	NIL
Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	1.5x10^3	9.7x10^4	9.11x10^3	7.3 x 10^3
Total Heterotrophic Fungi Count (x10^1 cfu/ml)	NIL	7.0x10^2	2.14x10^2	2.0 x10^2

Total heterotrophic fungi in Inland Waters ranged from 0.0 to 1.8 x 10^4 cfu/ml in the wet season and were heavier in density compared to the 0.0 to 2.0 x10^3 cfu/ml observed in the control stations. In the shallow Atlantic it ranged from 0.0 to 7.0 x 10^3cfu/ml. A range of 0.0 to 1.5 x 10^4cfu/ml was recorded in the Inland Waters during the dry season while in the shallow Atlantic it ranged from 0.0 to 7.0 x 10^3cfu/ml. A decline in total heterotrophic fungi density was observed in the dry season which may have been season induced.

Faecal coliform was scarcely present in the Inland Waters with a range of 0 to 20 and 0 to 21 MPN/100ml in the wet and dry seasons respectively. Faecal coliform was not present in the control stations in both seasons. Similar trend was observed in the shallow Atlantic. Total Coliform count ranged from 0.0 – 150 and 0.0 – 160 MPN/100ml in the wet season for Inland Waters and shallow Atlantic respectively whereas in the control stations, it was averagely 10.5 and 4 MPN/100ml respectively. In the dry season, a range of 0 – 111 MPN/100ml and 0.0 – 75.0 MPN/100ml was recorded in the Inland Waters and shallow Atlantic respectively indicating season induced decline in Coliform density.

4.3.7: Sediment Quality

Results of sediment physico-chemical analyses for the Inland Waters and shallow Atlantic are summarized in Tables 4.28 - 4.31 and detailed in Appendix 3.

Table 4.28: Inland Water Sediment Physico-chemical Analysis Result – Wet Season

Parameters	Wet Season					
	Study Area			Control		
	Min	Max	Mean	Min	Max	Mean
PHYSICAL TEST						
pH	4.11	5.47	4.70	4.29	4.93	4.61
EC (µS/cm)	51	193	87.47	66	72	69
Temperature (^oC)	24.99	29.76	27.22	27.98	28.45	28.22
ANIONS and NUTRIENTS						
Nitrate (NO_3) (mg/kg)	2.5	13	6.88	3.75	6	4.875
Ammonia (As Nitrogen) (mg/kg)	0.07	0.33	0.22	0.25	0.31	0.28
Phosphate (PO_4^{3-}) (mg/kg)	1.17	4.51	2.22	0.16	2.31	1.23
Sulphate (SO_4^{2-}) (mg/kg)	2.25	8.59	4.68	5.25	5.95	5.60
Chloride (Cl^-) (mg/kg)	562.36	1537.02	984.25	924.71	999.69	962.20
ORGANICS						
TOC (%)	0.38	1.72	0.89	0.55	1.04	0.80
Oil & Grease (mg/kg)	0.98	3.76	2.05	1.47	1.86	1.67
THC (mg/kg)	ND	ND	ND	ND	ND	ND
TPH (mg/kg)	ND	ND	ND	ND	ND	ND
PAH	ND	ND	ND	ND	ND	ND
BTEX (mg/kg)	ND	ND	ND	ND	ND	ND
TEXTURE						
Clay (%)	5.17	52.38	23.23	1.29	33.02	17.16
Silt (%)	25.53	87.17	54.15	25.43	35.96	30.70
Sand(%)	5.43	41.99	22.62	31.03	73.38	52.21
METALS						
Copper Cu (mg/kg)	ND	1.47	0.27	ND	0.12	0.06
Potassium K (mg/kg)	ND	2.11	0.75	0.41	0.67	0.54
Sodium Na (mg/kg)	2.33	6.42	4.81	2.41	4.66	3.53
Chromium Cr (mg/kg)	ND	2.53	0.80	0.84	1.44	1.14
Cadmium Cd (mg/kg)	0.10	0.99	0.36	0.42	0.57	0.49
Nickel Ni (mg/kg)	ND	1.34	0.45	0.21	0.54	0.38
Arsenic As (mg/kg)	ND	1.23	0.20	ND	0.12	0.06
Iron Fe (mg/kg)	12.64	145.43	97.01	81.34	96.54	88.94
Mercury Hg (mg/kg)	ND	2.54	1.09	1.22	2.04	1.63
Lead Pb(mg/kg)	0.04	2.78	1.62	1.39	2.32	1.85
Zinc Zn (mg/kg)	0.01	0.68	0.37	0.26	0.33	0.29
Manganese Mn (mg/kg)	0.06	6.67	0.66	0.31	0.46	0.39
Magnesium Mg (mg/kg)	3.89	7.45	5.20	5.61	6.13	5.87

Table 4.29: Inland Water Sediment Physico-chemical Analysis Result – Dry Season

Parameters	Dry Season					
	Study Area			Control		
	Min	Max	Mean	Min	Max	Mean
PHYSICAL TEST						
pH	4.88	8.59	6.01	5.49	6.05	5.77
EC (µS/cm)	68.00	6923.00	300.35	79.00	6906.00	3492.50
Temperature (^oC)	28.26	34.94	30.54	29.66	31.55	30.61
ANIONS and NUTRIENTS						
Nitrate (NO_3) (mg/kg)	3.00	15.08	7.86	4.70	6.96	5.83
Ammonia (As Nitrogen) (mg/kg)	0.12	0.38	0.29	0.32	0.36	0.34
Phosphate (PO_4^{3-}) (mg/kg)	1.31	5.58	2.44	0.17	2.62	1.40
Sulphate (SO_4^{2-}) (mg/kg)	2.18	8.60	4.58	5.16	5.84	5.50

Chloride (Cl^-) (mg/kg)	472.33	1824.56	1020.72	824.71	1008.63	916.67
ORGANICS						
TOC (%)	0.41	1.68	0.95	0.72	1.12	0.92
Oil & Grease (mg/kg)	0.88	3.52	1.97	1.36	1.80	1.58
THC (mg/kg)	ND	0.90	0.21	ND	0.08	0.04
TPH (mg/kg)	ND	ND	ND	ND	ND	ND
PAH (mg/kg)	ND	ND	ND	ND	ND	ND
BTEX (mg/kg)	ND	ND	ND	ND	ND	ND
TEXTURE						
Clay (%)	3.81	63.96	23.03	31.19	32.73	31.96
Silt (%)	14.15	84.25	54.82	32.26	32.44	32.35
Sand(%)	8.36	57.92	22.15	34.83	36.55	35.69
METALS						
Copper Cu (mg/kg)	ND	1.50	0.29	ND	0.14	0.07
Potassium K (mg/kg)	0.01	2.21	0.76	0.42	0.62	0.52
Sodium Na (mg/kg)	2.41	7.40	4.88	2.44	4.67	3.56
Chromium Cr (mg/kg)	ND	2.53	0.80	0.86	1.45	1.16
Cadmium Cd (mg/kg)	0.11	0.98	0.37	0.47	0.57	0.52
Nickel Ni (mg/kg)	ND	1.38	0.45	0.21	0.56	0.38
Arsenic As (mg/kg)	ND	0.61	0.13	ND	0.13	0.07
Iron Fe (mg/kg)	15.30	163.82	101.73	85.06	98.21	91.64
Mercury Hg (mg/kg)	ND	2.52	1.11	1.24	2.09	1.67
Lead Pb(mg/kg)	0.06	2.80	1.65	1.34	2.33	1.83
Zinc Zn (mg/kg)	0.01	0.90	0.41	0.30	0.42	0.36
Manganese Mn (mg/kg)	0.06	6.65	0.69	0.33	0.47	0.40
Magnesium Mg (mg/kg)	4.00	7.45	5.21	5.81	6.24	6.03

Table 4.30: Shallow Atlantic Sediment Physico-chemical Analysis Result – Wet Season

	Wet Season			
	Study Area			
Parameters	**Min**	**Max**	**Mean**	**Control**
PHYSICAL TEST				
pH	4.12	5.31	4.76	5.01
EC (µS/cm)	49.00	120.00	79.57	55.00
Temp	24.76	29.91	26.92	27.54
ANIONS and NUTRIENTS				
Nitrate (NO_3) (mg/kg)	2.25	9.75	6.36	11.75
Ammonia (As Nitrogen) (mg/kg)	0.06	0.50	0.21	0.21
Phosphate (PO_4^{3-}) (mg/kg)	0.18	3.89	2.25	4.09
Sulphate (SO_4^{2-}) (mg/kg)	1.20	8.24	4.49	4.19
Chloride (Cl^-) (mg/kg)	712.28	1249.61	1026.91	1861.92
ORGANICS				
TOC (%)	0.21	1.42	0.92	0.76
Oil & Grease (mg/kg)	1.12	3.33	1.96	1.66
THC (mg/kg)	ND	ND	ND	ND
TPH (mg/kg)	ND	ND	ND	ND
PAH (mg/kg)	ND	ND	ND	ND
BTEX (mg/kg)	ND	ND	ND	ND
TEXTURE				
Clay (%)	1.16	52.16	9.21	1.23
Silt (%)	3.21	77.84	14.73	8.55
Sand(%)	9.57	93.56	76.05	90.22
METALS				
Copper Cu (mg/kg)	ND	1.92	0.21	0.19
Potassium K (mg/kg)	0.05	2.43	0.80	0.39
Sodium Na (mg/kg)	2.31	7.46	4.65	3.74
Chromium Cr (mg/kg)	ND	2.59	0.85	0.39

Cadmium Cd (mg/kg)	0.09	0.94	0.42	0.53
Nickel Ni (mg/kg)	ND	0.91	0.55	0.54
Arsenic As (mg/kg)	ND	0.42	0.08	ND
Iron Fe (mg/kg)	27.99	147.30	105.68	121.43
Mercury Hg (mg/kg)	ND	2.32	1.13	1.66
Lead Pb(mg/kg)	0.87	3.18	1.87	2.48
Zinc Zn (mg/kg)	0.13	1.35	0.42	0.34
Manganese Mn (mg/kg)	0.11	0.86	0.35	0.41
Magnesium Mg (mg/kg)	3.80	8.45	5.29	4.32

Table 4.31: Shallow Atlantic Sediment Physico-chemical Analysis Result – Dry Season

Parameters	Dry Season			
	Study Area			Control
	Min	Max	Mean	
PHYSICAL TEST				
pH	4.28	6.79	5.68	6.11
EC (µS/cm)	54.00	134.00	89.29	68.00
Temperature (°C)	28.04	34.25	30.25	29.58
ANIONS AND NUTRIENTS				
Nitrate (NO_3^-) (mg/kg)	2.89	10.53	7.24	12.37
Ammonia (As Nitrogen) (mg/kg)	0.10	0.64	0.28	0.28
Phosphate (PO_4^{3-}) (mg/kg)	0.19	3.98	2.46	4.44
Sulphate (SO_4^{2-}) (mg/kg)	1.25	8.19	4.38	4.11
Chloride (Cl^-) (mg/kg)	638.07	1532.89	1085.35	993.42
ORGANICS				
TOC (%)	0.39	1.51	0.99	0.72
Oil & Grease (mg/kg)	1.04	3.24	1.92	1.50
THC (mg/kg)	0.94	0.94	0.94	ND
TPH (mg/kg)	ND	ND	ND	ND
PAH (mg/kg)	ND	ND	ND	ND
BTEX (mg/kg)	ND	ND	ND	ND
TEXTURE				
Clay (%)	1.72	43.06	9.95	3.43
Silt (%)	0.65	66.33	13.43	3.84
Sand(%)	9.72	93.81	76.63	92.73
METALS				
Copper Cu(mg/kg)	0.02	1.87	0.35	0.20
Potassium K (mg/kg)	0.06	2.50	0.82	0.40
Sodium Na (mg/kg)	2.31	7.48	4.68	3.76
Chromium Cr (mg/kg)	0.20	2.58	0.88	0.40
Cadmium Cd (mg/kg)	0.09	0.99	0.43	0.55
Nickel Ni (mg/kg)	0.29	0.91	0.57	0.55
Arsenic As (mg/kg)	0.01	0.42	0.14	ND
Iron Fe (mg/kg)	28.55	156.32	110.35	123.18
Mercury Hg (mg/kg)	0.41	2.34	1.54	1.65
Lead Pb(mg/kg)	0.91	3.28	1.89	2.49
Zinc Zn (mg/kg)	0.13	1.43	0.44	0.37
Manganese Mn (mg/kg)	0.11	0.92	0.36	0.49
Magnesium Mg (mg/kg)	3.85	7.99	5.34	4.46

Sediment Physico-chemical Characteristics

Particle Size Distribution

As shown in Tables 4.28 and 4.29, silt particles were dominant across the sample locations in the Inland Waters during the wet and dry seasons with respective mean for silt – 54.15 and 54.82%, clay – 23.23 and 23.03% and sand 22.62 and 22.15%. However, sand sized particles were dominant and closely trailed by silt particles in the control points during the wet and dry seasons.

In the shallow Atlantic, sand sized particles were evidently dominant in both seasons. Wet and dry season mean values were 76.05 and 76.63% respectively. Silt grade particles followed with respective wet and dry season mean of 14.73 and 13.43% while Clay particles recorded 9.21 and 9.95% respectively (Tables 4.30 and 4.31). The same trend was observed in the control station with even higher sand sized particles observed (wet season = 90.22%; Dry season = 92.73%). The distribution pattern therefore put the sediment in the shallow Atlantic in the sandy loam textural class.

pH

As shown in Tables 4.28 and 4.29, the pH of the sediment samples during the wet and dry seasons in the Inland Waters was observed to be strongly acidic. pH range of 4.11 – 5.47 was recorded in the wet season and was consistent with control stations range of 4.29 – 4.93. Dry season sediment pH in the Inland Waters ranged from 4.88 – 8.59 with average of 6.01 (acidic sediments). Upon comparison, Sediments pH remained mostly acidic in the Inland Waters but a slight increase in pH was observed in the dry season which may be season induced.

In the shallow Atlantic, pH range was between 4.12 – 5.31 in the wet season and 4.28 – 6.79 (mean = 5.68) in the dry season which puts the sediment in acidic class. These values were consistent with control station pH of 5.01 and 6.11 obtained in the wet and dry seasons respectively. Season induced increase was evident in the shallow Atlantic Sediments in the dry season.

Electrical Conductivity (EC)

EC of sediment indicates its total ionic strength (anions and cations). Sediment EC in the Inland Waters during the wet season was low ranging from 51 -193 µS/cm while significant increase was noted in the dry season with a range of 68 – 6923 µS/cm. In the control stations, EC was consistent with values obtained in the sampling station (wet season range 66 - 72 µS/cm; dry season range = 79 - 6906 µS/cm).

In the shallow Atlantic, the wet and dry season mean were 79.57 and 89.29 µS/cm which is consistent with 55 and 68 µS/cm observed in the control station.

Sediment Anions

Sediment Sulphate contents in Inland Waters and shallow Atlantic ranged from 2.25 – 8.59 mg/kg and 1.20 – 8.24 mg/kg in the wet season, 2.18 - 8.60 mg/kg and 1.25 – 8.19 mg/kg in the dry season respectively. These values were consistent with those obtained in the control stations (wet season: 5.25 – 5.95 mg/kg and 4.19 mg/kg; dry season: 5.16 – 5.84 mg/kg and 4.11 mg/kg). Sulphate is considered adequate when the levels are >8 mg/kg (Baker and Gourley, 2011).

Phosphate content in the Inland Waters and shallow Atlantic sediments ranged from 1.17 – 4.51 mg/kg and 0.18 – 3.89 mg/kg in the wet season and from 1.31 – 5.58 mg/kg and 0.19 – 3.98 mg/kg in the dry season. The wet and dry season concentration of phosphate is consistent with control stations values in both seasons.

Nitrate contents ranged from 2.5 – 13 mg/kg in the Inland Waters and 2.25 -9.75 mg/kg in the shallow Atlantic during the wet season. Their mean values during the dry season (Inland Waters = 7.86 and shallow Atlantic = 7.24 mg/kg) is indicative of season induced increase.

Among the anions in the sediment samples, chloride recorded the highest concentrations. Wet season range was 562.36 – 1537.02 mg/kg in Inland Waters and 712.28 – 1249.61 mg/kg in the shallow Atlantic while dry season range was from

472.33 – 1824.56 mg/kg in Inland waters and 638.07 – 1532.89 mg/kg in the shallow Atlantic. Season induced increased in the dry season was observed.

Sediment Cation Concentrations

Sediment exchangeable cations during the wet and dry seasons were moderate in concentration for Mg^{2+} and Na^{+} but low for K^{+}. Concentrations of cations in the sampling stations were consistent with values recorded in the control stations.

Mean concentrations of Mg, Na and K in Inland Waters during the wet and dry seasons were 5.20 and 5.21 mg/kg, 4.81 and 4.88 mg/kg, 0.75 and 0.76 mg/kg respectively. While in the shallow Atlantic the mean concentrations of Mg, Na and K in the wet and dry seasons were 5.29 and 5.34 mg/kg, 4.65 and 4.68 mg/kg, 0.80 and 0.82 mg/kg respectively

In general, slight increase was noted in the mean concentrations of the cations in the dry season.

Heavy Metals in Sediments

The results of the heavy metals analyzed indicate their presence in the sediment samples in appreciable concentration in both seasons in Inland Waters and shallow Atlantic (Tables 4.28 – 4.31).

The respective wet and dry season mean concentrations recorded in the Inland Waters were 0.27 and 0.29 mg/kg for Cu, 0.80 mg/kg each for Cr, 0.37 mg/kg each for Cd, 0.45 mg/kg each for Ni, 97.01 and 101.73 mg/kg for Fe, 1.09 and 1.11 mg/kg for Hg, 1.62 and 1.65 mg/kg for Pb, 0.37 and 0.41 mg/kg for Zn, 0.66 and 0.69 mg/kg for Mn.

The respective wet and dry season mean concentrations recorded in the shallow Atlantic were 0.21 and 0.35 mg/kg for Cu, 0.85 and 0.88 mg/kg for Cr, 0.42 and 0.43 mg/kg for Cd, 0.55 and 0.57 mg/kg for Ni, 105.68 and 110.35 mg/kg for Fe, 1.13 and 1.54 mg/kg for Hg, 1.87 and 1.89 mg/kg for Pb, 0.42 and 0.44 mg/kg for Zn, 0.35 and 0.36 mg/kg for Mn.

Sediment Organics

Total Organic Carbon (TOC) mean concentration in the Inland Waters and shallow Atlantic sediments were 0.89 and 0.92 mg/kg during the wet season and 0.95 and 0.99 mg/kg in the dry season. Similar concentrations of TOC were observed in the control stations in both seasons. Oil & Grease content in Inland Water sediments recorded mean values of 2.05 and 1.97 mg/kg in the wet and dry seasons respectively. In the shallow Atlantic, it was 1.96 and 1.92 mg/kg in the wet and dry seasons respectively.

Total Hydrocarbon (THC) concentration in the sediment samples was not detected in the wet season in both Inland Waters and shallow Atlantic but had mean values of 0.90 and 0.94 mg/kg in Inland Waters and shallow Atlantic in the dry season. In the control stations, THC was only detected in Inland Waters during the dry season (mean = 0.04 mg/kg).

Total Petroleum Hydrocarbon (“TPH), PAH and Benzene-Toluene-Ethylene-Xylene (BTEX) were undetected in the sediment samples of Inland Waters and shallow Atlantic and at the control stations in both wet and dry seasons.

Microbiological Contents of Sediment Samples

The result of microbiological analysis of the sediment samples in the project area are highlighted in Tables 4.32 – 4.35. The assessment of the sediment samples indicated the presence bacteria and fungi biota. Coliform was scarcely present.

Table 4.32: Inland Water Sediment Microbiology Results – Wet Season

Parameters	Wet Season					
	Study Area			Control		
	Min	Max	Mean	Min	Max	Mean
Total Coliform Count (MPN/100ml)	NIL	160	18.2	NIL	14	7
Faecal Coliform (MPN/100ml)	NIL	27	2.6	NIL	NIL	NIL
Total Heterotrophic Bacteria Count ($x10^3$ cfu/ml)	$2.1x10^5$	$1.53\ x10^6$	$7.83\ x10^5$	$7.2\ x10^5$	$8.1\ x10^5$	$7.7\ x10^5$
Total Heterotrophic Fungi Count ($x10^3$ cfu/ml)	NIL	$1.6\ x10^5$	$4.03\ x10^4$	NIL	NIL	NIL

Table 4.33: Inland Water Sediment Microbiology Results – Dry Season

Parameters	Dry Season					
	Study Area			Control		
	Min	Max	Mean	Min	Max	Mean
Total Coliform Count (MPN/100ml)	NIL	93	10.47647	NIL	7.2	3.6
Faecal Coliform (MPN/100ml)	NIL	11	0.6	NIL	NIL	NIL
Total Heterotrophic Bacteria Count ($x10^3$ cfu/ml)	$1.9\ x10^5$	$1.37x10^6$	$6.61x10^5$	$3.2x10^5$	$6.3\ x10^5$	$4.75x10^5$
Total Heterotrophic Fungi Count ($x10^3$ cfu/ml)	NIL	$1.2x10^5$	$3.2x10^4$	$1.0x10^4$	$1.0\ x10^4$	$1.0\ x10^4$

Table 4.34: Shallow Atlantic Sediment Microbiology Results – Wet Season

Parameter	Wet Season			
	Study Area			Control
	Min	Max	Mean	
Total Coliform Count (MPN/100ml)	NIL	64	5.6	14
Faecal Coliform (MPN/100ml)	NIL	NIL	NIL	NIL
Total Heterotrophic Bacteria Count ($x10^3$ cfu/ml)	$1.2\ x10^5$	$1.08x10^6$	$5.31x10^5$	$4.6\ x10^5$
Total Heterotrophic Fungi Count ($x10^3$ cfu/ml)	NIL	$5.0\ x10^5$	$3.86\ x10^4$	$2.0\ x\ 10^4$

Table 4.35: Shallow Atlantic Sediment Microbiology Results – Dry Season

Parameter	Dry Season			
	Study Area			Control
	Min	Max	Mean	
Total Coliform Count (MPN/100ml)	NIL	21	2.8	11
Faecal Coliform (MPN/100ml)	NIL	NIL	NIL	NIL
Total Heterotrophic Bacteria Count ($x10^3$ cfu/ml)	$1.8x10^5$	$9.7x10^6$	$9.96x10^5$	$3.8x10^5$
Total Heterotrophic Fungi Count ($x10^3$ cfu/ml)	NIL	$9.0\ x10^4$	$1.5x10^4$	$2.0x\ 10^4$

As shown in Tables 4.32 and 4.33, the total heterotrophic bacteria in Inland Water sediment samples during the wet season ranged from (0.21 to 1.53) x 10^9 cfu/ml which exceeded the range recorded in the control stations (7.2 to 8.1) x10^8 cfu/ml. In the dry season, a range of (0.19 – 1.37) x 10^9 cfu/ml was obtained while in the control stations it was from 3.2 to 6.3 x10^8 cfu/ml. In the shallow Atlantic, total heterotrophic bacteria ranged from (0.21 to 1.08) x 10^9 cfu/ml during the wet season and 0.18 – 9.7 x 10^9 cfu/ml in the dry season.

Total heterotrophic fungi in Inland Water sediment ranged from (0 to 1.6) x 10^8 cfu/ml during the wet season and (0 to 1.2) x10^8 cfu/ml in the dry season. It was undetected in

the control stations during the wet season but recorded a mean of 1.0 x10^7 cfu/ml during the dry season.
A range of (0 to 5.0) x 10^8 cfu/ml and (0 – 9.0) x 10^7 cfu/ml was recorded during the wet and dry season respectively in the shallow Atlantic. In the control stations it was 2.0 x 10^4 cfu/ml each in the wet and dry season. A decline in total heterotrophic fungi density was observed in the dry season which may have been season induced.
Faecal coliform was scarcely present in sediment samples with a range of 0 to 27 MPN/100ml in the wet season and 0 -11MPN/100ml in the dry season in the Inland Water sediment. Faecal coliform was not present in the control stations in both seasons. Faecal coliform was undetected in the shallow Atlantic in both seasons.

Total Coliform count in Inland Water sediments ranged from 0 – 160 MPN/100ml in the wet season whereas in the control stations, it was between 0 and 14 MPN/100ml. In the dry season, a range of 0 – 93 MPN/100ml was recorded which implies season induced decline in Coliform density of the Inland Water sediment samples. In the shallow Atlantic, the same trend was observed (0 – 64 MPN/100ml in the wet season and 0 - 21 MPN/100ml in the dry season).

4.3.8: Hydrobiological Characteristics

Phytoplankton

A checklist of the phytoplankton within the aquatic systems of creeks and marine are presented in **Appendices 3** Five (5) major families of phytoplankton were recorded in both both water bodies; namely Bacillariophyta, Cyanophyta, Chlorophyta, Euglenophyta and Dinophyta and this composition is in conformity with observations made by Nwankwo *et*. *al*. (2008), Akoma and Opute (2010), Dike and Adedolapo (2012). The contribution of each of the major families of phytoplankton in both environment is graphically presented in **Fig. 4.7.** Bacillariophyta were the dominant family and constituted 55.48% and 57.18% for swamp and marine environment respectively (**Fig 4.7**). In the swamp, Cyanophyta with a relative abundance of 24.42% was the second dominant division of phytoplankton. The Cyanophyta had a relative abundance of 22.13% was the second dominant group of phytoplankton in the marine environment..

In all the dominance pattern of the various families of phytoplankton in the swamp waters within the study area is Baccillariophyta > Cyanophta > Chlorophyta > Dinophyta > Euglenophyta and was similar to that in the marine environment (**Fig 4.7**). These patterns were in conformity with literature reports of the Lagos coasts (Nwankwo 1993 and 2003).

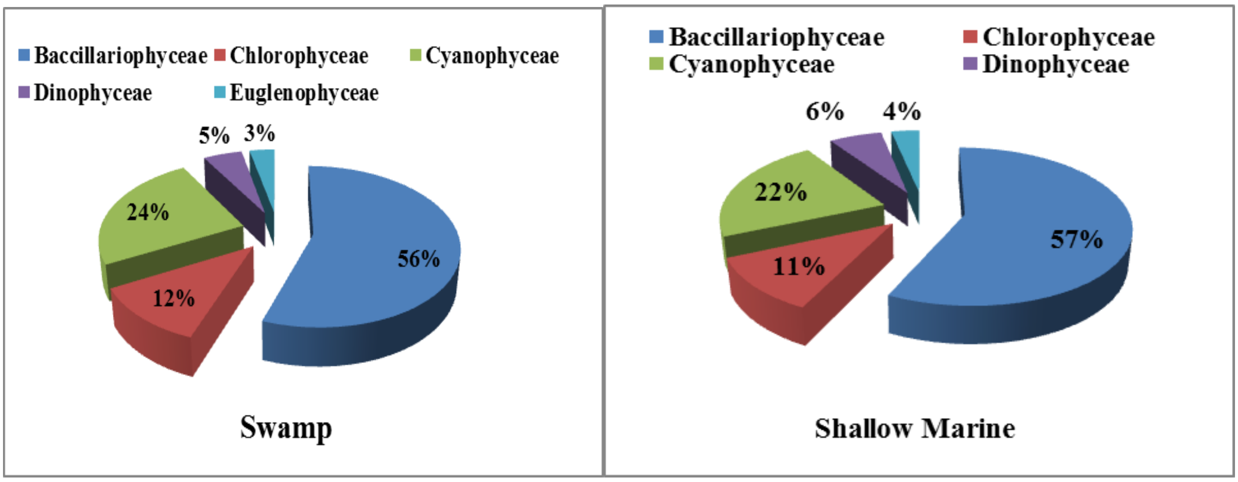


Fig 4.7: Percentage relative abundance of phytoplankton (Source: Field work 2019)

The spatial variation in total phytoplankton count in both environments is presented in **Fig 4.8.** In the swamp (creeks), total phytoplankton count varied between 1678 x 10^3 organisms per litre of water (sample point SW11) to 3103 x 10^3 organisms per litre of water (sample Point SW 8). In the marine environment, phytoplankton population was 1885 x 10^3 organisms per litre in SW 44 and 3183 x 10^3 organisms per litre in SW47 (**Fig 4.8**).

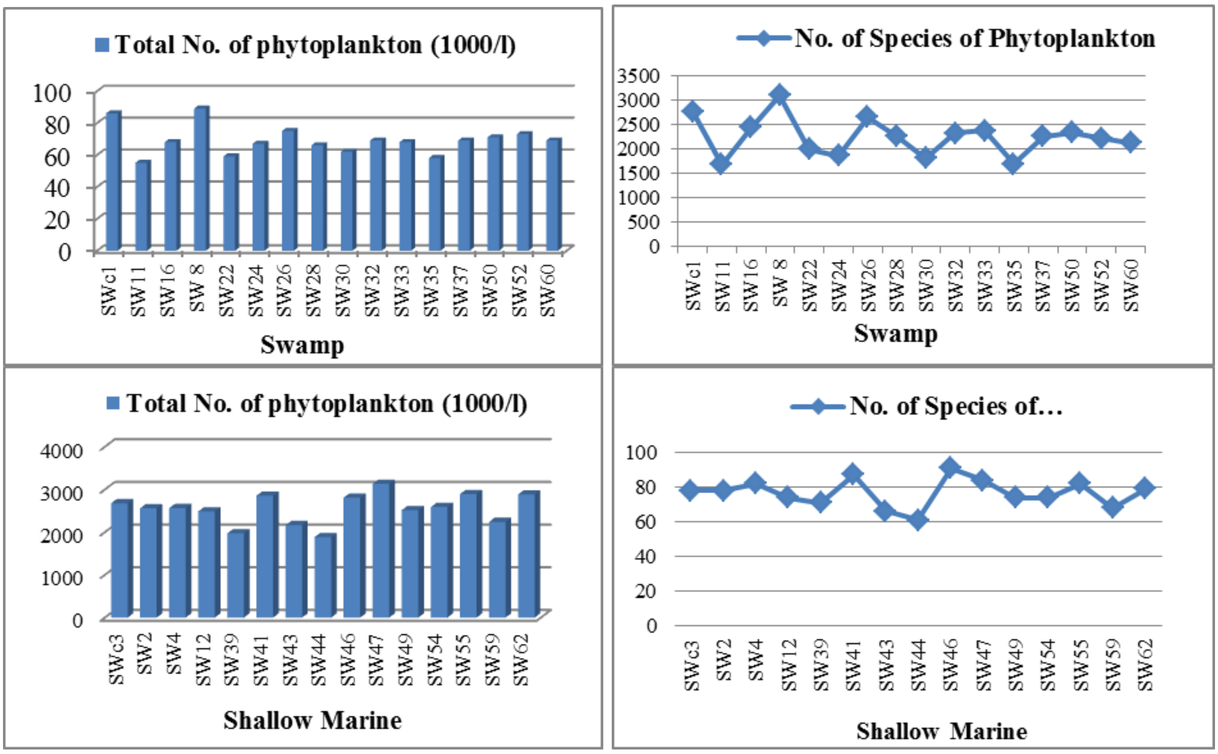


Fig 4.8: Variation in population density and number of species of Phytoplankton

Variation in number species of phytoplankton in the swamp and marine environment is presented in **Fig 4.8**. In the swamp environment a total of one hundred and five (105) species of phytoplankton were recorded within the study area and control varying between 55 and 89. In the marine environment, a total of 115 were recorded with a range of 61 in SW 44 to 91 in SW46 (**Appendix 3)**.

Zooplankton

Zooplanktons are minute free-floating or weakly swimming animals within the pelagic zone of the water column. A checklist of the zooplankton species recorded in the study area is presented in **Appendices 3.** The identified zooplankton fauna in the swamp environment were categorized into Rotifera, Crustaceans (Copepoda), Crustacea (Decapods) and Cladocera while that of marine environment were categorized into Rotifera, Crustaceans (Copepoda), Crustacea (Decapods), Cladocera, Molluscan larvae and Euphausiacea. The percentage composition of each of these major zooplankton groups is presented in Fig 4.9

In the marine environment, copepod crustaceans were the dominant zooplankton and contributed 38.56%, followed by the Rotifers (22.25%). Molluscan larvae (6.00%) and Euphausiacea (2.53%) were the least represented of the zooplankton. copepods were the dominant zooplankton with respect to density and constituted 43.26% in the swamp environment (Fig. 4.9).

Spatial variation in study area is pictorially presented in Fig 4.10. In marine environment, the lowest zooplankton numbers of 370 x 10^2 organisms/l was recorded in sample point SW 46 and the highest count of 643 x 10^2 organisms/l was recorded in sample point SW 7. In the swamp environment, zooplankton density ranged from 296 – 592 x 10^2 organisms/l. A total of 26 species of zooplankton were recorded in SW 34 while 37 species were recorded in SW 51. In the marine environment, the number of zooplankton taxa was 31 (SW48) and 42 in SW 6. These figures on number of species are considerably comparable to those recorded in literature (Chowdhury, 2008; Davies *et*. *al*. 2009; Dike and Adedolapo, 2012).

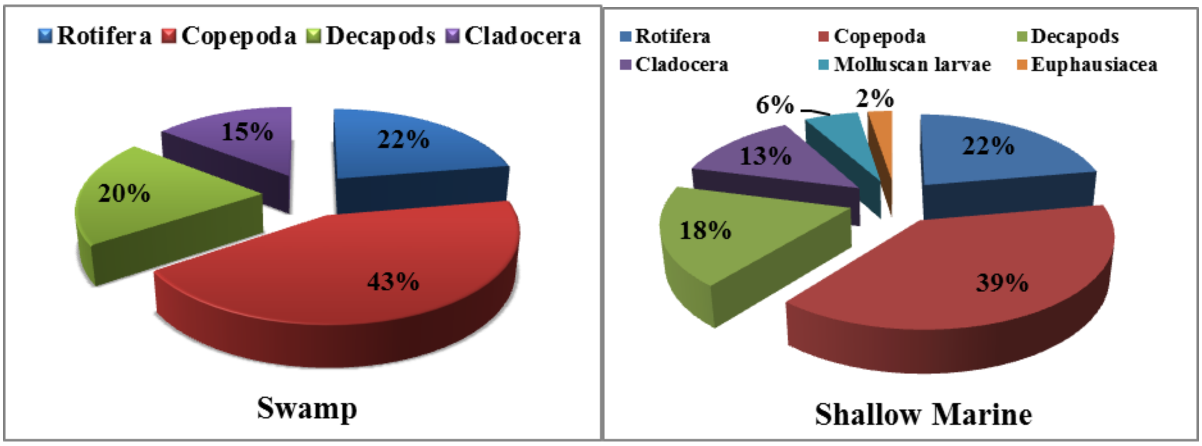


Fig 4.9: Relative Abundance of zooplankton in aquatic systems of study area

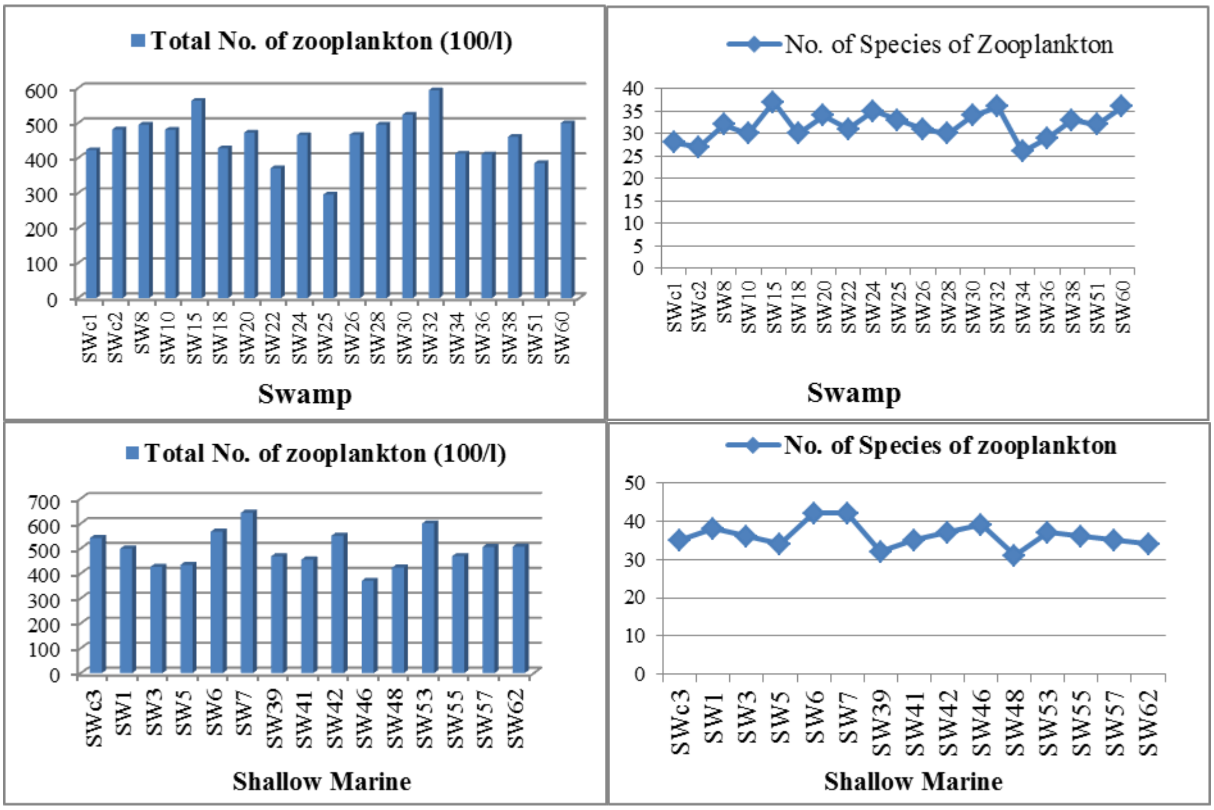


Fig 4.10: Variation in population density and number of species of Zooplankton

Benthos

Benthos Population and Abundance

The checklist of the benthic fauna of the sediment in the water body of the study area is presented in **Appendices 3.** A total of twenty-six (26) benthic organisms were recorded in the swamp environment and thirty-two (32) were recorded in shallow marine water. In both water environments, benthic fauna encountered in the study belong to four (4) major taxonomic groupings namely Annelida, Crustaceans, Gastropods Molluscs, Bivalve Molluscs, and Polychaetes. Fig 4.11 shows the relative abundance of each of the major taxonomic groups that were recorded in both water environments. In the swamp, Polychaetes with relative abundance of 53.15% were the dominant benthos. Similarly, in the shallow marine, Polychaetes constituted 44.41% of the total benthos, followed by the Crustaceans (24.68% in swamp) and (29.72% in the shallow marine). The Gastropods (19.19%) and Bivalve (6.68%) were the least represented.

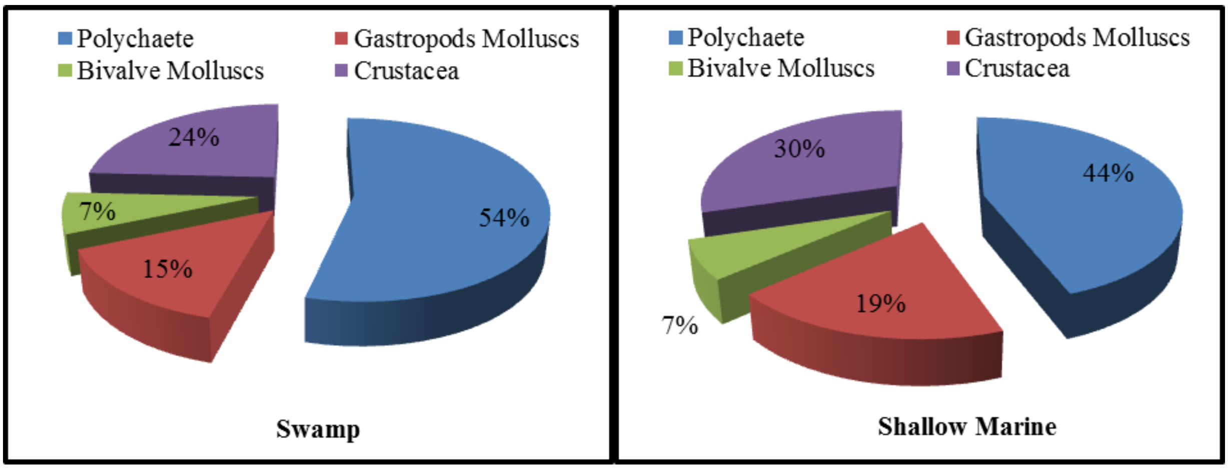


Fig 4.11: Relative Abundance of benthos in aquatic systems of study area

The spatial variations in the total number of benthos in the study are presented graphically in Fig 4.12. The number of benthos was stable at 13 (SW22) – 62 (SW56) organisms per m^2 across the sampled points in the swamp waters and fluctuated between 26 in sample points SW 48 and 68 organisms per m^2 in SW 5 in the shallow marine.

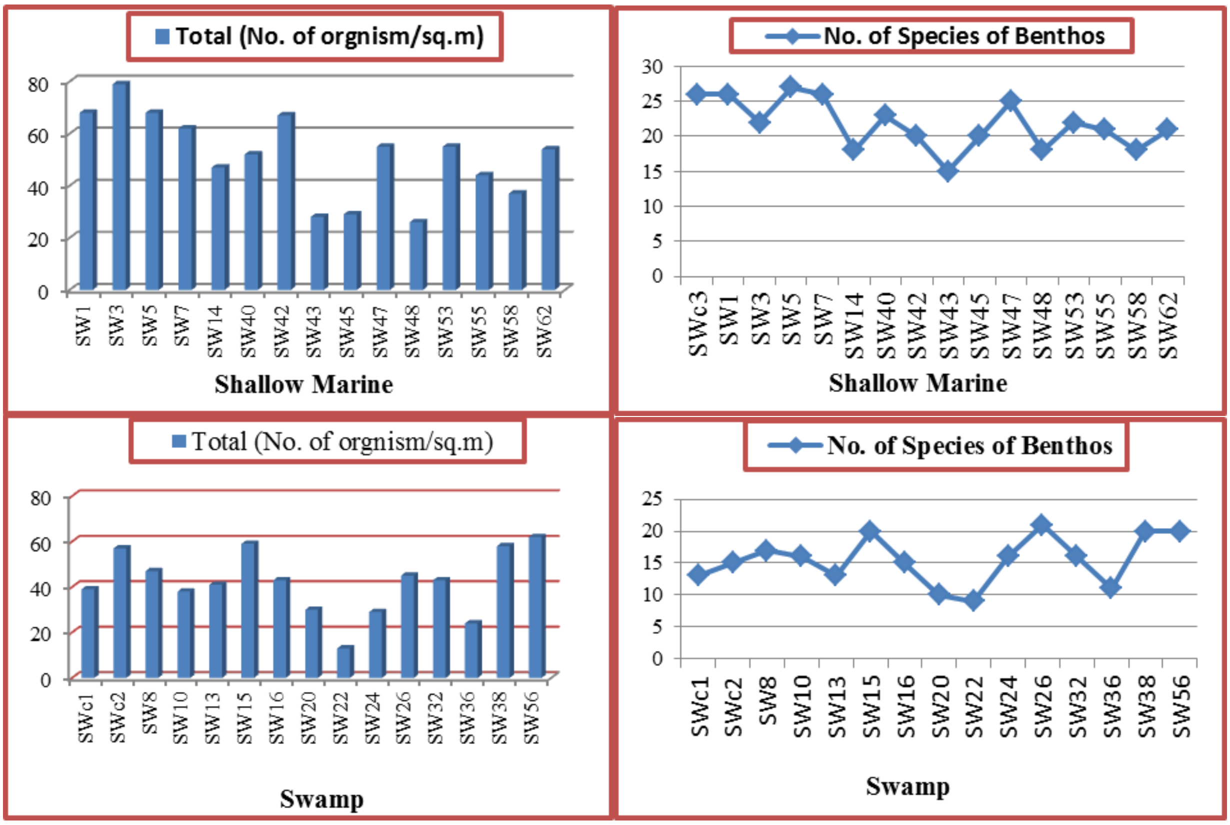


Fig 4.12: Variation in population density and number of species of benthos

The high abundance of the Bacillariophyceae among the phytoplankton, Copepoda among the zooplankton and Polychaetes among the macro-benthos is a strong indication that the water column and sediment of study area creeks and shallow Atlantic were at the time of sample not under any ecological threat. This also indicates that the water was clean and unpolluted.

Fish and Fisheries

Artisan fishers or small scale fishers dominate the fishery of the study area. 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 may also be set. The list of fishes and fisheries obtainable in the river systems in the area, as documented in the literature, visual observation and information obtained from the villagers are presented in Plate 4.12 and Table 4.36

Plate 4.12: Fish species caught from rivers in the study area

Fisheries Species Assessment

The result of the fisheries assessment indicated the presence of variety of fishes of various taxa in the creeks and shallow atlantics. Specifically, 10 species representing 6 Orders and 9 families were observed during the rainy season sampling period. Extensive sampling was impossible due to the security concerns in the water body. The represented taxa include Order Suliriformes, Mugiliformes, Beloniformes, Perciformes, Clupeiformes, Plueronectiformes and Elopiformes. The sighted species abundance varied because of the euryhaline nature of the water. Thus species ranged from fresh water to marine forms. Catfishes (*Clarias gariepinus*) are commonly harvested at the near shore/ flood plain areas of the river, while more salt tolerant forms such as *Cynoglossus senegalensis* is inhabit the seaward areas.

Table 4.36: Checklist of fish species observed within the project area.

S/N	Order	Family	Species	IUCN Status
1	Suliriformes	Claroteidae	*Chrisichthys nigrodigitatus*	LC
2		Claridae	*Clarias agriepinus*	LC
3	Mugiliformes	Mugilidae	*Mugil cephalus*	LC
3	Perciformes	Sciaenidae	*Pseudotolithus elongates*	LC
4		Cichlidae	*Oreochromis niloticus*	NE
5			*Sarotherodon melanopteron*	NE
6	Clupeiformes	Clupeidae	*Etmalosa fimbriata*	NE
7			*Sardinella marderensis*	VU
8		Pristigasteridae	*Ilisha Africana*	LC
9	Plueronectiformes	Cynoglossidae	*Cynoglossus senegalensis*	NT

10	Beloniformes	Hemiramphidae	*Hemiramphus saltator*	NT
10	Elopiformes	Elopidae	*Elops senegalensis*	DD

DD- Data deficient; LC- Least Concerned; NT- Near threatened; NE-Not Evaluated

Fish Catch Assessment

The prevailing condition factors showed that the fishes have favourable conditions to thrive. Some of the fishes within the study areas are seasonal migratory species, with some being dominant during a particular season (Plate 4.12). The catch per unit area is generally low in the wet season as reported by the fishermen in the localities due to very high amount of rainfall causing migration of fishes. Assessment was made by engaging fishermen with the use of surface set gill nets, the catch per unit area was low, and this corroborated the assertion of the fishermen earlier interviewed in the different communities.

Those engaged in fishing include women, men and seldom children. Fishing is done generally in the community early in the morning in the open atlantics and creeks and cool evenings in small rivers around the neighborhood. No modern fish pond was found in the whole of the areas visited, but local fish ponds created by constructing barriers in creeks and water inlets are common.

Fishing gears

The fishermen operate different types of gears in the study area and the fishing gear used is dependent on the target fish species. Some gears used are mainly rod and line, basket traps, and gill nets (Plate 4.13). Women fish mainly using basket traps but sometimes they use long lines, set gill nets and lift nets. The men operate different types of gears such as gill nets, long lines and encircling nets in near and distant waters.

Plate 4.13: Various types of gear used for Fishing in study area

4.3.9: Geology and Hydrogeology

Regional Geology

The Niger Delta is situated in the Gulf of Guinea (Figure 4.13) and extends throughout the Niger Delta Province as defined by Klett *et al.* (1997). From the Eocene to the present, the delta has prograded southwestward, forming depobelts that represent the most active portion of the delta at each stage of its development (Doust and Omatsola, 1990). These depobelts form one of the largest regressive deltas in the world with an area of some 300,000 km^2 (Kulke, 1995), a sediment volume of 500,000km^3 (Hospers, 1965), and a sediment thickness of over 10 km in the basin depocenter (Kaplan *et al.,* 1994).

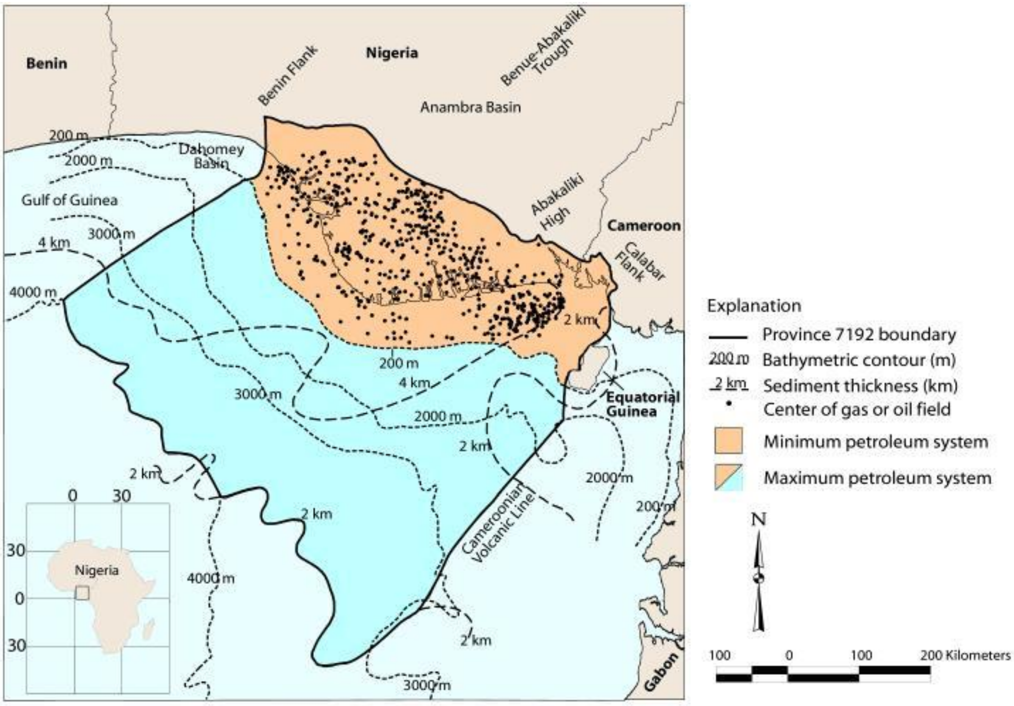


Figure 4.13: Regional Geological Map of the Niger Delta showing Province Outline
Source: Petroconsultants (1996a)

The onshore portion of the Niger Delta Province is delineated by the geology of southern Nigeria and southwestern Cameroon (Figure 4.13). The northern boundary is the Benin flank--an east-northeast trending hinge line south of the West Africa basement massif. The northeastern boundary is defined by outcrops of the Cretaceous on the Abakaliki High and further east-south-east by the Calabar flank--a hinge line bordering the adjacent Precambrian. The offshore boundary of the province is defined by the Cameroon volcanic line to the east, the eastern boundary of the Dahomey basin (the eastern-most West African transform- fault passive margin) to the west, and the two-kilometer sediment thickness contour or the 4000-meter bathymetric contour in areas where sediment thickness is greater than two kilometers to the south and southwest. The province covers 300,000km^2 and includes the geologic extent of the Tertiary Niger Delta (Akata-Agbada) Petroleum System.

Lithology
The Cretaceous section has not been penetrated beneath the Niger Delta Basin, the youngest and southern most sub-basins in the Benue-Abakaliki trough (Reijers *et al.*, 1997). Lithologies of Cretaceous rocks deposited in what is now the Niger Delta basin can only be extrapolated from the exposed Cretaceous section in the next basin to the northeast, the Anambra basin (Figure 4.14).

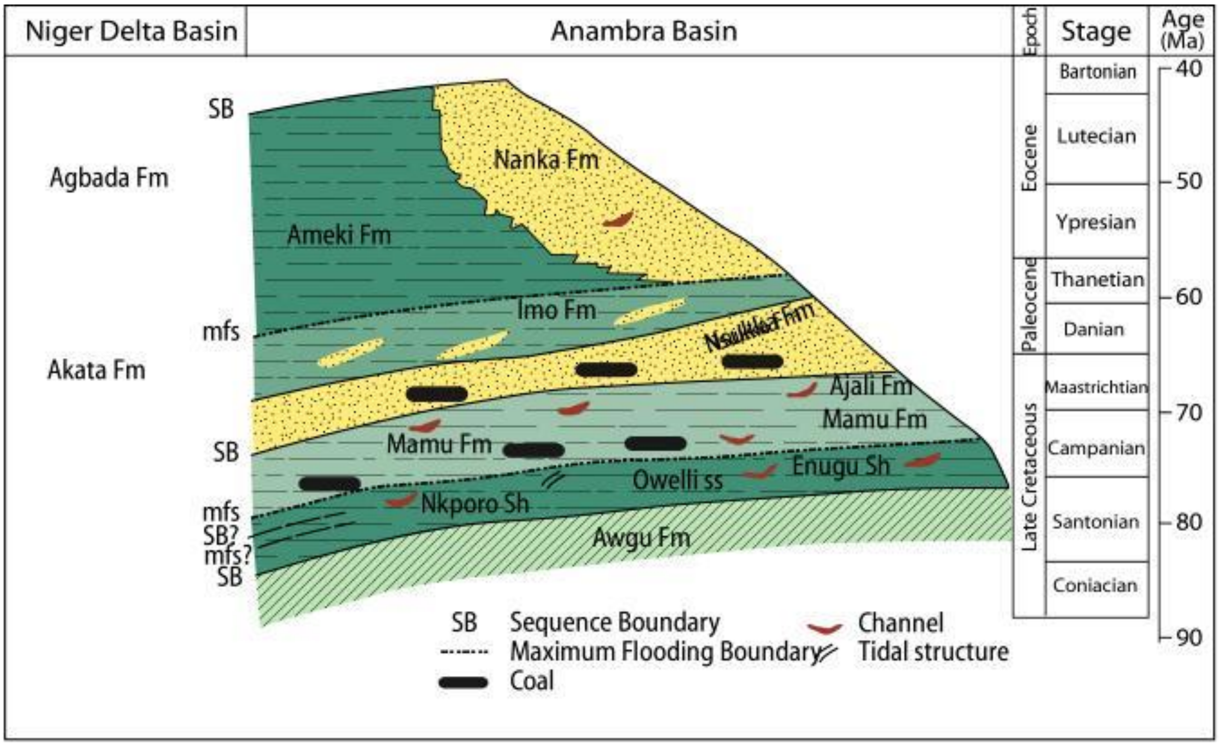


Figure 4.14: Stratigraphic Section of the Anambra Basin and Time Equivalent Niger Delta Formations: *Source: Reijer et al., 1997*

Shallow marine clastics were deposited farther offshore and, in the Anambra basin, are represented by the Albian-Cenomanian Asu River shale, Cenomanian-Santonian Eze-Uku and Awgu shales, and Campanian/Maastrichtian Nkporo shale, among others (Nwachukwu, 1972; Reijers *et al.,* 1997). The distribution of Late Cretaceous shale beneath the Niger Delta is unknown (Michele *et al.,* 1999). The Tertiary section of the Niger Delta is divided into three formations, representing prograding depositional facies that are distinguished mostly on the basis of sand-shale ratios.

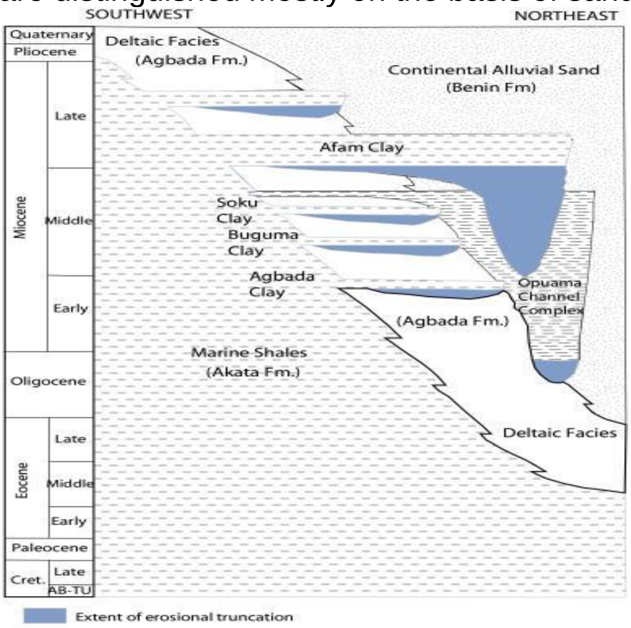


Figure 4.15: Stratigraphic Column showing the Three Formations of the Niger Delta

Modified from Shannon and Naylor (1989) and Doust and Omatsola (1990)

The Akata Formation at the base of the delta is of marine origin and is composed of thick shale sequences (potential source rock), turbidite sand (potential reservoirs in deep water), and minor amounts of clay and silt (Figures 4.14 and 4.15). Beginning in the Paleocene and through the Recent, the Akata Formation formed during lowstands when terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen deficiency (Stacher, 1995). Little of the formation has been drilled; therefore, only a structural map of the top of the formation is available (Figure 6A). It is estimated that the formation is up to 7,000 meters thick (Doust and Omatsola, 1990). The formation underlies the entire delta, and is typically overpressured. Turbidity currents likely deposited deep sea fan sands within the upper Akata Formation during development of the delta (Burke, 1972)

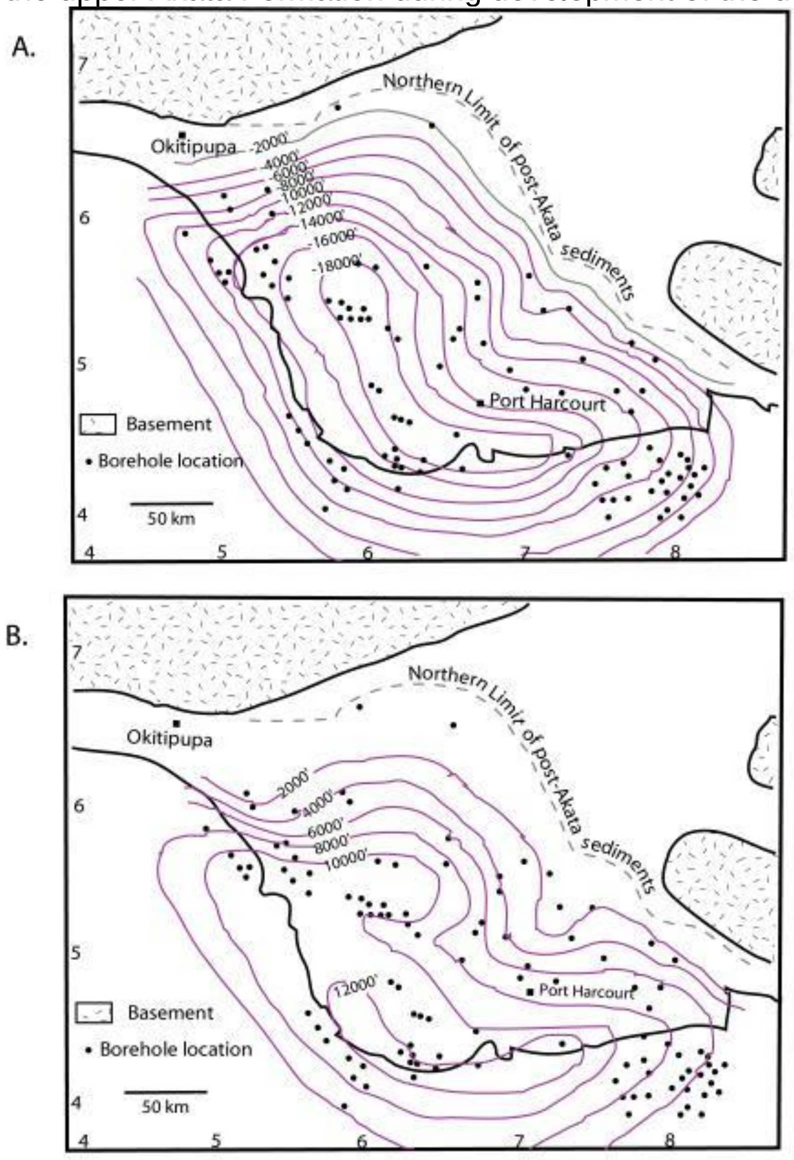


Figure 4.16: Structural Map of the top of Akata Formation (A) and ThicknessIsopachContours (in feet) of the Agbada Formation (B) *Source: Avbovbo, 1978*

Deposition of the overlying Agbada Formation, the major petroleum-bearing unit, began in the Eocene and continues into the Recent (Figures 4.14 and 4.15). The formation consists of paralic siliciclastics over 3700 meters thick (Figure 4.16B) and represents the actual deltaic portion of the sequence. The clastics accumulated in delta-front, delta-topset, and fluvio-deltaic environments. In the lower Agbada Formation, shale and sandstone beds were deposited in equal proportions, however, the upper portion is mostly sand with only minor shale interbeds.

The Agbada Formation is overlain by the third formation, the Benin Formation, a continental latest Eocene to Recent deposit of alluvial and upper coastal plain sands that are up to 2000m thick (Avbovbo, 1978).

Geomorphology

The terrain in the OML 13 concession is expectedly muddy at the riverbanks and wetland inside the mangrove/Niya palm forest. The entire extent of the river appears to be very deep at high tide but at low tide, the mud flats are exposed, with many areas reaching a depth of only 0.5m.

The lithofacies includes channels and point bar, back swamp etc. The hydrolithology characteristics includes: fine-medium-coarse grained point bar sands and clayey backswamp deposits. The sands form the major aquifers in the area while the clays form the aquitards. The water table in the area varies with season. The water table declines during the dry season. Generally, the water table is closer to the surface with a range of about 0.3-3.0m below the ground surface depending on the season and closeness to the swamp. The topography of the area is characterized by a gently undulating land form that can be described as flat, monotonous landform.

Coastal Geomorphology

Runoff water from land brings sediments and debris into the shelf. The Gulf of Guinea shelf is about 1,360 nautical miles (2,518.7km) and runs along the West African Atlantic coast from parts of eastern Liberia, through Cote d'Ivore, Ghana, Togo, Benin, Nigeria, the Cameroon, Equatorial Guinea, Gabon, Congo (Brazzaville up to parts of Kinshasa). Off the coast of Nigeria, there are vast reserves of oil, especially off the Niger Delta. The Gulf is to a large extent passive although tremors have been recorded. The shelf is narrow but extends to a maximum width of 85 km off Calabar. It is divided into three zones namely the Inner continental shelf (0-45m deep), the Middle continental shelf (45-85m deep) and the Outer continental shelf (85-120m deep) which generally breaks at about 100 to 120m (MPL, 2014). The study area falls under the Inner continental shelf. The inner continental shelf runs almost parallel to the coastline. This bathymetric configuration is punctured by sand ridges, which are shaped by tidal currents especially near river mouths. Prominent sand bars and ridges are found off Calabar and the Niger Delta coast.

Hydrogeology

Two stratigraphic units form the main aquifer systems in the Niger Delta region (Table 4.37). These are:

1. **The Alluvium**
   The aquifer systems within the alluvial deposits, especially the near surface beds close to the shore are often saline bearing.
2. **The Benin Formation**
   This chrono-stratigrahic unit forms the aquifer system. Its lithologic composition is mainly 90% sands and sandstones and 10% clay and lignitic beds (MPL, 2014). Recharge to this system is mainly from rainfall, while discharge sources include run-offs from the basin and abstraction through boreholes (Offodile, 1992).

Table 4.37: Stratigraphic Sequence of the Niger Delta Basin with Aquifer Prospectivity

Geologic Age	Stratigraphic Units	Lithologic Description	Aquifer Prospect
QUATERNARY	Alluvium	Gravely sands, sands, silt and clays	Good
	Meander Belt Deposit	Gravely sands, sands with thin clay units	Good
	Wooded Back Swamps and Fresh-Water Swamps Deposits	Mainly silt and silty clays with clayey intercalations	Poor
	Mangrove Swamps Deposit	Fine sands to silty clays and clays with organic matter	Poor (Saline water)
	Sombriero-Deltaic Plain Sediments	Coarse to fine grained sands, silts and clays	Medium
MIOCENE TO RECENT	Benin Formation	Mainly coarse-medium grained, lenticular with clay and shaly lens	Prolific Aquifer

Source: MPL. 2014

Lithology and Aquifer

The monitoring boreholes drilled within Utapate Field revealed varied lithologies from top to bottom (Tables 4.38a- 4.38b and Figure 4.17). The lithologies conform to alluvial deposits of Quaternary age in the Niger Delta basin. The water table aquifer was encountered from 3-8m (bgl). The static water level (SWL) measured during the wet and dry seasons ranged from 0.30m in GW4 to 2.59m in GW1 and from 0.50m in GW4 to 2.63m in GW1 respectively.

Table 4.38a: Monitoring Boreholes Lithologic Logs (GW1-GW5)

<table>
<tr><th rowspan="2">Depth (m)</th><th colspan="6">Description</th></tr>
<tr><th colspan="2">GW1</th><th>GW2</th><th>GW3</th><th>GW4</th><th>GW5</th></tr>
<tr><td rowspan="2">0-2</td><td colspan="2" rowspan="4">Lateritic Clay, Dark Brown</td><td rowspan="2">Silty Sand, Brown</td><td>Silty Sand, Brown</td><td>Silty Clay, Brown</td><td rowspan="5">Silty Sand, Yellow to Birch</td></tr>
<tr><td>Sandy Clay, Grey</td><td>Silty Clay, Grey</td></tr>
<tr><td rowspan="3">2-4</td><td rowspan="2">Fine Sand, Grey</td><td>Sandy Clay, Chicoco, Grey</td><td rowspan="5">Very Fine Sand, Grey</td></tr>
<tr><td rowspan="2">Fine Sand, Clayey</td></tr>
<tr><td colspan="2">Silty Clay, Brown</td><td>Clay, Dark Grey</td></tr>
<tr><td rowspan="2">4-6</td><td>Silty Sand,</td><td rowspan="2">Dark Grey</td><td rowspan="4">Fine Sand, Grey</td><td rowspan="2">Very Fine Sand, Grey</td><td rowspan="2">Silty Clay, Brown</td></tr>
<tr><td>Sandy Clay</td></tr>
<tr><td>6-8</td><td colspan="2" rowspan="2">Fine Sand, Grey</td><td rowspan="2">Sand Clay, Dark Grey</td><td>Fine Sand, Grey</td><td>Sandy Clay, Brown</td></tr>
<tr><td>8-10</td><td>Sandy Clay, Dark Grey</td><td>Very Fine Sand, Grey</td></tr>
</table>

Source: NPDC/NOSL Field Survey, 2020

Table 4.38b: Monitoring Boreholes Lithologic Logs (GW6-GW8, GWC1-GWC2)

Depth (m)	Description				
	GW6	GW7	GW8	GWC1	GWC2
0-2	Silty Sand, Yellow to Birch	Silty Sand, Brown	Silty Sand, Brown	Clay	Silty Sand, D/Brown
		Silty Sand, Birch	Silty Sand, Birch	Clay, Chicoco	
2-4		Very Fine Sand, Birch	Very Fine Sand, Birch	Very Fine Sand, Grey	Silt, L/Brown
					Silty Clay
4-6	Silty Clay, Brown				Silty Clay, L/Brown
6-8	Sand Clay, Brown		Fine Sand, Brown	Sandy Clay, Dark Grey	Sandy Clay
					Silty Sand, Grey
	Silty Sand, Grey	Fine Sand, Brown			
8-10	Very Fine Sand, Grey				Fine Sand, Grey

Source: NPDC/NOSL Field Survey, 2020

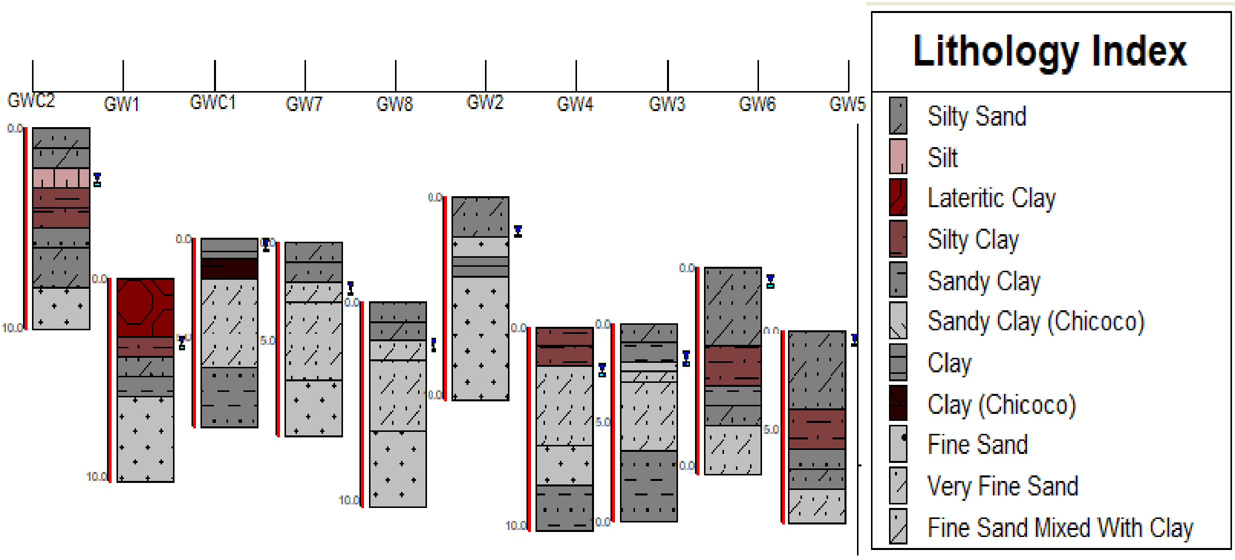


Figure 4.17: Lithologic Profiles for the Monitoring Boreholes

Groundwater Flow Direction

Groundwater flow direction of the project area was computed from the static water levels and the elevation above sea level across three monitoring boreholes drilled in a triangular pattern in the area (Table 4.39). These parameters were used to establish the general hydraulic head (HH) across the boreholes, based on Buddermeir and Schloss (2000). The calculated direction of groundwater flow is based upon the assumption that the 3 points define a plane and the slope of the plane defines a groundwater flow direction (Robert, 2007). In the subsurface, water flows from the region of high hydraulic head to the region of low hydraulic head. Hydraulic head ranged from 1.58 to 3.41m and from 1.42 to 3.37m across the area in the wet and dry seasons respectively. Figure 4.18 shows that the groundwater flows from the northeast to the southwest towards the Atlantic Ocean in the study area. This is consistent with the findings of an earlier study carried out in close proximity to the study area (MPL, 2014).

Table 4.39: Groundwater Levels in the Study Area

Borehole Location	GW1	GW2	GW3	Remarks
Elevation (m)	6.00	3.00	5.00	

ASL				
Depth to water level (m) BGL	2.59	1.42	1.75	*Wet season*
Reduced water level (m) ASL	3.41	1.58	3.25	Hydraulic Head (HH)
Depth to water level (m) BGL	2.63	1.58	1.80	*Dry Season*
Reduced water level (m) ASL	3.37	1.42	3.20	Hydraulic Head (HH)

Note: ASL = above sea level; BGL = below ground level *Source: NPDC/NOSL Field Survey, 2020*

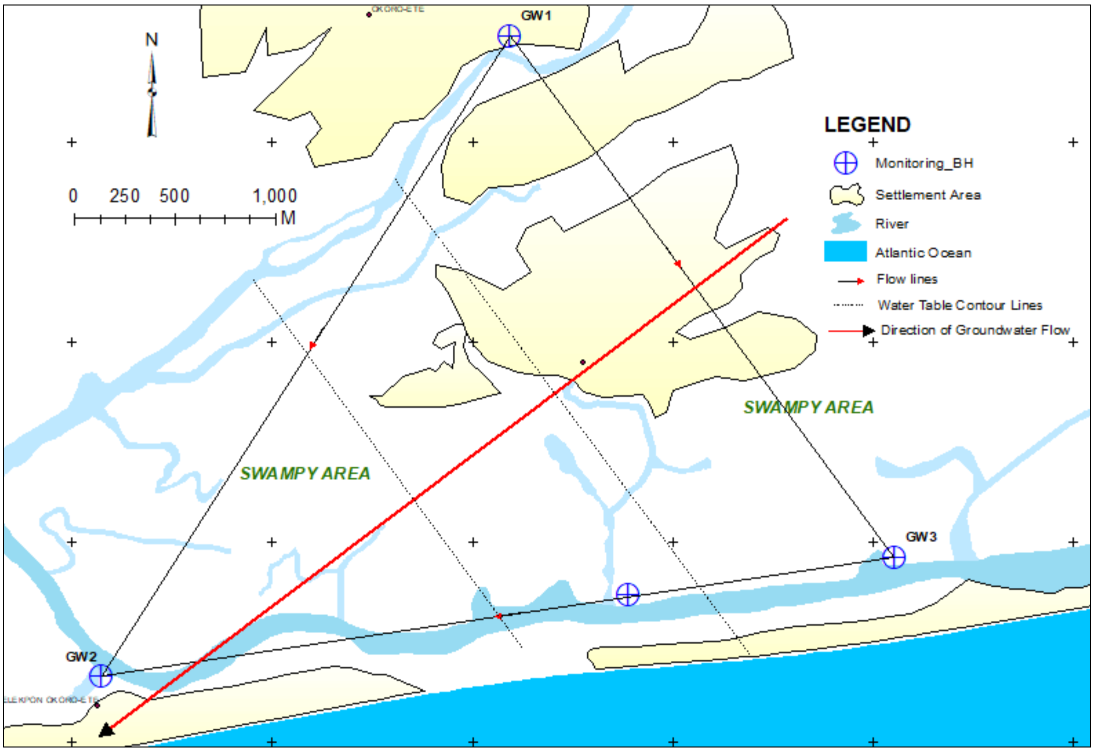


Figure 4.18: Groundwater Flow Direction

Groundwater Quality

Results obtained during the wet and dry season field survey for groundwater measurement insitu are presented in Table 4.40.

pH

Groundwater pH ranged from 6.92 to 9.22 in the wet season and 8.18 – 10.22 in the dry season. Wet and dry season respective mean of 7.86±0.71 and 9.02±0.70 falls within the range of 7.44 – 9.67 obtained in the control stations across both seasons.

The computed dry season mean clearly puts the groundwater above 6.5 – 8.5 pH recommended standard.

Temperature

Measured mean temperature during the wet season was 28.47±1.11°C from a range of 26.55 to 29.81°C. A slightly higher mean of 30.75±0.98°C from a range of 29.81 to 32.47°C was recorded in the dry season.

Electrical Conductivity (EC)

Electrical conductivity, which is a measure of the ionic richness of the groundwater ranged from 61.00 to 11790 µS/cm in the wet season and 210 to 11000 µS/cm in the dry season.

Total Dissolved Solids (TDS

TDS average concentration was 869 mg/l in the wet season and 1144 mg/l in the dry season with both having high spatial variation.

Salinity

Measured salinity of the groundwater was averagely 0.99 psu in the wet season and 1.26 psu in the dry season.

Oxidation-Reduction Potential (Redox)

The potential for oxidation and reduction in the groundwater samples was averagely 40.39 mV in the wet season and lesser in the dry season (1.19 mV).

Turbidity

Groundwater mean turbidity value of 5.25±3.45 FNU was obtained in the wet season while in the dry season it was 4.38±1.69 FNU.

Table 4.40: Summarized Groundwater Physicochemical Results

Parameter (mg/l)		Mean	Std. Dev.	Min	Max	GWC1	GWC2	FMEnv Limit	WHO Limit
pH	Wet	7.86	0.71	6.92	9.22	8.61	7.44	6.5-8.5	6.5-8.5
	Dry	9.02	0.7	8.18	10.32	9.46	9.67		
Temp oC	Wet	28.47	1.11	26.55	29.81	29.78	29.26	30	35
	Dry	30.75	0.98	29.81	32.47	31.74	34.36		
EC (µS/cm)	Wet	1720	4072	61	11790	24380	162	-	-
	Dry	2279	3551	210	11000	1140	503		
TDS	Wet	869	2026	34	5878	12190	81	500	500
	Dry	1144	1758	109	5464	570	217		
Salinity (psu)	Wet	0.99	2.31	0.03	6.69	14.71	0.07	-	-
	Dry	1.26	2.01	0.22	6.19	0.56	0.2		
ORP (mV)	Wet	40.39	64.55	-100	93.2	10.1	23.4	-	-
	Dry	1.19	5.47	-3.9	10.5	16.16	-27.8		
Turbidity (FNU)	Wet	5.25	3.45	2	12	1	1	-	-
	Dry	4.38	1.69	3	8	2	2		
DO	Wet	3.93	0.08	3.77	4.03	3.6	3.9	>3.5	7.5
	Dry	3.79	0.08	3.68	3.89	3.61	3.59		
Colour (Pt.Co)	Wet	70	56	0	183	64	124	-	-
	Dry	63	30	16	122	53	73		
TSS	Wet	7.9	5.2	3	18	1.5	1.5	>10	5
	Dry	5.4	1.8	3	8	3	2		
Nitrate (NO_3)	Wet	5.06	3.12	1.5	9.2	4.91	9.64	10	10
	Dry	4.1	3.26	1	11.7	3.2	11.4		
Ammonia (As Nitrogen)	Wet	8.12	6.99	0.72	22.56	2.14	7.23	<1.0	-
	Dry	6.71	4.36	0.76	13.87	2.93	3.17		
Chloride (Cl^-)	Wet	298.3	643.97	12.8	1889.5	2689.35	37.14	250	200
	Dry	628.17	1124.49	53.98	3347.9	253.92	98.97		

Sulphate (SO_4^{2-})	Wet	19.19	10.55	5.32	40.86	53.8	18.3	500	200
	Dry	19.08	7.29	11.78	30.41	49.56	17.63		
Phosphate (PO_4^{3-})	Wet	0.0475	0.09	0	0.27	0.04	0.34	>5	-
	Dry	0.035	0.05	0	0.16	0.06	0.22		
Hardness mg CaCO3/l	Wet	746.78	591.42	260.18	1801.3	2421.72	2001.42	200	-
	Dry	953.18	989.43	20.01	3262.3	2261.6	76.05		
Alkalinity	Wet	59.13	84.22	12	266	18	60	-	-
	Dry	27.65	21.32	0.4	74.4	26	44		
Biological Oxygen Demand BOD	Wet	50.58	27.22	15.76	105.09	52.55	57.8	-	10
	Dry	54.41	14.59	39.94	79.87	49.92	59.9		
Chemical Oxygen Dema0 COD	Wet	96.1	51.72	29.95	199.68	99.84	109.82	20	-
	Dry	28.64	7.68	21.02	42.04	26.27	31.53		
Magnesium Mg	Wet	2.36	0.2	2.049	2.681	2.694	2.064	–	-
	Dry	2.736	0.439	2.185	3.452	3.072	1.392		
Sodium (Na)	Wet	4.47	1.45	2.079	6.527	4.813	2.462	200	-
	Dry	3.919	0.646	3.225	5.153	3.485	3.797		
Copper Cu	Wet	0.035	0.04	0	0.099	0.047	0.023	0.1	0.05
	Dry	0.036	0.029	0	0.086	0.022	0.013		
Chromium Cr	Wet	0.002	0.002	0	0.004	0.006	0.003	0.05	0.05
	Dry	0	0.001	0	0.002	ND	ND		
Cadmium Cd	Wet	0.15	0.04	0.095	0.211	0.146	0.182	0.01	-
	Dry	0.07	0.06	0	0.141	0.115	0.136		
Nickel Ni	Wet	0.447	0.1	0.304	0.625	0.524	0.445	1	0.1
	Dry	0.152	0.175	0	0.514	0.182	0.247		
Arsenic As	Wet	ND	ND	ND	ND	ND	ND	0.1	0.001
	Dry	ND	ND	ND	ND	ND	ND		
Iron Fe	Wet	5.355	2.51	2.608	9.386	7.206	9.516	1	0.1
	Dry	3.458	2.277	1.264	8.052	0.457	1.076		
Mercury Hg	Wet	0.648	0.57	0	1.901	0.583	0	0.001	0.001
	Dry	0.333	0.262	0	0.728	0.381	0.042		
Lead Pb	Wet	ND	ND	ND	ND	ND	ND	0.05	0.05
	Dry	ND	ND	ND	ND	ND	ND		
Zinc Zn	Wet	0.43	0.12	0.264	0.611	0.356	0.384	5	5
	Dry	0.167	0.197	0	0.548	0.189	0.193		
Manganese Mn	Wet	0.42	0.04	0.372	0.488	0.386	0.416	0.05	-
	Dry	0.217	0.129	0.072	0.428	0.192	0.284		

Table 4.41: Ground Water Organics Summarized Result

Sample ID	THC		Oil & Grease		TPH		PAH		BTEX	
	mg/l									
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
OML13/UTP/GW1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GW8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mean	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Std. Dev.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Minimum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Maximum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML3/UTP/GWC1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OML13/UTP/GWC2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FMEnv Limit	-		-							
WHO Limit	-		-							

DO
DO levels were observed to be averagely 3.93±0.08 and 3.79±0.08 mg/L in the wet and dry seasons respectively.

Total Suspended Solids
The mean TSS of groundwater samples was 7.9 mg/l in the wet season with high spatial variation compared to 5.4 mg/l in the dry seasons.

Anions
Nitrate value recorded in the groundwater sample fluctuated between 1.50 – 9.20 mg/l in the wet season and 1.00 – 11.70 mg/l in the dry season with respective mean of 5.06±3.12 and 4.10±3.26 mg/l which are well below FMEnv/DPR limit of 10mg/l. Similarly, ammonia recorded wet and dry season respective mean of 8.12±6.99 and 6.71±4.36 mg/l.
Chloride recorded wet and dry season average values of 298.30 and 628.17 mg/l respectively with high spatial variation.

Phosphate values recorded in the groundwater samples ranged from 0 - 0.27 mg/l in the wet season and 0 to 0.16 mg/l in the dry season. In the control stations, a range of 0.04 – 0.22 across both seasons was recorded.

Wet and dry season mean values for sulphate were 19.19 and 19.08 mg/l respectively with high spatial variation. These values are within the DPR set limit of 200mg/l, FMEnv and WHO limits for groundwater which is set at 500 and 400mg/l respectively.

Total Hardness
Total hardness results obtained for the groundwater samples ranged from 260.18 to 1801.28 mg/l and average of 746.78 mg/l in the wet season and 20.01 to 3262.31 mg/l and average of 953.18 mg/l in the dry season.

Biological Oxygen Demand
BOD ranged from 15.76 to 105.09 mg/l with an average of 50.58 mg/l in the wet season and 39.94 to 79.87 mg/l with an average of 54.41 mg/l in the dry season.

Chemical Oxygen Demand
COD values obtained for all samples ranged from 29.95 to 199.68 mg/l, with an average of 96.10 mg/l in the wet season and 21.02 to 42.04 mg/l; average of 28.64 mg/l in the dry season. These values are consistent with those obtained in the control stations; 99.84 – 109.82 mg/l (wet season) and 26.27 – 31.53 mg/l (dry season). Generally, the groundwater COD was high and mostly exceeded the 20mg/l FMEnv recommended limit.

Exchangeable Cations in Groundwaters
Mean sodium concentration in the wet and dry season was observed to be 4.47±1.45 and 3.919±0.646 mg/l respectively while mean magnesium concentrations was 2.36±0.20 and 2.736±0.439 mg/l respectively.

Heavy Metals in Ground waters
The results of the heavy metals analyzed show that Arsenic and Lead were below equipment detection limit of 0.001mg/l in all groundwater samples in both seasons. Maximum concentration of Cr (0.006 mg/l) was recorded in the wet season. While the respective wet and dry season mean concentrations recorded were 0.035±0.04 and

0.036±0.029 mg/l for Cu, 0.150±0.04 and 0.070±0.06 mg/l for Cd, 0.447±0.10 and 0.152±0.175 mg/l for Ni, 5.355±2.51 and 3.458±2.277 mg/l for Fe, 0.648±0.57 and 0.333±0.262 mg/l for Hg, 0.43±0.12 and 0.1671±0.197 mg/l for Zn, 0.42±0.04 and 0.217±0.129 mg/l for Mn.
The mean concentrations of Cadmium, Iron, Mercury and Manganese exceeded their FMEnv set limits in both seasons while mean Nickel concentration breached its FMEnv set limit of 1mg/l in the wet season only.

Organics in Groundwater
All organic parameters analyzed (THC, oil and grease, TPH, PAH and BTEX) were not detected in both seasons.

Groundwater Palatability
Results of most of the parameters analyzed did not reveal any serious concern with regards to the palatability of groundwater in the study area except for certain heavy metals which exceeded their set limit. Consequently, for the purpose of drinking, there will be need for further treatment to meet recommended criteria.

Groundwater Microbiology
As shown in Tables 4.42 and 4.43, the total heterotrophic bacteria in the groundwater samples during the wet season ranged from (1.2 to 9.4) x 10^2 cfu/ml which exceeded the maximum recorded in the control stations (8.4 x10^4 cfu/ml).
In the dry season, a range of (3.1 – 9.9) x 10^2 cfu/ml was obtained while in the control stations it was from 6.4 to 8.3 x10^2 cfu/ml.

Table 4.42: Groundwater Microbiology - Wet Season

Sample ID	Total Coliform Count (MPN/100ml)	Faecal Coliform (MPN/100ml)	Total Heterotrophic Bacteria Count (cfu/ml)	Total Heterotrophic Fungi Count (cfu/ml)
OML13/UTP/GW1	1100	NIL	7.3 x 10^2	3.0 x10^2
OML13/UTP/GW2	NIL	NIL	1.2 x 10^2	NIL
OML13/UTP/GW3	3	NIL	9.4 x 10^2	5.0 x10^2
OML13/UTP/GW4	NIL	NIL	4.7 x 10^2	3.0 x10^2
OML13/UTP/GW5	11	NIL	5.6 x 10^2	NIL
OML13/UTP/GW6	3	NIL	4.9 x 10^2	NIL
OML13/UTP/GW7	NIL	NIL	3.2 x 10^2	NIL
OML13/UTP/GW8	460	NIL	1.56 x 10^3	NIL
OML3/UTP/GWC1	NIL	NIL	8.4 x 10^2	NIL
OML13/UTP/GWC2	3	NIL	7.7 x 10^2	3.0 x10^2
FMEnv Limit	-	-	-	-
WHO Limit	-	-	-	-

Table 4.43: Groundwater Microbiology - Dry Season

	Total Coliform Count (MPN/100ml)	Faecal Coliform (MPN/100ml)	Total Heterotrophic Bacteria Count cfu/ml	Total Heterotrophic Fungi Count (cfu/ml)
OML13/UTP/GW1	28	NIL	6.8 x 10^2	4.0 x10^2
OML13/UTP/GW2	NIL	NIL	3.1 x 10^2	2.0 x10^2
OML13/UTP/GW3	3	NIL	8.7 x 10^2	4.0 x10^2
OML13/UTP/GW4	NIL	NIL	5.5 x 10^2	3.0 x10^2
OML13/UTP/GW5	6.1	NIL	5.6 x 10^2	NIL
OML13/UTP/GW6	3	NIL	7.1 x 10^2	NIL

OML13/UTP/GW7	NIL	NIL	4.6×10^2	NIL
OML13/UTP/GW8	35	NIL	9.9×10^2	1.0×10^2
OML3/UTP/GWC1	NIL	NIL	6.4×10^2	NIL
OML13/UTP/GWC2	3.6	NIL	8.3×10^2	3.0×10^2
FMEnv Limit	-	-	-	-
WHO Limit	-	-	-	-

Total heterotrophic fungi in the groundwater ranged from (0 to 5) x 10^2 cfu/ml during the wet season and was heavier in density compared to the (0 to 3) x10^2 cfu/ml observed in the control stations. A range of (0 to 4.0) x 10^2 cfu/ml was recorded during the dry season. In the control stations it was from 0.0 to 3.0 10^2 cfu/ml. A decline in total heterotrophic fungi density was observed in the dry season which may have been season induced.
Faecal coliform was undetected in groundwater. Total Coliform count ranged from 0.0 – 1100 MPN/100ml in the wet season whereas in the control stations, it was between 0.0 and 3.0 MPN/100ml. In the dry season, a range of 0.0 – 28.0 MPN/100ml was recorded which implies season induced decline in Coliform density in the groundwater.

4.3.10: Social Profile

Project influences and receptor exposure are felt by the human population. This section of the EIA focuses on the baseline Socio-Economic parameters such as settlement history, population characteristics, educational status, occupation, employment, income, expenditure, land and, water resource ownership, housing, infrastructure, social structure, religion, customs, belief, power and governance, conflicts, conflict resolution and inhabitants perception of the proposed Utapate Field of OML13 re-entry project.

Study Communities

The study communities are those that are within 5km radius of the Utapate Field. The project affected communities are Atabrikang I, Okorombokho, Okoroiti, Okoroete, Iko, Elile, Amadaka, Kwampa, Edowink, Elekpo-Okoroete, Emerioke I & II, Okwanaobolo, Otuenene, Emeriemen, Akpabom, Bethlehem, Isotoyo, Amanglass, Okoromeobolo, Ayama, Okorobilom, Amangbuiji, Ozoubo, Amauka, Okoroinyang, Iwofe, Nkonta, Obianga, and Engwewe in Eastern Obolo LGA of Akwa-Ibom State. The communities are predominantly inhabited by the Obolo ethnic group of Akwa Ibom State. Though autonomous in terms of traditional leadership, the communities have historical links. Eastern Obolo LGA whose Local Government headquarters is in Okoroete town has an area of 120km², a Density of 702.5/km² and a population of 59,970 based on the 2006 National Population Census figures, projected at 84,300 in 2016 and currently in 2020 projected at 95620 using 3.2% annual growth rate. However, the male-female population ratio in 2006 was 30,229(50.4%) and 29,741(49.6%) respectively. See Fig. 4.19

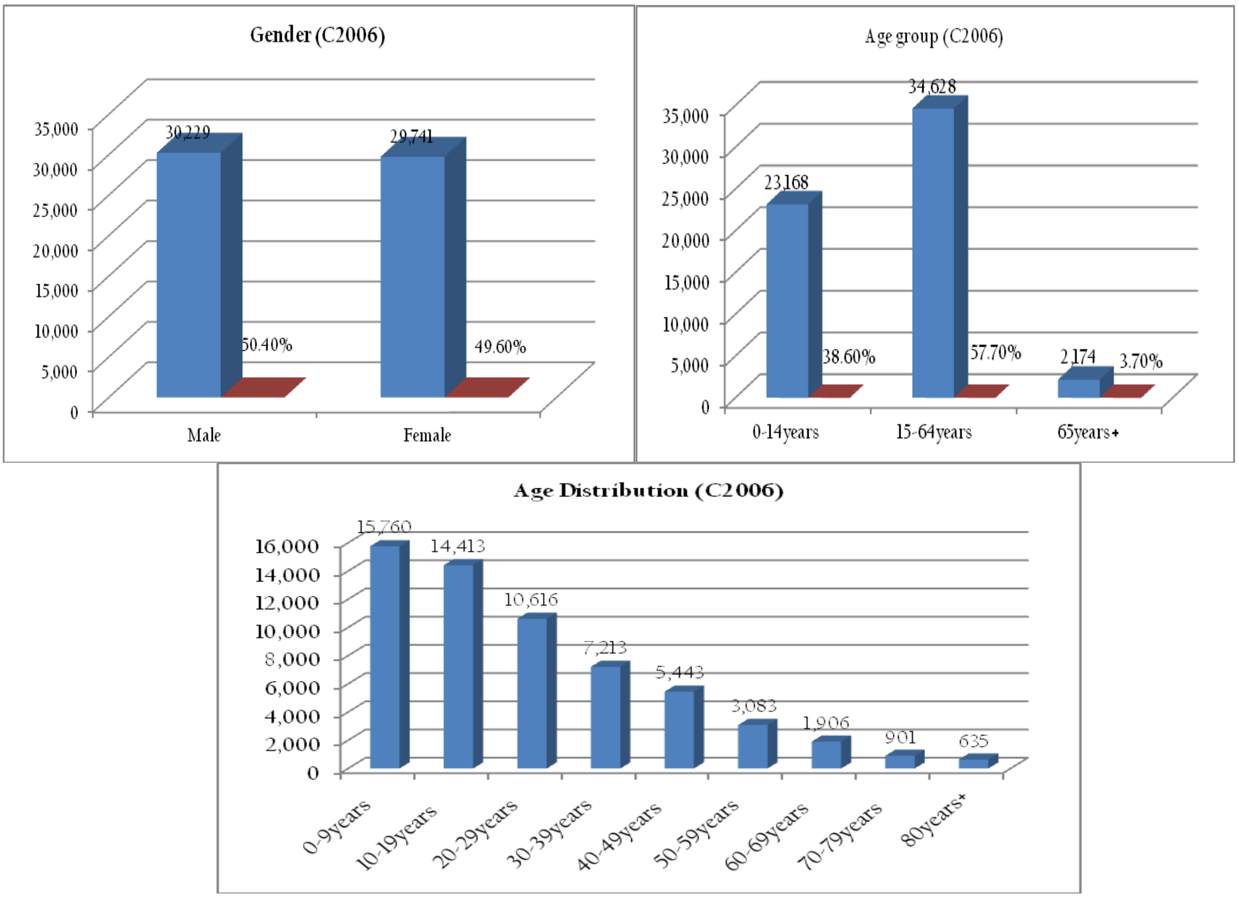


Fig. 4.19: Gender, Age group and Age distribution of Eastern Obolo LGA (C2006)
Source: NPC, NBS

Akwa-Ibom State: Akwa Ibom State was created out of Cross River State in 23rd September, 1987 with capital in Uyo. It has a total square meter of 7,081km^2 (2,734sq mi) with a total population of 2,359,736 according to 1991 census and in 2006, the population was estimated to about 4,805,470. However, GTZ projected the state population in 2005 to be 3,343,000; 2010 (3,895,000); 2015 (4,537,000) and in the current year 2020 as 5,285,000, See Fig. 4.20. Given the population size, the state was ranked 15th position out of 36 State of the federation. Akwa Ibom State is located in the coastal southern part of Nigeria, lying between latitudes $4^{0}32^{0}$N and $5^{0}33^{0}$N and longitudes $7^{0}25^{0}$N and $8^{0}25^{0}$E. The state is boarded on the east by Cross River State and Abia State and on the south by the Atlantic Ocean and the southernmost tip of Cross River State.

Akwa Ibom is one of Nigeria's 36 states, with a population of over 5million people. It was created in 1987 from the former Cross River and currently the highest oil-and-gas-producing state in the country. Akwa Ibom State has 31 local government areas. The people are predominantly Christian faith. The main ethnic groups of the state are Ibibio, Annang, Oron, Eket and Obolo. The Ibibio, Annang, Eket, who speak a dialect of the Ibibio language, Oron and Obolo, comprising Ibono (Ibeno) and Eastern Obolo people are the largest ethnic group similar to the Efik, which also speak a dialect of Ibibio language and predominant in neighbouring Cross River State, and found in five of the state's local government areas. Located at the Atlantic Ocean seafront are the Eket, Ibeno, and Eastern Obolo people. The Ibono have similarities with the Oro and Obolos.

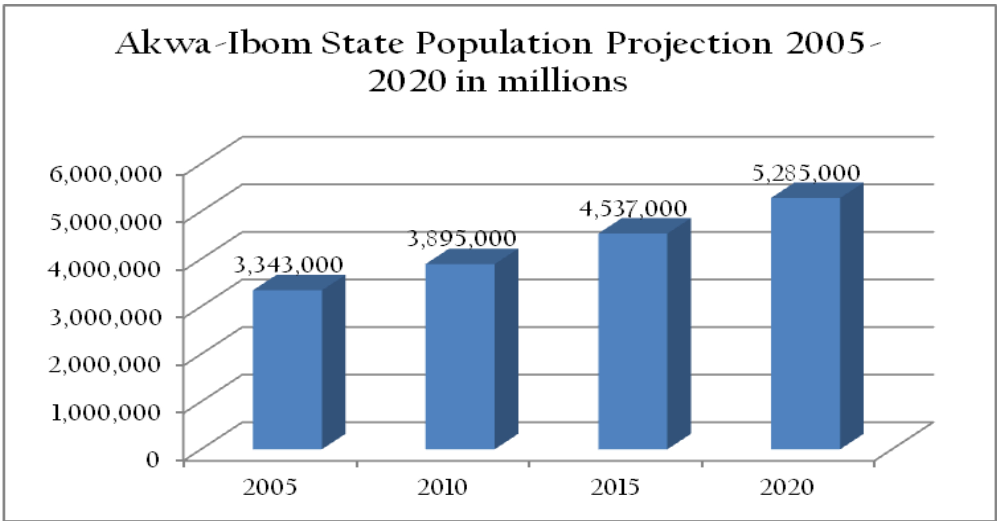


Fig 20: Akwa-Ibom population projection
Source: GTZ projections (2004) based on National Population Commission Data

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

Niger Delta**:** The Niger Delta, situated in the southernmost part of Nigeria and covering an area of about 70,000 km2, is the largest river delta in Africa and the third largest in the world. From a coastal belt of swamps, stretching northwards the land becomes a continuous rainforest which gradually joins with woodland and savanna grasslands in central Nigeria. The swamp, forest and woodland areas occupy about 12 per cent of the delta's land surface. Nigeria gained independence from the United Kingdom in 1960. With a population in excess of 158 million people, Nigeria is a multi-ethnic federation divided into 36 states and the Federal Capital Territory, within which lies the capital city of Abuja. More than 250 ethnolinguistic groups are spread across the country; however the three dominant groups are the Hausas in the north, the Igbos in the south-east and the Yoruba mainly living in the south-west. Nigeria is rich in natural resources, including natural gas, petroleum, tin, iron ore, coal, limestone, niobium, lead, zinc, timber and extensive arable land. Prior to the discovery of oil in the 1950s, agriculture was the mainstay of the economy, with agricultural produce exported to the more developed parts of the world. By 1971 there had been a shift from agriculture to petroleum production, such that between 1973 and 1981 the value of agricultural exports declined from more than USD 1.5 billion to about USD 0.3 billion. Currently, oil and gas provides 80% of budget revenues and 95% of forex earnings.

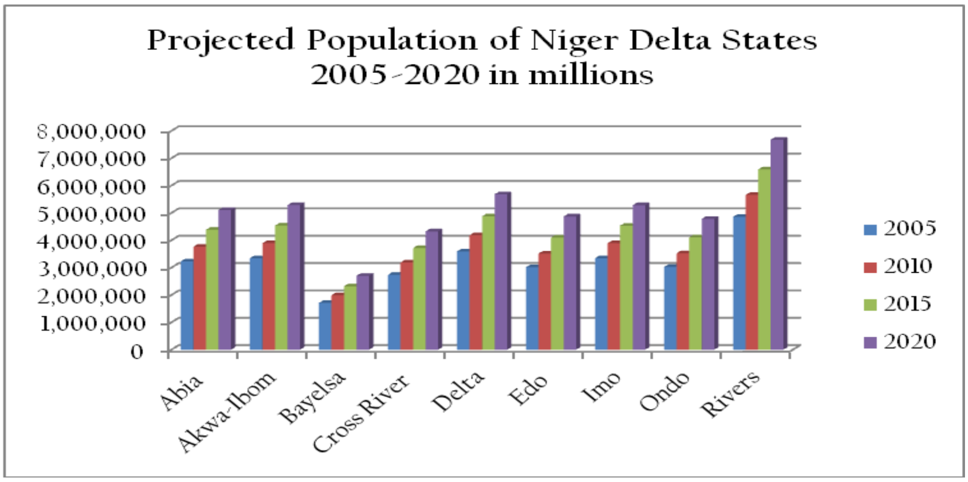


Fig. 4.21: Niger Delta State Population Projection
Source: GTZ projections (2004) based on NPC Data & growth rates

Political Structure/ Governance
Community Power Structure and Governance
Prior to and immediately after the colonial era, Obolo communities were governed on the principle of gerontocracy. Executive, legislative and judicial functions were vested in the oldest man and a cabinet constituted of randomly selected elders from the lineage groups. The *Oldest man* was also the chief priest of the community deity, and knowledge of herbs and historical wisdom were the basic qualifications for the position of the non-hereditary executive members. However, a more dynamic indigenous political system based on representative participation and the fair sharing of power and responsibilities among the lineages, wards and age-grade associations have emerged. As a consequence and in response to democratic requirements, two levels of governance structures are now recognized in the Utapate Field projects communities - formal governmental and the traditional administration.

In most of the Obolo settlements, a Paramount Chief, heads the Council-of-Chiefs/Elders and he is supported by other Chiefs (Deputy Chiefs 1 and 2 and others). The Council of Chiefs consists of traditional chiefs among whom a Chairman is elected. The responsibility of the council is to ensure peace, progress and stability in the community. The CDC membership ensures representation from each section of the community. The CDC also has responsibility for the infrastructural development of the community. The Chairman is the spokesman for the community in all matters. The different councils support and complement each other in a harmonious way. For community cohesion, all tiers of administration are established with the approval of the community structure, notably the founding compounds/families. Each compound has its own elected chief and power sharing is such that each family is duly represented in the council of chiefs or other body that has to do with making laws/taking decision for the community, mobilizing the citizenry and even enforcing all agreed rules and decisions. All of the organs have traditional roles, geared towards a harmonious co-existence of the communities.

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 autonomous communities of the Obolo ethnic group are still being governed on the principles of gerontocracy; executive, legislative and judicial functions are still vested in the hands of the oldest man and his cohorts. As a result, majority, if not all of the Obolo communities, 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 leadership structure is as follows: Village Head, Chairman Village Council, Secretary Village Council, Village Treasurer, Youth President, and Women Leader. The quarter chairmen, the youth group, and the women's forum respectively constitute the local and traditional administrative structures of the Utapate Field project affected communities (Fig 4.22).

Meanwhile, depending on the clan and the system of administration, the King or clan head is called the Etubom and such title may be hereditary in some clans. Although, it was revealed that it is rotational in the study area and usually shift to the next person after the death of the existing one. In other word, the existing Etubom remains as long as he lives. While the kingship system maintained a highly centralized type of government with the Etubom (King) assisted by council of chiefs, the clan head (the most elderly) is assisted in the day-to-day administration of the polity by titled officers selected from the various age grades recognized in the clan. Due to political expediency and the King in modern day Nigeria, the number of Obolo clans adopting the Kingship system has increased. Today, the traditional political system operates side by side with the Western system.

In the same vein, the Etubom in Obolo land oversees his kingdom, while the Royal Majesty in each of the communities that makes up the kingdom takes charge of the community and report to the Etubom. Meanwhile, the CDC Chairmen (Development Association) takes charge of the developmental issues and daily running of the community with his cabinet. The Etubom as the general overseer of the Kingdom usually have his Council of Chiefs attached to him. The Council of Chiefs takes decision collectively with the Etubom. 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.

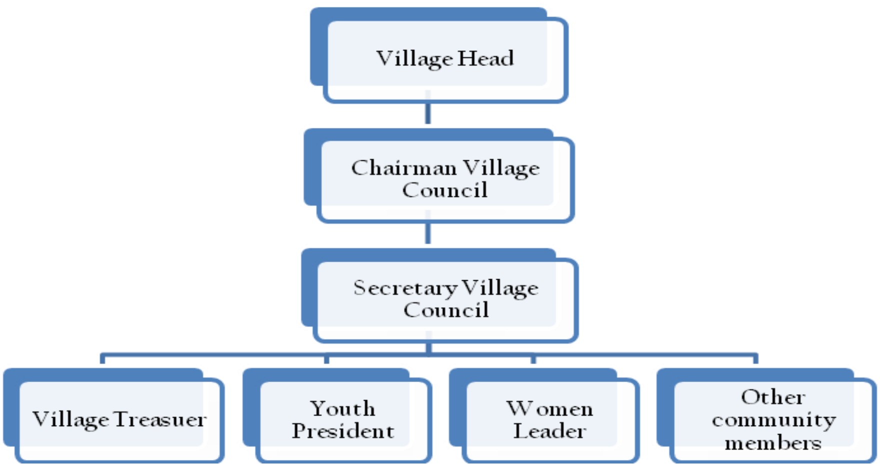


Fig. 4.22: Traditional Administrative Structure in Obolo communities

On the other hand, at the formal level of modern governance system, apart from the roles of the Federal and State Governments in fostering development and security of lives and properties, the Local Government Area (LGA) administration is overseen by an elected Executive Chairman. There is also the legislative arm of the LGA administration made up of Counselors elected from the political wards in the LGA. Communities in each LGA are grouped into political wards for purposes of representation and administration. Political participation is very keen in the communities and the main political parties with offices in the communities studied in Akwa-Ibom

State are: All Peoples Congress (APC) and Peoples Democratic Party (PDP) and others.

Population and Socio-demographic Characteristics

Population Size, Growth and Distribution

Akwa Ibom State was created out of Cross River State in 23rd September, 1987 with capital in Uyo. It has a total square meter of 7,081km^2 (2,734sq mi) with a total population of 2,359,736 according to 1991 census and in 2006, the population was estimated to about 4,805,470. Given the population size, the state was ranked 15th position out of 36 State of the federation. Akwa Ibom State is located in the coastal southern part of Nigeria, lying between latitudes $4^0 32^0$N and $5^0 33^0$N and longitudes $7^0 25^0$N and $8^0 25^0$E. The state is boarded on the east by Cross River State and Abia State and on the south by the Atlantic Ocean and the southernmost tip of Cross River State.

Akwa Ibom is one of Nigeria's 36 states, with a population of over 5million people. It was created in 1987 from the former Cross River and currently the highest oil-and-gas-producing state in the country. Akwa Ibom State has 31 local government areas – Abak, Eastern Obolo, Eket, Esit-Eket, Essien Udim, Etim-Ekpo, Etinan, Ibeno, Ibesikpo-Asutan, Ibiono-Ibom, Ika, Ikono, Ikot Abasi, Ikot Ekpene, Ini, Itu, Mbo, Mkpat-Enin, Nsit-Ibom, Nsit-Ubium, Obot-Akara, Okobo, Onna, Oron, Oruk Anam, Ukanafun, Udung-Uko, Uruan, Urue-Offong/Oruko and Uyo. Meanwhile, the Utapate Field falls within Eastern Obolo local government area in Akwa Ibom State. The people are predominantly Christian faith. The main ethnic groups of the state are Ibibio, Annang, Oron, Eket and Obolo. The Ibibio, Annang, Eket, who speak a dialect of the Ibibio language, Oron and Obolo, comprising Ibono (Ibeno) and Eastern Obolo people are the largest ethnic group similar to the Efik, which also speak a dialect of Ibibio language and predominant in neighbouring Cross River State, and found in five of the state's local government areas. Located at the Atlantic Ocean seafront are the Eket, Ibeno, and Eastern Obolo people. The Ibono have similarities with the Oro and Obolos. See www.wikipedia.com.

Population Growth Rate

Population growth is determined by the demographic processes of fertility, mortality and migration. Considering the impact of these demographic processes, NPC has estimated annual population growth across Nigeria at 3.2% (NDHS, 2008). Fertility rates are influenced by a number of factors in the communities studied, which include early procreation and the practice of polygamy. The most commonly used measures of fertility in Nigeria are the Total Fertility Rate (TFR) and the Crude Birth Rate (CBR). The TFR provides an indication of the total number of children a woman will have in her reproductive life time. There were no available TFR values for the communities and LGAs, but the National Bureau of Statistics (NBS) in its Annual Abstract of Statistics (ABS), 2010 provides a TFR value of 4.6 for the South-South geo-political region and 5.9 for the nation. The implication of these values is that the rate of fertility in the South-South states, including Akwa-Ibom is lower than the national average. Another measure of fertility, the Crude Birth Rate (CBR) describes the relationship between the number of life births per 1000 of the population and the midyear population in an area. Expressing the CBR in percentage, the NBS estimates the national CBR at 13.65% and in Akwa-Ibom State at 16.09% (ABS, 2010). Akwa-Ibom State has a higher CBR of 2.59 % than the national average of 1.78%. A major factor that has influenced mortality in the communities is the non-availability of adequately staffed and equipped medical facilities.

Migration is another factor that is responsible for population growth rate in Nigeria. This has been mostly characterized by a rural to urban movement of individuals and families. Overall, results obtained from the survey of the communities indicate that about 72% of respondents across the study area were non-migrants and 28% were migrants. Specifically, the figure was 75% non-migrants to 25% migrants across Utapate stakeholder's communities. Thus, there has been increased ethnic mix arising from migration by non-indigenous population in search of services for the oil and gas operations of Sterling in the area.

Socio-Economic Characterization and Age Distribution of Respondents

The age distribution of respondent is dominated by youth ranging between 20–49years (50.5%). About 45.2% were found to fall within the age bracket of 50 – 69 year while above 70 years accounted for only 4.3% as depicted in (Fig. 4.23a &b). This result suggests that the population of the project people has great potentials for future growth. The age range is in conformity with the local and state government age group where the bulk of the population falls with 15-64years of age.

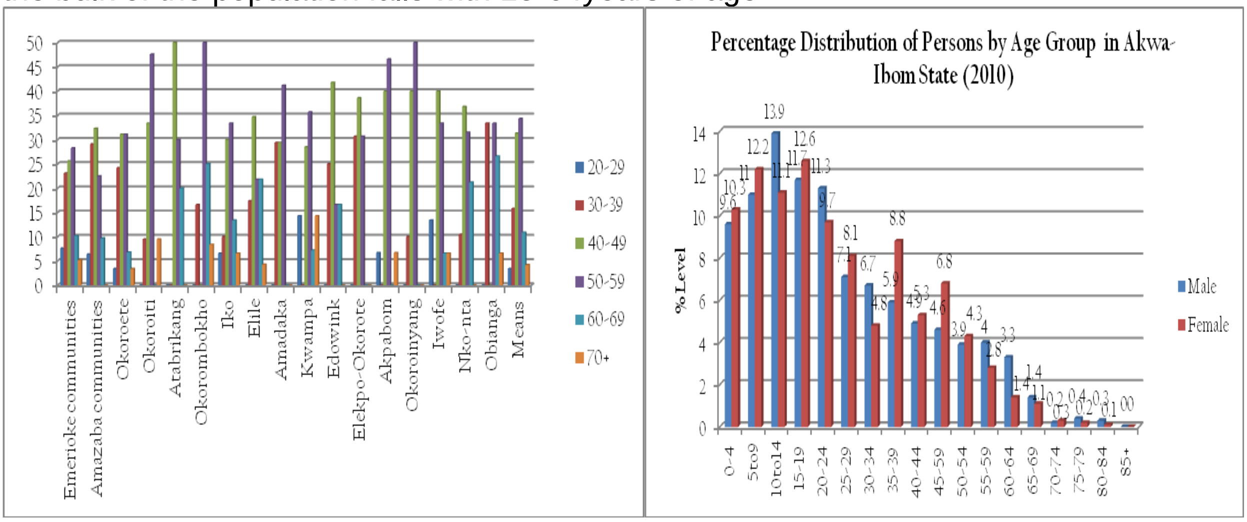


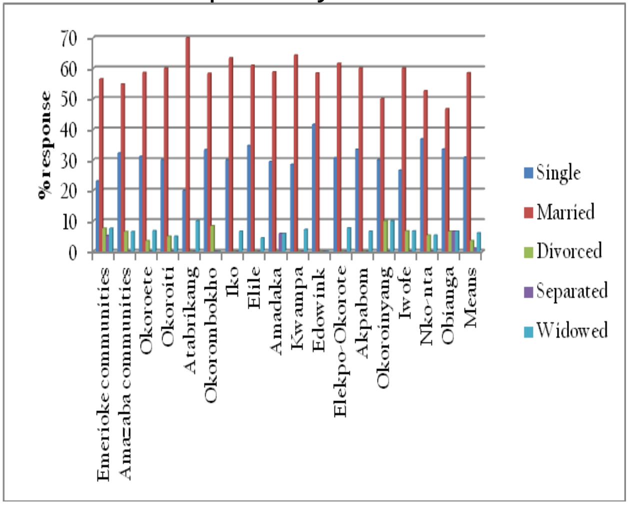
Fig. 4.23a &b: Age Range of Respondents & Percentage Distribution of Person by Age Group

Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2010

Household Size and Marital Status of Sampled Population

Sizes of families vary from community to community and this is influenced greatly by the cultural attitude of the people. Another critical determinant of household size and marital status is economy of the settlement as well as educational status/awareness of the resident population. Specifically, the average household size in the Utapate Field communities was 5.3 according to number of households and total population in (NPC 2006); socioeconomic survey of the sampled communities revealed however, that household sizes have since increased beyond this level.

Women have an average of 5 children and average household size approximates to 5.3. If other dependants living in the households are added, (a minimum of 2 and maximum of 5 was reported within the communities), household size now comes to 10. This trend of large household sizes can be attributed to several reasons in the studied communities in particular and the South-South (Niger Delta) region as a whole. For instance, people marry at a relatively early age thereby extending their period of child bearing. On the other hand, the men marry more than one wife (i.e polygamy) as well as keep other concubines. On the average, about 58.5% of the sampled respondents are married while about 30.8% are single. Widows' people account for about 6.1%, Divorced 3.5% and Separated 1.1% as depicted in (Fig.4.24a &b). This is in line with the Akwa-Ibom State marital status where the married and single are higher with 28.1% and 64.8% respectively.



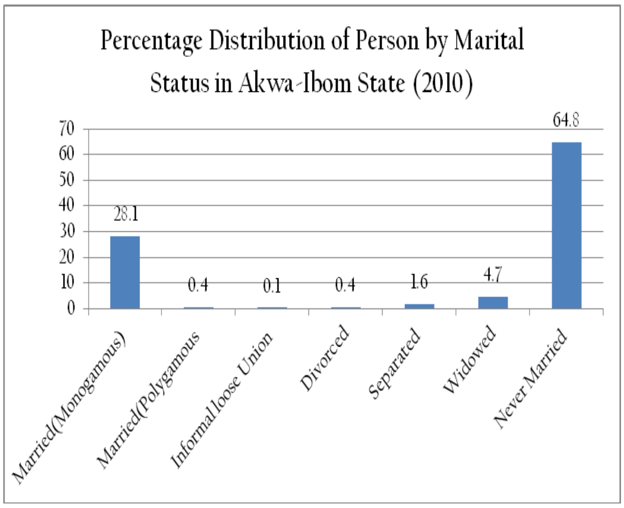


Fig 4.24a: Marital Status of Sampled Respondents; Fig. 4.24b: Akwa-Ibom State marital status; *Source: National Bureau of Statistics (NBS)*

House Hold Size

Households in the study communities were also found to have an average of seven members as shown in Fig. 4.25. This is explained by the culture of the people which permits polygamy with men marrying more than one wife to procreate children that support activities in their traditional occupations of farming and fishing (UNDP, 2006).

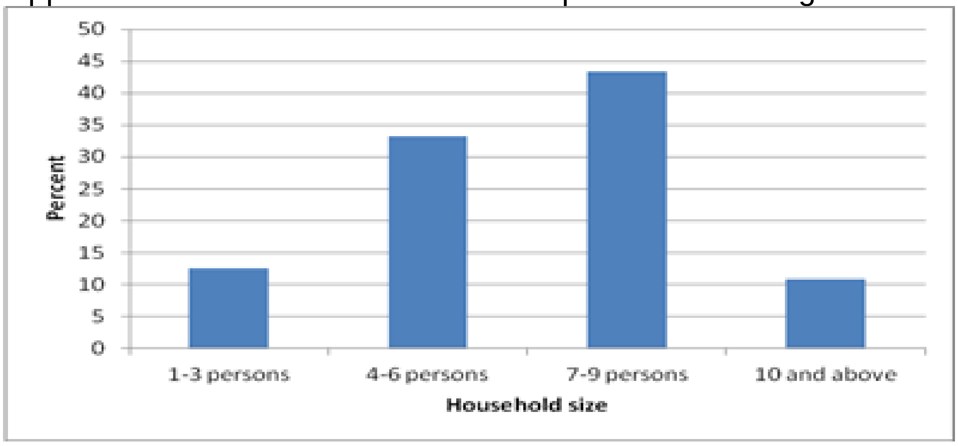


Fig. 4.25: Household size in Utapate Field Study communities

Household and Population Structure (Age/Sex Distribution and Ratio)

Age and Age-Sex Structure

Age and sex are important demographic classification variables. As high as 28.4% of the household population is aged 0-12 years while 18.9% is within the 13-18 years age bracket. Together therefore, children make up 47.3% of total household population. Almost half (41.9%) of the household members are within the productive workforce age cohort of 19-59 years. Household members aged 60 years and above are few, constituting only 10.8% (Fig.4.26a & b).

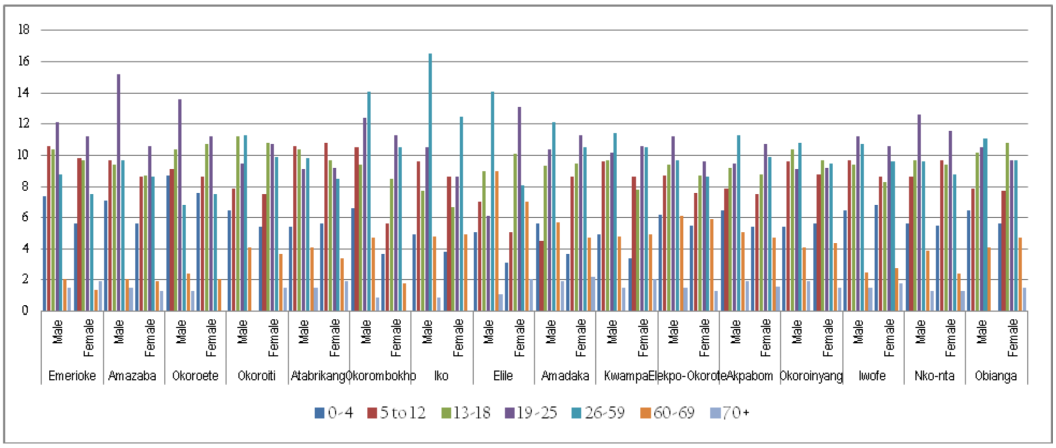


Fig 4.26a: Age and Sex Structure of Sampled Households

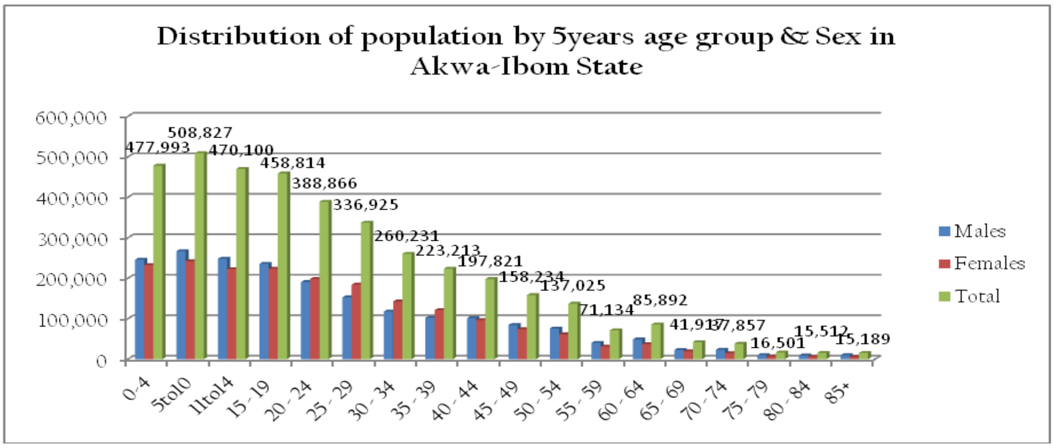
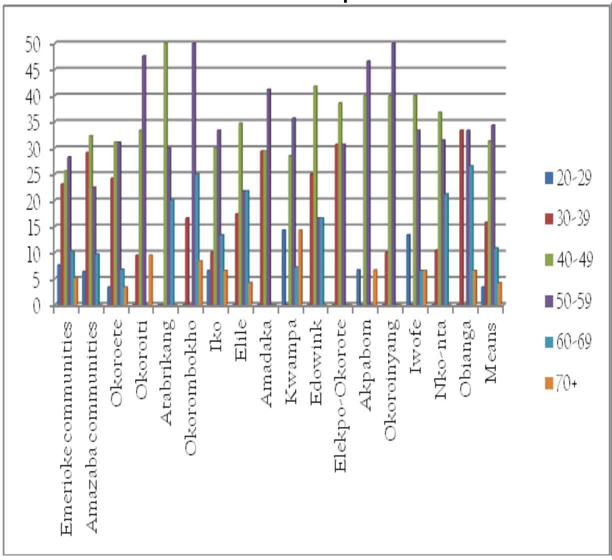


Fig.4.26b: **Distribution of population by 5years age Group and Sex in Akwa-Ibom State**
Source: NPC 2006

This household Age-Sex composition conforms to what was found for all of Akwa-Ibom State, and indeed Nigeria's population age-sex structure (National Population Commission, 2006). By this structure, the population is overwhelmingly loaded from the lower age-cohorts with the bulk of the population made up of persons below 18 years, and descriptively classified as children (NPC, 2002). As a result, communities in Akwa-Ibom State have high dependency ratio with child dependency ratio (for age group of 0-14 years) of 31.23%, disaggregated into 16.37% for males and 14.86% for females. The implications of this age profile is that the population is young and growing and places heavy burden of dependence on the workforce population especially with regards to provision of education and health care services for the young and medical care for the aged. The household structure of Utapate Field host communities shows that there are more male (62.9%) heads of households than females (37.1%). The three (3) different type of male-headed household structures are as follows; (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 survey of the communities also showed that households' structural composition is 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 (infants) is about 11.3% of the household members and children aged 5-12 years (primary school age) makes-up about 17.1% of the population. The age range of 13-18 years

(Secondary school age) is about 21.4% while 19-25years (Tertiary education) made up of 20.5%. Also 20.1% make up 26-59 years (active working proportion) and the aged (60 years and above) make up 10.8% of the household composition. The socio-economic data also indicates that most of those surveyed are adults of at least 20 years old. On the average, about 19.3% and 65.7% of the community respondents were respectively in the 20-39 and 40-59 years age brackets, 31.4% were aged 40-49; 34.3% (50-59) while 15% were aged 60+ years and above (Fig 4.27). Sex distribution of the population in the communities shows the males are more in number constituting approximately 62.9% to the females' 37.1% of the population (Fig.4.28). According to the 2006 census, the males outnumbered the females. At the State level, the male-female ratio is almost equal at 50.8% males to 49.2% females.



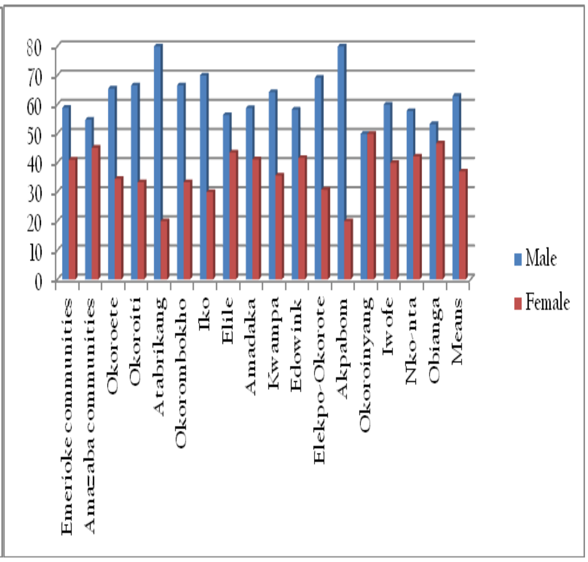


Fig.4.27: Age Range of Respondents **Fig.4.28: Sex Respondents**

Educational Status and Characteristics

Education is a key determinant of lifestyle and social status among individuals. Studies have consistently shown that educational attainment is highly correlated with socio economic wellbeing, health behaviours and attitudes. A large proportion of the sampled population has formal education indicating a literate society. The common classes of educational attainment among the sampled population are the tertiary, post primary and primary education. On the average, 8.3% of the respondents had tertiary education training. Those with post primary (secondary) and primary education accounted for 44.3% and 27.3% respectively. The possession of vocational/technical education among the sampled population is quite high (14.8%) and this is good on occupational skill needed for prospective employment positions that may be offered to members of the communities. Those of NFE constitute 3.9% and 1.4% others (Fig 4.29).

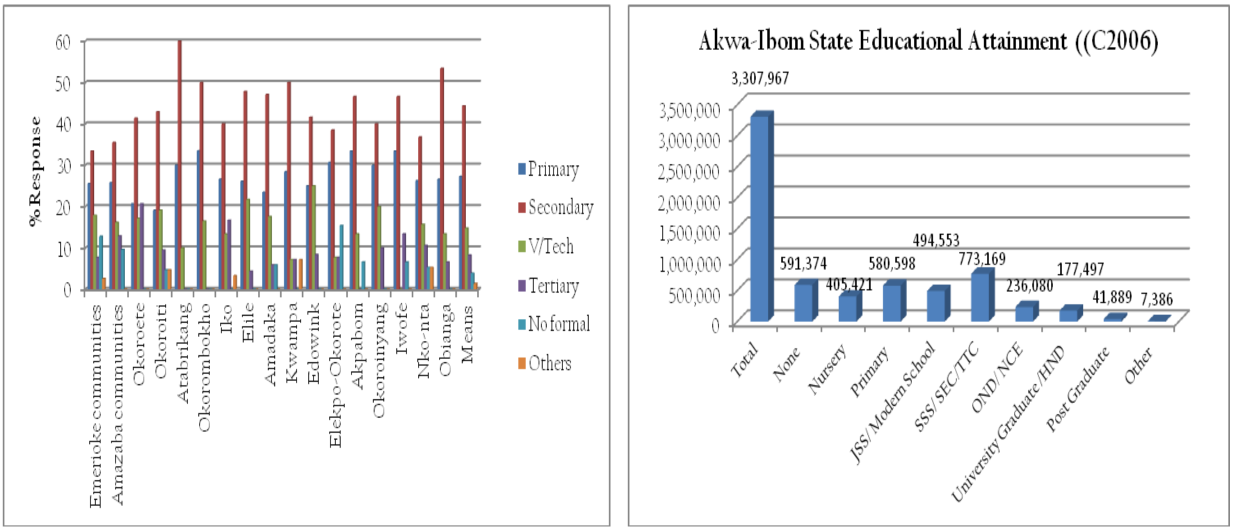


Fig.4.29a & b: Educational attainment of respondents and Akwa-Ibom State Educational Attainment.

Beyond the aggregate figure for Akwa-Ibom State, the literacy level amongst the respondents in the project area of influence, indicate that mostly the retirees make up the bulk of those with tertiary education. 5.3% of the respondents had either Teachers certificate while some have other training in addition to WASC/GCE; Another 4.3% of the respondents had intermediate non-degree qualification such as OND. Furthermore, about 17.8% and 24.6% of the respondents fall within the categories of junior and senior secondary school certificate holders. Also, 15.4% had vocational/technical education while 26.5% had primary school leaving certificate, 4.6% and 1.5% had Non-Formal education and others respectively.

Table 4.44: Educational Status of Respondents in the Study Area

Educational Category	Male	Female	Total	Percentage
No Formal Education	6	9	15	4.6
Primary	47	39	86	26.5
Junior Secondary	35	23	58	17.8
Senior Secondary	43	37	80	24.6
Post-Secondary (non-degree)	8	6	14	4.3
Post-Secondary (degree)	12	5	17	5.3
Vocation/ Technical education	30	20	50	15.4
Others	2	3	5	1.5
Total	**183**	**142**	**325**	**100**

Source: Field Survey, 2019

Livelihood and Micro-economy

Occupation, Employment and Income Generating Activities

Opportunities as well as constraints in a micro- and macro-economic life of a society are known to influence the socioeconomic characteristics of the inhabitants. These opportunities and constraints manifest as positive or negative effects on nutrition levels and health, geographic mobility, educational attainment, and overall quality of life. The economic livelihood activities in Utapate Field communities depend much on the natural resource-base and traditional occupations like farming, fishing, hunting and lumbering. Farming and Fishing are the major activity of the people and majorly on rice farming, vegetable, maize, pepper etc. Artisanal fishing and processing of sea products, essentially drying, are part of economic livelihood activities in the study communities.

Fishing is done in the rivers like, and other water bodies around the communities as well as in the Atlantic Ocean. Fishing nets, hooks, fish traps and machetes are used. Fishing activities in the communities are most lucrative in the dry season months from about October to April. The catch is generally reduced and, therefore, expeditions are less during the rainy season. High water levels from floods hamper fishing in the rivers and residents fish mostly in the wetlands and swamps in their communities. The usual catch includes tilapia, catfish, mudfish, electric fish, sardines, shrimps and craw fish, among others.

Among the fisher folk, there are different categories. There are those who own fishing equipment and give them out on lease to others; those who own and use their own equipment and those who function as assistants to others during fishing expeditions. The reward system practiced locally among resident fisher folk ensures that proceeds from every expedition are shared into three equal parts, one part is taken by those who physically participated in the expedition, one part for the equipment and one part for the equipment owner. This practice ensures that entrepreneurship, investment and labour are duly rewarded. Some of the unsold fish catches are processed by drying on local ovens fired by firewood. Women and children dominate the fishing for shrimps and craw fish and drying of fish products. The average healthy fisher folk are able to go out fishing several times in a week. Fisherfolks are estimated to earn aboutN250, 000 monthly. The investment varies, depending on the type and number of equipment employed. A canoe and the accompanying equipment would cost about N100, 000.

Apart from farming and fishing, trading has been a significant traditional livelihood activity for residents in the study communities. Farm and fish products intended for sale are transported to various periodic markets. Residents of Utapate Field communities have their market usually held every seven-seven days. The people also carry their fish to Eket and the state capital (Uyo) where prices are perceived to be higher.

The markets apart, there is considerable daily sales of goods in the communities. This type of economic livelihood activity is done by petty traders who hawk their wares and others who sell from shops. The shops are usually one room from which traders sell a wide variety of items like clothing, shoes and bags, electrical fittings, alcoholic and nonalcoholic beverages and stationery, among others. Some of the traders in this latter category include Andonis, Ogonis, Ibibios, Yoruba, and the indigene (Obolos). Hawking is done mostly by women and children. Traders deal with a wide variety of goods and also operate on different scales and so their incomes vary. Indications from responses during interviews are that their monthly incomes are as varied as between N10, 000 to N250, 000, particularly those involved in fishing at the Ocean.

Plate 4.14: Fishers encountered in the Creeks carrying normal daily fishing expedition at Edowink, one of the Utapate Field host communities; a fisherwoman at Elekpo-Okoroete preparing items used in drying fish and the other at Ellile processing cassava into flour/garri as major source of livelihood of the people.

Artisanship practices provide major forms of small scale livelihood activities in the study communities. Artisanship practices in the study communities' include making of crafts like tailoring, electrical works, welding, masonry and hair plaiting. These occupations account for 5.0% of livelihood activities across the study area.

Estimated monthly income from artisanship practices is between N10, 000 and N20, 000. Some residents also work at other activities including providing internal transportation by riding commercial canoe and speedboat. Residents commonly engage in more than one livelihood activity. Engaging in multiple livelihood activities provides household members complementary sources of income. In many cases it is an indication that each of these activities only provides a subsistence income. Analysis revealed that, farming 12.7%, fishing 35.8% and trading 14.6% account for the primary occupation of the people respectively. Also, 6.2% of the population engages in technical/artisan jobs. Other economic activities include Business/Contracting 0.4% and unemployment 12.2%. Also 7.5% of the sampled populations are civil servants, students/apprentice 8.3%, industrial works 0% and others 2.3%. The 12.2% unemployment shows that employment issues are of serious concern in Utapate Field host communities (Fig. 4.30).

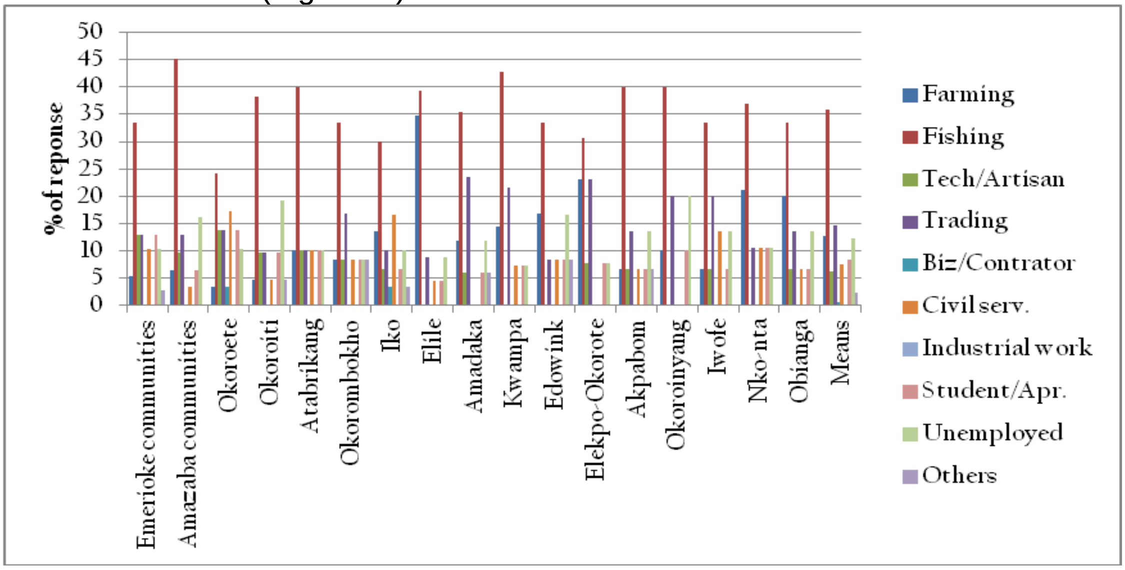


Fig 4.30: Livelihood Activities in the Study Communities

Employment Status in the Communities

Residents of the communities experience employment and unemployment. The employed are engaged in one or more of the identified livelihood activities as identified in the preceding section. The Unemployed here refers to those who are ready and willing to work but are unable to secure one. During discussion and interview sessions, community sources indicate that several households among them had one or two unemployed members. They estimate the rate of unemployment among residents at between 30% and 35%. Sources at host communities estimated the higher figure at 35%. These figures conform to the unemployment situation in Nigeria. For instance, in its 2011 Annual Socio-Economic Report, the National Bureau of Statistics (NBS) estimated the level of unemployment among rural residents in the country as follows:

Among the uneducated, the rate of unemployment was 22.8%, among primary school levers it was 22.7%, among JSS graduates it was 36.9% and among SSS graduates it was 22.5%. The age distribution showed that among 18-24 year olds, unemployment rate was38.2% in the rural areas, among 25-44 year olds it was 24.1% while for those aged 45-59 years it was 19.65 and among those aged 60-64 years it was 22.1%. The sex distribution of unemployment was 25.1% among males and 26.1% among females. This would suggest that the rate of unemployment across these communities is highest among females aged between 15 and 24 years whose only qualification is Junior Secondary School Certificate (NBS, 2011). The International Labour Organization (ILO), however, estimated that unemployment rate across Nigeria in 2014 was 10%. It also indicated that the main employment problem in the country was underemployment rather than unemployment (This Day Newspaper, 23 July 2014). The proposed Utapate Field re-entry project obviously will provide employment for some residents of the host communities.

Income Levels and Distribution

Monthly income levels from primary and secondary livelihood activities in the communities are presented in Table 4.45.

Table 4.45: Monthly Income Levels in the Study Communities (Cont'..)

xstttfIncome Range and Midpoint (N)	**Community/Frequency**				**Total of Study Communities**			
	Emerioke group of communities		**Amazaba group of communities**		**Okoroete**		**Okoroiti**	
	(No.)	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**
1,000-5,000 (2,500)	0	0	1	2.5	0	0	2	5.0
6,000-10,000 (7,500)	2	15.0	2	15.0	1	7.5	0	0
10,001-15,000 (12,500)	1	12.5	2	25.0	2	25.0	2	25.0
15,001-20,000 (17,500)	5	87.5	3	52.5	4	70.0	3	52.5
20,001-25,000 (22,500)	5	112.5	4	90.0	4	90.0	2	45.0
25,001-30,000 (27,500)	3	82.5	4	110,0	1	27.5	1	27.5
30,001-35,000 (32,500)	4	130.0	1	32.5	5	162.5	2	65.0
35,001-40,000 (37,500)	4	150.0	5	187.5	0	0	0	0
40,001-45,000 (42,500)	5	212.5	2	85.0	4	170.0	2	85.0
45,001-50,000 (47,500)	4	190.0	5	237.5	3	142.5	4	190.0
Above 50,000 (52,500)	6	315.0	2	105.0	5	262.5	3	157.5
Total	39	**1,307,500**	31	**942,500**	29	**957,500**	**21**	**652,500**
Community Average Income (N)	**33525.64**		**30403.22**		**33,017.24**		**31071.43**	

Table 4.45: Monthly Income Levels in the Study Communities (Cont'..)

Income Range and Midpoint (N)	**Community/Frequency**			**Total of Study Communities**	
	Atabrikang	**Okoro mbok**		**Iko**	**Elile**

	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)
1,000-5,000 (2,500)	0	0	0	0	1	2.5	0	0
6,000-10,000 (7,500)	0	0	0	0	2	15.0	0	0
10,001-15,000 (12,500)	0	0	1	12.5	3	37.5	1	12.5
15,001-20,000 (17,500)	1	17.5	1	17.5	2	35.0	0	0
20,001-25,000 (22,500)	1	22.5	2	45.0	3	67.5	2	45.0
25,001-30,000 (27,500)	1	27.5	1	27.5	4	110.0	8	220.0
30,001-35,000 (32,500)	1	32.5	1	32.5	5	162.5	1	32.5
35,001-40,000 (37,500)	0	0	0	0	1	37.5	4	130.0
40,001-45,000 (42,500)	1	42.5	1	42.5	2	85.0	1	42.5
45,001-50,000 (47,500)	1	47.5	1	47.5	3	142.5	2	95.0
Above 50,000 (52,500)	4	210.0	4	210.0	4	210.0	3	157.5
Total	**10**	**400,000**	**12**	**435,000**	**30**	**905,000**	**22**	**735,000**
Community Average Income (N)	**40,000**		**36,250**		**30,166.66**		**33,409.10**	

Table 4.45: Monthly Income Levels in the Study Communities (Cont'...)

Income Range and Midpoint (N)	**Community/Frequency**				**Total of Study**	**Communities**		
	Amadaka		**Kwampa**		**Edowink**		**Elekpo-Okorete**	
	(No.)	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**
1,000-5,000 (2,500)	1	2.5	1	2.5	0	0	0	0
6,000-10,000 (7,500)	2	15.0	1	7.5	0	0	0	0
10,001-15,000 (12,500)	1	12.5	2	25.0	1	12.5	0	0
15,001-20,000 (17,500)	1	17.5	0	0	0	0	1	17.5
20,001-25,000 (22,500)	4	90.0	3	67.5	1	22.5	3	67.5
25,001-30,000 (27,500)	2	55.0	2	55.0	2	55.0	3	82.5
30,001-35,000 (32,500)	0	0	1	32.5	1	32.5	0	0
35,001-40,000 (37,500)	0	0	0	0	1	42.5	1	42.5
40,001-45,000 (42,500)	1	42.5	2	85.0	2	95.0	1	47.5
45,001-50,000 (47,500)	2	95.0	0	0	4	210.0	4	210.0
Above 50,000 (52,500)	3	157.5	2	105.0	**1**	**42.5**	**1**	**42.5**
Total	**17**	**487,500**	**14**	**380,000**	**12**	**470,000**	**13**	**467,500**

Income Range and Midpoint (N)	Community/Frequency				Total of Study Communities			
	Amadaka		Kwampa		Edowink		Elekpo-Okorete	
	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)
Community Average Income (N)	**28,676.47**		**27,142.85**		39,166.66		35,961.53	

Table 4.45: Monthly Income Levels in the Study Communities

Income Range and Midpoint (N)	Community/Frequency				Total of Study Communities						No	%
	Akpabom		Okoroinyang		Iwofe		Nka-nta		Obianga			
	No	Total Income (N'000)	No.	Total Income (N'000)	No.	Total Income (N'000)	(No.)	Total Income (N'000)	(No.)	Total Income (N'000)		
1,000-5,000 (2,500)	0	0	0	0	2	5.0	0	0	1	2.5	**8**	**2.5**
6,000-10,000(7,500)	2	15.0	0	0	0	0	1	7.5	0	0	**13**	**4.1**
10,001-15,000 (12,500)	1	12.5	0	0	2	25.0	1	12.5	1	12.5	**21**	**6.5**
15,001-20,000 (17,500)	1	17.5	0	0	1	17.5	2	35.0	1	17.5	**26**	**8.2**
20,001-25,000 (22,500)	2	45.0	2	45.0	3	67.5	2	45.0	2	45.0	**45**	**13.9**
25,001-30,000 (27,500)	1	27.5	1	27.5	1	27.5	4	110.0	3	82.5	42	13.1
30,001-35,000 (32,500)	2	65.0	0	0	2	65.0	2	65.0	1	32.5	29	8.9
35,001-40,000 (37,500)	0	0	0	0	0	0	0	0	0	0	14	4.3
40,001-45,000 (42,500)	1	42.5	1	42.5	1	42.5	2	85.0	1	42.5	29	8.9
45,001-50,000 (47,500)	2	95.0	2	95.0	2	95.0	2	95.0	2	85.0	38	11.7
Above 50,000 (52,500)	3	157.0	4	210.0	1	52.5	3	157.5	3	157.5	58	17.9
Total	**15**	**477,000**	**10**	**420,000**	**15**	**397,500**	**19**	**612,500**	**15**	**477,500**	323	100
Community Average Income (N)	**31,800**		**42,000**		26,500		32,236.84		31,833.34			

The mean monthly incomes in the communities are as follows; Emerioke group of communities N33,525.64, Amazaba group of communities ₦30,403.22, Okoroete ₦33,017.24, Okoroiti ₦31,071.43, Atabrikang ₦40,000, Okorombokh ₦36,250, Iko 30,166.66, Ellile ₦33,409.10, Amadaka N28,676.47, Kwampa 27,142.85, Edowink ₦22,380.95, Elekpo-Okoroete ₦35,961.54, Akpabom ₦31,800, koroinyang ₦42,000, Iwofe ₦26,500, Nka-nta ₦32,236.84 and Obianga ₦31,833.34. The modal income bracket across the communities is N50, 000 and above. Given the mean income values and assuming naira to United States of America dollar (USD) conversion rate of N365: 1USD and 30 days in a month, the daily individual incomes will be N1,117.52 or

3.1USD in Emerioke communities, N1,013.44 or 2.77USD in Amazaba, N1,100.57 or 3.01 USD in Okorete, N1,035.71 or 2.84USD in Okoroiti, N1,333.34 or 3.65USD in Atabrikang, N1,208.34 or 3.31USD in Okorombokh, N1,005.55 or 2.75USD in Iko, N1,113.64 or 3.05USD in Ellile, N955.88 or 2.62USD in Amadaka, N904.76 or 2.47USD in Kwampa, N746.03 or 2.04USD in Edowink, N1,198.72 or 3.28USD in Elekpo-Okorete, N1,060.00 or 2.90USD in Akpabom, N1,400 or 3.83USD in Okoroinyang, N883.34 or 2.28USD in Iwofe, N1,074.56 or 2.94USD in Nka-nta and N1,061.11 or 2.91USD in Obianga . Using the midpoint of the modal income range (i.e. N52, 500) individual daily incomes in the communities will be N1, 733.34 or 4.7USD. Daily incomes in the communities are higher than the World Bank extreme poverty income of 1.9USD.

Expenditure Pattern

The major items expend for by the households in the study communities include food (40%), education (20%), healthcare (5%), purchase of household items including groceries and utilities (15%), transportation (10%) and clothing (5%), as depicted in Fig 4.31.

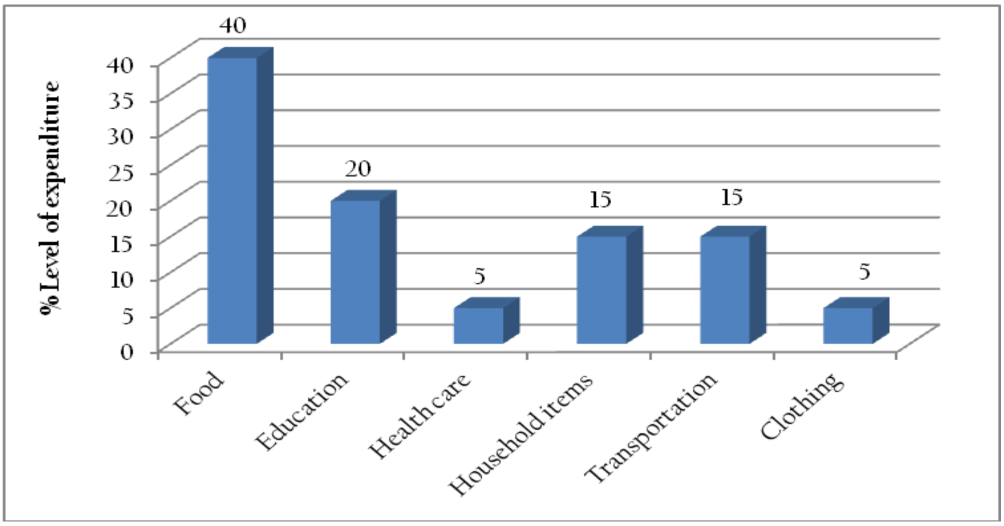


Fig.4.31: Household Expenditure Pattern

The major food items that are expended on are those that are either not grown or produced locally. These include beef and beverages. Expenditure on health care is quite significant. Many residents spend considerable sums of money on drug purchases from drug stores (‘chemists’) in their communities. Recreation and leisure are not significant expenditure items. Expenditure on food, education and health accounts for 65% of total household expenditure. These expenses are estimated to account for about 70% of their monthly incomes. Despite the foregoing, the primary economic activities in the study area revolve around farming and fishing. Both men and women are involved in farming and fishing. The youths dominate the private company employment and artisanship.

There has however been a shift in economic livelihood activities. This, the respondents attribute to the recent availability of oil and gas employment opportunities in the area. It is pertinent to note that although farming, fishing, and lumbering activities are major economic livelihood ventures, these are increasingly becoming less important income source since the activities of the oil and gas operation began. There is no longer bumper harvest of agricultural produce and fish catch have dwindled. Hence, the occupational shift from these two main employment sectors to oil and gas operations and services.

For those that are involved in farming, cassava is the most popular crop cultivated in the communities. Other important crops are plantain, oil palm, water yam, sugarcane, maize, banana, cocoyam, sweet potatoes, groundnut, okra, pepper, pawpaw and vegetables. Cassava (either in its raw form or processed into cassava flour/garri), plantain, oil palm and yam are the most important food and cash crops. However, cassava, plantain, banana, cocoyam, oil Palm and maize yield more income to the households than other crops. Fishing is carried out in the nearby water courses in the area including ponds as well as in the seasonally flooded water area. Several types of traps, nets and hooks are used for fishing. This makes aquaculture a common economic activity in the Utapate Field project area. Fishponds are owned by individuals, families or communities. Stocking of fish and feed are at small scale levels. In addition, ponds are used to trap fishes that come inland during the flood seasons and are harvested when the floods recede. The communities have bye laws that restrict fishing to certain periods of the year, which serve as traditional conservation measures that ensure sustainable exploitation of fish resource.

Religion, Customs, Belief System and Heritage

Religious Affiliations, Customs, Belief Systems, and Heritage

A 100% response to administered questionnaire and Focus Group Discussants confirmed that Christianity is the predominant religion in the Utapate Field study communities. This indicates that a very high proportion of the resident population ‘’go to church’’ or associate with a religious organization, with a minority practicing the traditional African religion (ATR) and/or do not identify with any religion. The orthodox churches like the Anglican (CMS), spiritual (Christ Army Church – CAC) are easily the dominant denominations, while the presence of several Pentecostal sects were observed as sign-posted in all the nooks and crannies of the studied communities. For example, many churches were observed in the communities. The churches include the Roman Catholic, Anglican, Assembles of God, Redeemed Christian Church of God (RCCG), Brotherhood of the Cross and Star (aka OOO), Qua-Ibom Church and Apostolic Faith. Focused Group Discussion sessions and previous studies of the area have revealed that in spite of the overwhelming presence and influence of Christianity, the communities still retain some of their traditional beliefs. Thus, in practice, some of the Christians at the lineage and community levels participate in existing traditional festivals and religious rites.

In the affected communities, there are places that are considered sacred and ‘’unauthorized’’ to non- initiate. Trespassers are sanctioned for any trespass. Cultural and traditional practices relating to such ‘’forbidden grounds and forests’’, are either conducted at the individual level with the nuclear family or at the community level. Such sacred sites are regarded as the abode of the gods. In fact, the beliefs of the people as it relates to their existence are still very much reliant on the deities/gods. However, such sacred areas can only be trespass on conditions of making some sacrifice or appeasement by the priests in charge of the forbidden areas.

Amongst the most important of the peoples’ culture presently are their festivals. While generally, most festivals in Eastern Obolo communities are in commemoration of historical events or in honour of the spirits of departed heroic ancestors. Some of the communities with close familial affinity up till now engage in a few festivals which have bearing with their way of life and economic well- being. Again, in spite of the commemorative and religious coloration of the festivals, they also play highly aesthetic and recreational roles in the process (Okaba, 1999). For example, the Inovia festival takes place every December every year; 'Iwayu festival' take place September every year and 'Utakwali' festival usually celebrated during Easter period. While the Masquerade festival takes place in September every year. Another festival celebrated annually is the Yok-Izong, usually celebrated on November and in market day. Other festivals celebrated are Isi-Agba, Isi-Ayajaso, Isi-Isoama, Isoamama, Isoloko, and Oke. These are the prominent festivals in the proposed re-entry Utapate Field communities. Other belief systems revolve around the common taboos, which forbid some acts like having sexual intercourse in the bush, and adultery. There are also few shrines (Okpukpo, Ngalage and Ukan) that are not to be trespass by unauthorized persons. Violation of all laid down taboos is regarded as sacrilegious.

The people of Utapate Field project area are also mainly Christians and traditional religious practitioners. As revealed during the field work, a greater proportion of the samples surveyed are Christians while a few are traditional religion worshippers. As a result too, Churches of various denominations are seen in the area. These churches include Anglican diocese, Assemblies of God, Redeemed Christian Church of God (RCCG) Apostolic Faith, Baptist Church, and Roman Catholic particularly. In spite of the Christian majority among the surveyed communities, some still believe in their ancestors and deities that they worship. In furtherance of traditional worship, there are shrines and forbidden forests scattered within the project area. These are held sacred by the people. Contact with some of these spots are restricted with the list of "dos and don'ts" which when violated attract very severe sanctions.

Taboos

In addition to the shrines (Okpukpo and Ngalage, Ukan, Ofiogho, Azuzu, and Umariatabikom) and festival attached to them, the people of the people observed some taboos. These taboos are:

- Having sexual intercourse with a woman in the bush/forest.
- A woman under menstruation is not allowed to enter the shrine.
- Sleeping with another man's wife (adultery)

It is a general belief of the traditional worshippers that these shrines and forbidden forests provide their community spiritual protection against external aggression and promote progress. As a result, these shrines and forest are held in high esteem and ensure that nothing is done to desecrate them.

Festivals

Periodic cultural festivals and dances are also performed in the Utapate Field stakeholder communities. Communal festivals are a function of both entertainment and spirituality. Such festivals are many and vary from community to community. A number of festivals are usually celebrated in the Utapate Field project area. The most popular among them are the Inovia and Yok in Atabrikang community particularly usually take place on December annually. New Yam festival is also celebrated particularly by the upland communities of the Utapate Field like the Iko, Elile and Okoroete usually mark the harvest of New Yam and to appease the goddess for bumper harvest. In addition, the ceremony also signifies resting period for the people of the area as no individual is allowed to be involved in any active work. In general, the festivals have impacted on the people of the project area by creating awareness of Christianity. Others include promotion of peace, and unity within and between the neighbouring communities. Masquerade dance also perform occasionally in the communities and usually take place annually during Christmas period to cleanse the land. Social disorders such as adultery, stealing, fighting with dangerous weapons like knife or cutlass, bottles or gun, having sex with a woman in the farm are among the customs and beliefs that attract serious sanctions. Offenders are harshly sanctioned, either by paying fine or pacifying the gods and/or ancestors.

Family Structure and Marriage

Most traditional communities are composed of the nuclear families, the extended family units and the lineage wards, a conglomeration of which make up a settlement (Okaba, 1999). An amalgam of three to eight nuclear families of common descent constitutes an extended family unit, and these have residential locations that are easily distinguished. Four to six of these extended families make a lineage ward, all sharing a common ancestry (Okaba, Ibid.) Polygamy is a widely practiced form of matrimony. In fact, monogamy symbolized social degradation and failure, while polygamy symbolized success. Households are partrilineal and patrilocal, both serving as basic residential and economic units.

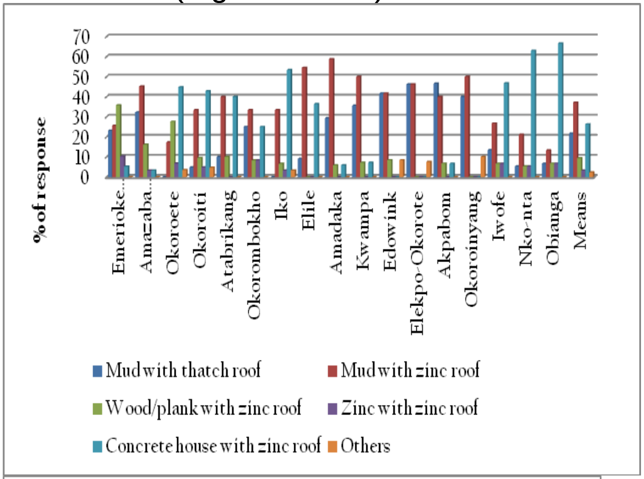
The marriage custom of bride price payment on woman and marriageable girls is widely practiced within the study area. The traditional marriage which requires the kith and kin of both family to gather while the bride price of the girl is paid. On paying the bride price as well as all traditional rite is done, the offspring belong to the man. On the other hand, where bride price of a woman is not paid, the offspring(s) more often than not belong to the woman's family. The categorization of the marriage custom as described here influences patterns of kinship relations and inheritance.

Housing

House Types

Housing is a basic social need and an integral part of the human environment and the physical structure of settlements. Housing has been defined by WHO as "residential environment which includes in addition to the physical structure that man uses for shelter, all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and social well-being of the family and individual" (WHO cited in Owei O. et. al., 2002). Housing in the communities is a mixture of modern and traditional designs and construction materials. A few houses have modern designs and they are built with utilities like kitchen, toilet and bath. Most houses in the communities are also constructed with stable and permanent materials like cement blocks and roofed with corrugated iron sheets.

Most houses across the upland communities of Utapate Field are bungalows and flats. The bungalows are built with many rooms and are mostly multi tenanted. A few houses are built with single rooms or as self-contained units of room and parlour. Bungalows account for a significant number of houses in the communities. Residents in Utapate Field communities believe that the proposed re-entry of Utapate Field in the area would encourage the building of more flats in the communities for rental purposes. Some of the houses are owner occupied houses; some, especially the flats, have toilets and baths located in-house; but most are not provided with these utilities. Some also have kitchens in-house. However, the survey analysis revealed 21.7% of the housing type in the host communities to be mud with thatch roof, mud houses with zinc roof 37.1%, wood/plank with zinc roof 9.4%, zinc with zinc roof 3.2%, while concrete houses with zinc roof are more in the communities with 26.3% and those others houses account to about 2.3% (Fig. 4.32a &b).



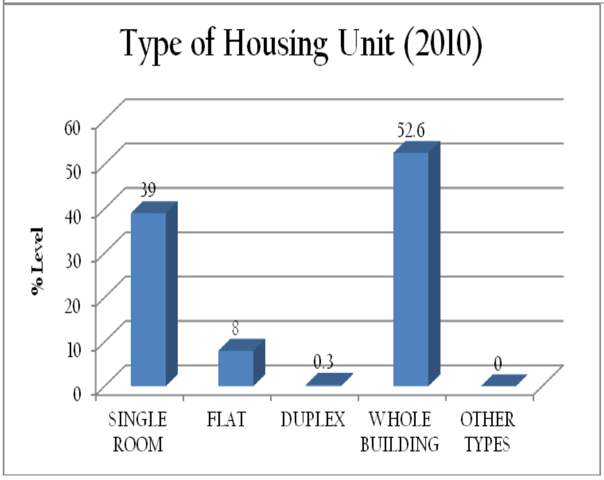


Fig. 4.32a & b: Housing type & Housing unit *Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2010*

Plate 4.15: Housing type/quality in Utapate Field stakeholder communities

Availability and Cost of Rental Accommodation

Rental accommodation is available in the communities. A number of residents, including indigenous members of the communities, live in rented accommodation. Value of house rent in the communities varies according to the construction material. A room in a house built with mud walls and roofed with zinc attracts N500 per month across the communities while a one room accommodation in cement block house costs N1000 monthly while a room and parlour in a similar house costs N2, 000. Flats, two and three bed rooms, cost between N4, 000 and N6, 000.

Available Housing Utilities

Houses in the communities are built with limited utilities. For instance, as a result of the problem of public power supply, residents use alternative sources like private electricity generators, kerosene lamps, torches and candles to light up their houses. Common sources of energy for cooking household meals are firewood and kerosene. About 90% of households across the communities cook with firewood. The Utapate Field stakeholder communities' drinks and cook from river/creek water around them. However, some have functional public and private borehole in their communities.

Plate 4.16: Functional borehole at Kwampa by Mary Remarkable Foundation and typical of non-functional boreholes by NDDC and hand dug well in Utapate Field communities.

Generally, houses in the communities do not have running pipe borne water because the public supply does not have the distribution network that facilitates delivery to houses in the communities. A few houses have private water boreholes installed, and these are the most reliable sources of water to many residents. In addition to the private boreholes, residents use water from the river and rain water.

Existing Businesses

Existing businesses in the communities are small scale. They comprise primary production activities as represented in the two traditional occupations of farming and fishing, commercial activities represented in trading, in shops and markets. The communities have one or two main provision store and drug stores. Apart from these there are a few business centres, welding shops, carpentry and furniture making shops, electrical and electronic repair shops, motorcycle repair and tire vulcanizing shops. Another existing business is transportation by commercial motorcycles, motor vehicles for the upland communities and paddle canoe and speedboat for riverine communities. Available businesses in the study communities are in the informal sector, there are no organized private sector businesses and industries in the communities.

Banking and Informal Credit Institutions

Residents do their banking transactions mainly at Uyo, the Akwa-Ibom State capital and Eket. Existing informal credit practices among residents are the traditional contribution and Osusu. Contribution entails a group, usually made up of friends and acquaintances, who commit themselves to a fixed monthly contribution over a number of months, usually determined by the number of members of the group. A member takes each monthly contribution, and this is done in rotation until every member has had an opportunity. For participants, this represents a source of funds for business investments, payment of fees and bills and purchase of various items, among others. Osusu, on the other hand is organized by an individual who collects money from participants in the scheme. The sum collected is agreed with the participant, the duration is varied but mostly daily or weekly. The total sum collected, less an agreed amount (usually one daily or weekly collection, depending on agreed frequency of collection) is returned to the participant at the end of the month. Osusu is common among petty traders and artisans and it provides some savings which is used at month end to pay salaries of their assistants and purchase essential materials for their trade. Usually the person who organizes the 'Osusu' deploys the funds collected as short term credit to micro and small scale businesses and charges an interest.

Land Use and Resource Harvesting

Available Resources

The proposed re-entry of Utapate Field project affected communities is endowed with a lot of natural resources. These resources have been exploited by generations of residents, and have kept and sustained the continuous human settlements in the entire area. The resources are the water bodies, the forest and the land mass. Water bodies in the study area include the rivers, ponds and wetlands. Ponds and wetlands are situated in bushes and forests around the communities. These water bodies yield the fishes on which the communities depend for food and livelihood. The forests are home to a number of resources including timber, firewood, economic trees like the raffia and bush mango (Ogbono). The timber is useful in building houses and supports canoe repairs activities. The land provides for the physical development of the communities including housing and infrastructure. It is a major resource for farmers as it supports the growing of a variety of crops like plantain, cassava and vegetables etc. A traditional natural resource conservation practice among farmers is shifting cultivation and its attendant bush fallow system practiced in the communities. The practice requires that farmlands are cultivated for a period and left fallow for a number of years. The period of lying fallow allows for the farmland to regenerate naturally. During the fallow period also, farmers cultivate alternative farmlands which had been left fallow in the previous period. This is a common cultural practice that has served to protect and conserve the communities' farmlands, which are a valuable natural resource, from excessive exploitation.

Land Ownership and Tenure

The Land Use Act of 1978 provides the framework for land ownership and payment of compensation for land acquisition for development purposes in Nigeria. However, some of its provisions like the ownership of all lands by the Government have not been well received, especially in southern Nigeria (including Akwa-Ibom State and the Utapate Field affected communities). The rejection stems mostly from the socio-cultural significance of lands. Therefore, in spite of the law, communities and families still assert their ownership rights over lands. Lands in the communities are primarily owned by extended families, compounds and the community. In the communities, families and compounds own lands. Ownership rights over lands are handed down from one generation to another within the extended family, compound and community. Such inherited land is put to any use as desired by the owners. These are the lands on which family, compound and community members build their houses. They are also allocated to members for use as farm lands and for other economic purposes. These lands revert back to the families and compounds at the end of the farming period. Farmlands can be leased by non-family and compound members. Such lands similarly revert back to the owners after the period of lease. Lands are managed by males within the extended families and compounds. Fig. 14.33 shows that 71.5% of lands are owned through family inheritance, 10.8% bought it, 12.8% rented/lease it, while 1.7% sharecropping and 3.2% others.

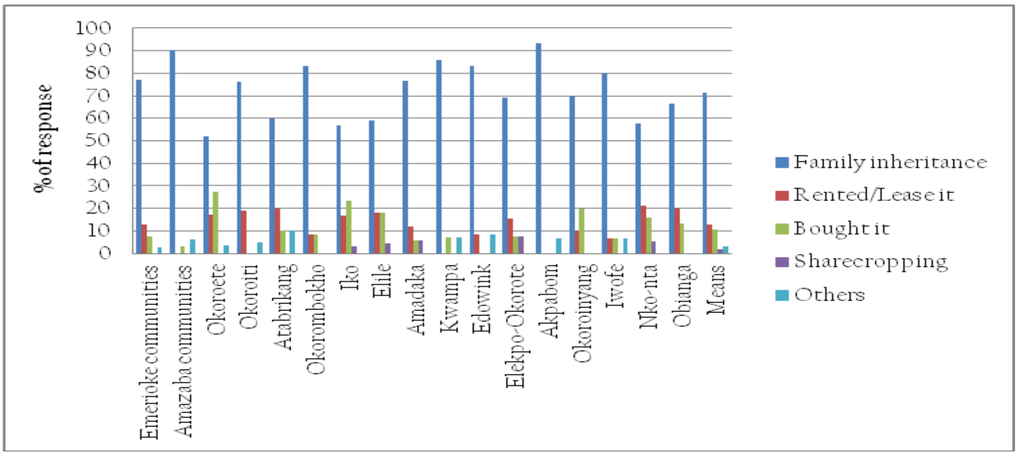


Fig. 4.33: Land ownership system

Classification of Land Use

Land in the Utapate Field communities is an invaluable resource. Traditionally, these have been used over the years for farming and housing, and in more recent times there have been additional uses for infrastructural development and industrial purposes. Residents were conscious of a gradual decrease of the lands in the communities over the years. Their perceptions and estimates of the proportion of lands put to various uses and lands lost to natural factors are presented in Table 4.46. Most of the lands have been put to agricultural use. Lands put to industrial use are mainly could be the one on the proposed re-entry of Utapate Field project. Land loss has been mostly attributed to the natural factors of erosion from the river and rain fall.

Table 4.46: Land Use Structure in the Utapate Field Study Communities

Land Classification	Communities/Frequencies (%)																
	Emeriok e	Amazaba	Okoroete	Okoroiti	Atabrika ng	Okoromb kho	Iko	Elile	Amadaka	Edowink	Elekpo	Akpabo m	Okoroiny ang	Iwofe	Nka-nta	Obianga	Kwampa
Agricultural	70.0	80.0	60.0	70.0	80.0	75.	75.	79.0	70.0	70.0	65.0	75.0	70.0	75.0	70.0	70	80.0
Industrial	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Housing	15.0	10.0	24.0	15.0	10.0	15.	15.	10.0	10.0	10.0	15.0	10.0	15.0	15.0	15.0	15.0	10.0
Institutional	0.0	0.0	10.0	0.0	5.0	0.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0	5	0.0
Loss from natural	15.0	10.0	5.0	15.0	5.0	10.	5.0	10.0	20.0	20.0	20.0	15.0	15.0	15.0	10.0	10	10.0
Total	100.0	100.	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: Field Survey, 2019.

Land use Tenure System and natural Resources

Land use and ownership system in any society is generally governed by a tenure system evolved over time and determined by the perceived demand as well as the potential and actual social pressure associated with its supply and use (Powell, 1995, Swallow and Kamaro, 2000). Land use pattern visible in all societies include public land use, commercial land use, industrial land use, recreational land use and social land use. As in the case in most communities in the South South (Niger Delta) area, land ownership is rested in individual, families as well as communities.

As shown in *Table 4b*, the predominant land tenure system practiced in the Utapate Field stakeholder communities was individual ownership (55.4%), family ownership (25.5%); communal (14.1%); while rented/leased was 5.0%. FGDs discussions conducted with members of the surveyed communities confirmed the arrangement. They also agreed that access to land was through inheritance while control is left in the hands of the individual families and communities that owned bush land. In most cases community, lands are used for developmental projects such as schools, health care service.

Table 4.47: Natural resources assessment of Utapate Field sampled communities

Community	Tenure Right			Access to land rent inheritance	Access to forest free	Access to water	Presence of forest reserved	Land control	Land used/ farming developme
	Land individual I/ family/	Forest individua I/ family/	Water/ Lake Community						
Emerioke	C F	F C	C	Inheritance	Yes	Yes	No	F C	✓
Amazaba	C F	C F	C	✓	✓	✓	✓	✓	✓
Okoroete	C F	C F	C	✓	✓	✓	✓	✓	✓
Okoroiti	C F	C F	C	✓	✓	✓	✓	✓	✓
Atabrikang	C F	C F	C	✓	✓	✓	✓	✓	✓
Okorobomkho	C F	C F	C	✓	✓	✓	✓	✓	✓
Iko	C F	C F	C	✓	✓	✓	✓	✓	✓
Elile	C F	C F	C	✓	✓	✓	✓	✓	✓
Amadaka	C F	C F	C	✓	✓	✓	✓	✓	✓
Kwampa	C F	C F	C	✓	✓	✓	✓	✓	✓
Edowink	C F	C F	C	✓	✓	✓	✓	✓	✓
Elekpo	C F	C F	C	✓	✓	✓	✓	✓	✓
Akpabom	C F	C F	C	✓	✓	✓	✓	✓	✓
Okoroinyang	C F	C F	C	✓	✓	✓	✓	✓	✓
Iwofe	C F	C F	C	✓	✓	✓	✓	✓	✓
Nka-nta	C F	C F	C	✓	✓	✓	✓	✓	✓
Obianga	C F	C F	C	✓	✓	✓	✓	✓	✓

Source: Field survey, 2019: C = Community, F = Family, I = Individual

Infrastructure

Functional Status of Available Infrastructure

The infrastructural framework in the Utapate Field study communities is made up of a few physical and social amenities. Some of the available amenities are not functional. Most of the amenities have been provided by governments and development agencies. The physical amenities include paved access roads, internal roads, community halls and telecommunication services. Social amenities consist mainly of education, health, water supply and electrification facilities.

The Utapate Field of OML13 project communities are accessed by both paved road and by water. Some sections of these roads have potholes and need extensive repairs. They also have some paved internal streets of varying lengths. The communities are accessible from Eket by commercial vehicles through Iko where there exist jetty to board speed boat to other riverine stakeholder communities. Taxis/Bus from Eket to Iko cost N500 per passenger. Internal transportation in each of the communities is by commercial motorcycles which cost N50 per passenger in upland communities like Okoroete, Iko, Elile and Atabrikang. Wooden boats and canoes are commonly used in the communities for fishing purposes. Another major physical infrastructure in all the communities is Telecommunication services. Telecommunication services from GSM service providers (MTN, Airtel and Glo) are received in the communities, though depending on your network and position.

Each of the communities has one public primary school and each has one public secondary school, however, this is only applicable to upland communities. The primary schools run classes 1-6 and the secondary schools have JSS 1-3 and SSS 1-3 classes. Health centers are located in few of the communities like in Okoroete and Iko. The centres are not adequately equipped and staffed. Residents of riverine communities access the General Hospital which is located at Okoroete, the Eastern Obolo LGA headquarter. Public water supply projects (water boreholes) had been built in few of the communities. However, it is no longer functional as it has been overgrown by grass. The communities (Okoroete and Iko) have electrification facilities and they are connected on the national grid. However, the people like other part of the country have power once in awhile and depend more on their individual generating set.

Okoroete and Iko have market built with open and lock-up shops. The markets are periodic. The youth organize themselves into vigilante groups. The closest security presence to Okoroete and Iko comprises the police station and military taskforce and checkpoint located at Okoroete. The communities do not have any developed public recreation facilities. Residents recreate by playing football in the school football fields or swimming in the river. Some stay at home and watch television for few who have television and can afford running cost of generator.

Estimated Monthly Personal Income

Personal income levels of self-employed community members are always difficult to access as typical of most Nigerian households. Many do not keep records and are therefore uncertain of the gross or net amount actually earned from self-employment. Most times, respondents inflate income figures on the assumption that such information could give some advantage in times of compensation payments. However, it is important to note that information on income should be handed with caution because of the high degree of unreliability.

Personal income levels of the people is typical of agrarian/fishing communities, wide variation and meagre and range from N1,000 to over N50,000 per month. As shown in Fig. 4.34, 2.8% earning less than NGN 5,000 in a month, 3.5% of the population had income in the bracket of NGN5001-10,000, 6.4% earn between NGN10001-15000. Also, 7.1% and 14.6% earn between NGN15001-NGN20000 and NGN20001-NGN25000 respectively. While 13.3% also earn between NGN25001-NGN30000, 8.2% earn NGN31001-NGN35000, 2.8% earn between NGN35001-NGN40000, 8.9% earn NGN40001-45000 and 11.7% earn NGN450001-NGN50000 while 20.7% earn N50000 and above per month. Residents who are into Business however, earn better incomes. Generally the income level of the project area is low. This could be due to the meagre income arising from their sources of livelihood and lack of others sources of additional income to supplement their main income.

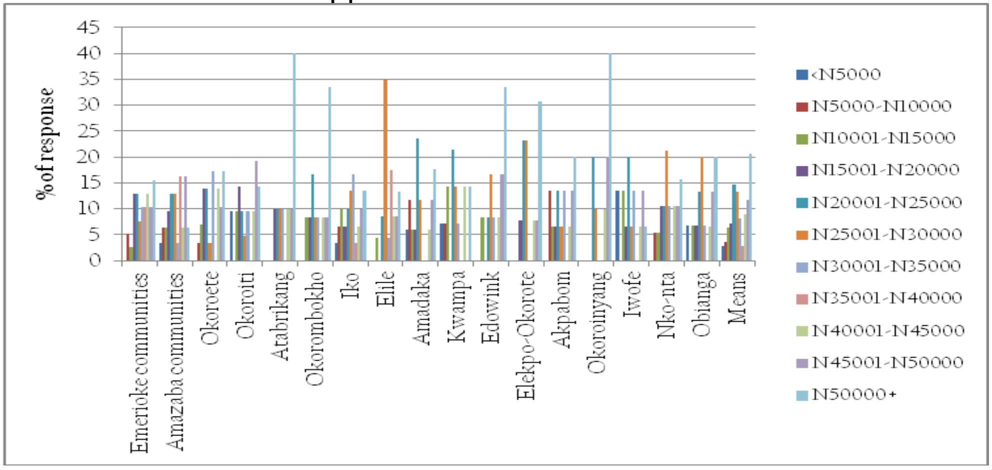


Fig 4.34: Estimated income of respondents/month

Available Social Infrastructure

Availability and access to basic social infrastructural facilities and a reasonable level of income have been used to measure the quality of life of people. The Utapate Field communities visited or sampled have some existing social infrastructure in different status and levels of functionality.

Educational Institutions

The Utapate Field project communities sampled have primary schools. Most of the schools lacked basic facilities such as chairs, tables and writing desks. Also, the schools lacked teachers' quarters etc. In addition to the primary schools, some of the communities have secondary schools provided by the state government. Just like the primary schools, the secondary schools lacked staff quarters, library, laboratory/science equipment and furniture (chairs, tables, desks etc). The primary schools at Okoroete, Okorobonkho, and Amadaka have population of over 400 pupils with only average of 6-7 teachers. The high population of pupils at these schools is as a result of lack of school in the riverine communities who send their children and wards to LGA headquarter for primary and secondary education. On the average each class is having about 67 pupils with one class teacher, which is contrary to UNICEF standard of 36pupils/class. On the other hand, Government Secondary School has population of 350 students with 8 teachers which amount to 43student to one teacher. This implies that teachers are grossly inadequate and therefore need more teachers with incentives to enable them to stay without necessarily working for their transfer out of the communities *(*See Plate 4.17*).*

Plate 4.17: Typical of educational institution at Utapate Field stakeholder communities

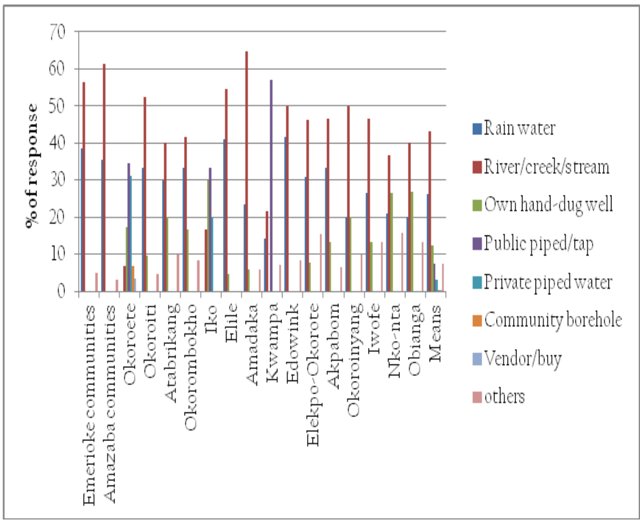
Electricity Supply

Electricity supply in the area is mainly from Power Holding Company of Nigeria (PHCN). Though the electrification could be seen but there has not been regular power supply in the communities. At the time of this fieldwork, there was still no supply of electricity in the project area. Power supply has therefore formed one the expectation of the people. The people currently depend absolutely on generator and for those who can't afford generator uses local lantern and candle light in some homes. Some respondents claim to spend more than N10,000.00 on fueling of their gen set on monthly basis.

Water Supply Facilities

Available data from the Federal Office of Statistics (National Bureau of Statistics) reveals that water in the majority of Southeastern states comes from unsafe supply facilities. These include rivers, lakes or ponds, unprotected wells and boreholes. The Bureau however, classifies available sources of potable water for household use as pipe borne, untreated pipe, borehole, protected well, unprotected well, river/lake/pond, vendor trucks and other categories.

There are pipe borne water facilities at Okoroete, Iko and Kwampa provided by NDDC and Mary Remarkable Foundation. However, the water project, it was said never function since inception except the one provided by Mary Remarkable Foundation which is still functional as at the time of our field visit. The people rely more on rain water, river/stream, hand dug well and sachet water (pure water)/bottle water as source of water supply. However, from the survey analysis 26.1% rely on rain water for source of domestic water, 43.1% depends on rivers/stream, 12.4% uses own hand dug well, 7.3% (public piped/tap), 3.1% (private piped water), 0.4% (community borehole), 0.2% buys from tanker/truck/vendor or private owned borehole owners and 7.4% others (fig. 4.35). However, when compared with Akwa-Ibom State distribution of households by source of water, the use of stream/pond/river/rainwater conform to Utapate Field communities' source of water as mainly river/stream. But contrary to rain water with mere 0.9% as source of water in Akwa-Ibom State generally to the riverine people who depend majorly on rainwater during raining season in the studied communities. National Bureau of Statistics (NBS) data could be correct but could run contrary to the riverine communities' source of water supply.



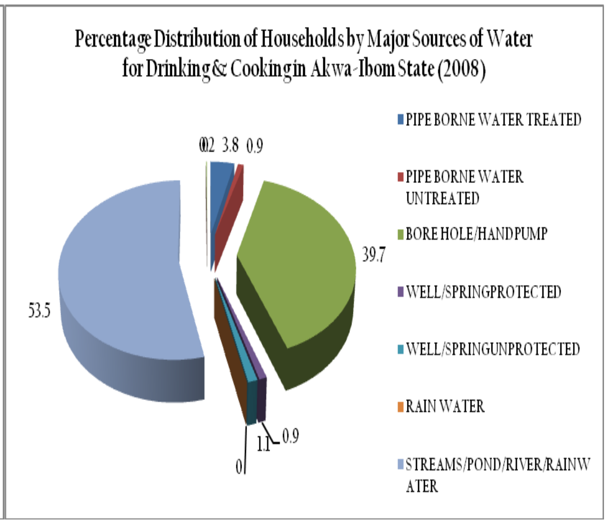


Fig 4.35: Source of water supply; Fig. 4.36: % of Akwa-Ibom State Distribution of Households by Source of Water NBS (2008)

Plate 4.18: Sources of water in Utapate Field stakeholder communities

Recreational Facilities

There are no sources of recreation, meetings and dancing spots for members of Utapate Field of OML13 communities. There are no town halls, no swimming pools and even club/rest houses. Meetings are held at the most eldest person's house and no designated place of meeting in the communities. The primary and secondary school are used for playing of football. No viewing center in the communities, in the case of watching international matches. The communities are in need of recreational facilities.

Communication and Transportation

The Utapate Field stakeholder communities sampled are accessible by land and water. The common transportation means/system consists of motor vehicle, Keke and Okada and paddle canoe and speedboat for the riverine communities. Be that as it may, vehicular traffic in the area could not be described as high. In terms of communication, the area is also accessible by the MTN, Glo and Airtel GSM mobile system, though depending on the network and position, in some area it fluctuates.

Conflicts and Conflict Resolution

Conflict in the area predates the advent of oil and gas exploitation. Most of these conflicts were related to issues of land ownership, possession of palm oil bearing land, quests for autonomy and struggles for leadership. And now are conflicts arising from issues surrounding crude oil exploitation. In the Niger Delta, where oil exploration has been going on since 1960s, causes of conflict has always been between communities and companies which include: Non-recognition of community as stakeholder, oil spillages, border/land disputes, agitation for employment, refusal of companies to repair damaged roads, non-payment of compensation, non-compliance with court rulings and orders, failure to honour MoUs, perceived intimidation of the communities, perceived “divide and rule tactics”, and ineffective communication channels. These conflicts obviously may surface in the area should NPDC/Sterling and communities fails to learn from other oil producing communities.

However, the conflict resolution strategies of communities in the study area are through dialogue in special meetings summoned by the most elderly person and his cabinet. Traditionally, issues are discussed at the lower levels of family, age grade and women or taken directly to the community leadership. In addition, appeals and summons are common processes utilized at community level. Issues are referred to the police and courts, when they are criminal offences that are mandatory to be reported and when the resolution of the conflict overwhelms community leadership. Conflict resolution at community level could attract penalties such as fines, seizures of assets and ostracizing.

Community Expectations and Suggestions to Mitigate & Enhance Socioeconomic Impacts

The primary concerns of the people focused on negative activities during the project development period as well as potential negative impacts on livelihood, health and environment as the project proponent embark on construction and its operational activities. They made suggestions on how best to improve their socio-economic conditions and lessen the negative impacts on their livelihoods. Community members want the project to bring about improvements in employment, education facilities and services, provide good health centres and improve access to health care, and access to potable water in line with their infrastructure needs. The communities are eagerly expecting some benefits; they expect to enter into a GMoU agreement with the company and total adherence with the terms of the contract. Social issues, including employment opportunities for skilled, semi-skilled and unskilled indigenes at various levels as company’s operations commence are expected. They also want economic empowerment of youths and women groups through skills training/acquisition and micro-credit programs; vendor services/minor supplies (contractor), compensation for resource losses, scholarships and provision of infrastructures, e.g., educational, health, electricity, water, among others are expectations of the communities. Pooled responses of these positive expectations put employment opportunities ahead of all expected benefits while a boost in education through awards of scholarships to children and wards, and the provision of primary healthcare facilities were recognized equally by respondents.

4.3.11: Community Health Profile

Community Health Environment and Related Issues

Water Supply Facilities

Increasing access to improved drinking water was part of Millennium Development Goal (MDG) 7 (ensuring environmental sustainability), adopted by Nigeria and other nations globally (United Nations General Assembly, 2002). The goal in Nigeria was for 77% of the country’s residents to have access to an improved drinking water source by 2015 (Federal Republic of Nigeria, 2010a). Nigeria met the MDG target; the proportion of the 2015 population that gained access to water since 1990 amounted to 48% (UNICEF and WHO, 2015). The statistics however, showed that while some 69% have access to improved sources of water, only 2% have piped water on premises, some 21% depend on ‘other’ improved sources while 10% still sources water from ‘’surface water’’ susceptible to contamination. A number of indicators are useful in monitoring household access to improved drinking water. The source of drinking water is an indicator of whether it is suitable for drinking. Sources that are likely to provide water suitable for drinking are identified as improved sources. These include a piped source within the dwelling, yard, or plot; a public tap/stand pipe or a borehole; a protected well or spring; and rainwater (WHO and UNICEF, 2010). Lack of easy access to a water source may limit the quantity of suitable drinking water 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 become contaminated during transport or storage. Especially in such situations, home water treatment can be effective in improving the quality of household drinking water.

According to the Nigerian Demographic Household Survey, 2013, some 61% of the households in Nigeria have access to an improved source of drinking water, with a much higher proportion among urban households (76%) than among rural households (49%). The results show an overall improvement in the quality of sources of water in Nigeria since the 2008 NDHS (when the figure was 56%). This improvement was higher in rural areas (45-49%) than in urban areas (75-76%). The most common source of improved drinking water in Nigeria is tube well or borehole water, used by 44% of urban and 32% of rural households. Thirteen percent of urban households and 10% of rural households have access to drinking water from a protected well. Use of sachet water, which is included under non-improved sources, is common in Nigeria, with 6% of households using it as their main source of drinking water. It is used more in urban areas than in rural areas (12% versus 1%).

In the 2013 NDHS, only 20% of households reported having water on their premises, as compared with 25% in the 2008 NDHS. Households not having water on their premises were asked how long it takes to fetch water. About a quarter of households (24%) travel 30 minutes or longer to obtain their drinking water (20% in urban areas and 28% in rural areas). In the 2013 NDHS, all households also were asked whether they treat their water prior to drinking. An overwhelming majority, 88%, do not treat their drinking water. Urban households (8%) are somewhat more likely than rural households (3%) to use an appropriate treatment method to ensure that their water is safe for drinking. The statistics indicates that many households in some of Nigeria’s states have no access to improved source of drinking water.

More than any other amenity, water facilities are present in most communities across the Niger Delta region but more often than not, water never flows from the facilities for the population (Ojile, 2010). The availability of social infrastructures in the Utapate Field proposed re-entry stakeholder communities, including those of potable drinking water presents a disproportionate access to potable water supplies for the resident population thus a challenge to human health and well-being. The communities with functional water facilities have complaints of inadequate capacity for the population served. Some stakeholder communities have access to potable water supplies, thanks to EU and MPP3 but no identifiable running public water in most of the communities like Atabrikang, Elile, Edowink, Elekpo-Okoroete, Emerioke I & II, Otuenene, Emeriemen, Bethlehem, Isotoyo, Amanglass, Ayama, Ozoubo, Okoroinyang, Obianga, and Engwewe, . The people depend more on private creek/river/stream water.




Plate 4.19: Typical of water source in Utapate Field communities.

Access to sanitation facility

About 50% of community's members do not have a toilet facility within the ideal 50m distance from their houses, even though most of the facilities were of pit toilet, and some excrete directly in the surrounding bush and creeks, a practice that often contaminate surface water, and are not technically considered a toilet facility. The use of these toilet facilities is really a threat to the community member's health as admitted by the respondents since it can contaminate the receiving water body with raw faeces...like one of the respondent asked, 'what will they do', since some of the community members can't afford an ideal toilet facility in their individual household.

Energy for cooking

The use of firewood and charcoal was observed from some members of the community as a source of fuel for domestic cooking as well as the predominant method of roasting plantain (bole) and smoking of ice fish, which is preservation in the community notwithstanding the health implications.

Waste management

Waste generated in the communities was mainly garbage and other domestic wastes. These wastes were usually dumped near residential buildings at the backyard. These wastes can become a source of contamination of the water body yet this is what is commonly practiced in the communities.

Alcohol usage and cigarette smoking

Smoking was common in the communities; a significant number of the young males in the communities are said to smoke cigarette...but an average smoker smoke at most three sticks of cigarette a day. Women in most of the communities rarely smoke cigarette, but female smokers could be found in the communities mostly at night smoking by the commercial sex workers.

Sexual behaviour

Sexual behaviour is directly related to the incidence of sexually transmissible infections and diseases, including HIV/AIDS. The two key behaviours useful in public health action are number of sexual partners and condom use. Majority at the Utapate Field community members claimed to have only one sexual partner while a few admitted to having more than one. The uptake of condoms from the drug stores was used as proxy indicator to measure the behaviour of the people with regards to preventive measures relating to unwanted pregnancies and sexually transmitted infections. Condom uptake was relatively low.

The knowledge of the existence of HIV/AIDS is high in the communities. The methods of STIs transmission (needles, razor blade and sexual contact) is also well known in the communities. The 2003 NDHS reported that 70.6% of female youths in the South-South reported having high risk (unprotected) sex in past one year (higher than the national averages of 29.4%). However, the HIV/AIDS Reproductive Health Survey showed figures for South West females and males to be 69.3% and 68.6% respectively (FMOH, Nigeria 2005). This shows a slight decline but is still higher than the National average of 67% for females and 63% for males from the same report.

This risky sexual behavior increases vulnerability to both STIs and HIV/AIDS. HIV sero-prevalence in Nigeria has not been increasing but the level is still worrisome. The factors that drive increase in HIV/AIDS prevalence such as industrialization, promiscuity; low condom use is prevalent in the study area. The high prevalence rate of HIV/AIDS in an area is sustained by several factors including; project-induced influx of workers who have a higher income level than locals, migration of commercial sex workers due to the economic attraction of workers, risky sexual behaviours, high sexual activities, early sexual exposures.

Housing

The provision of good housing is an important aspect of environmental health. It represents a significant part of man's environment; shelter from the elements; workshop (the kitchen for the housewife, the playroom for the children and tool-shed for the adult males); and home (the residence of the family), where this social institution carries out some of its major functions. Consequently, good housing should minimize physical and biological hazards in the environment, provide a good social environment and promote the health of the inhabitants.

The housing pattern, type and structure within any given community or communities and study area are more often than not, a reflection of the settlement pattern itself. As a consequence, the housing pattern, type and structure within the Utapate Field study communities are a reflection of its generally and predominantly rural environmental setting; old housing stocks are generally intermixed with emergent modern types. The bigger and more populated the community, the better the quality of housing stock with housing patterns depending on the status of a family/compound. Majority of the houses are of the rooming type, with modal walling and roofing materials being constructed of concrete block with corrugated iron sheets (zinc/aluminium) for roofing. A sizeable proportion of the housing stock are also of the wattle and daub (mud-wall) type, some of which have been rendered (plastered with cement) and have both corrugated iron zinc and thatched roofing. Going by responses from administered questionnaires, one could conclude that housing type and quality are generally better in Okorombokho, Okoroete, Iko, Amadaka, Kwampa, Okwanaobolo, Akpabom, Okoromeobolo, Ayama, Amauka, Iwofe, Nkonta, and Obianga.

The quality of housing in the communities measured by the walling, flooring and roofing materials used indicates that majority of the respondents (26.3%) live in houses constructed of concrete block or cement walls and with zinc roofing. Also 21.7% lives in mud with thatch roof, mud houses with zinc roof 37.1%, wood/plank with zinc roof 9.4%, zinc with zinc roof 3.2% and those others houses account to about 2.3% (Plate 4.20) show the variety of housing type in the study area communities.

Plate 4.20: Housing type and quality at Utapate Field stakeholder communities, characteristically rural and with mixed housing stock

The availability of durable consumer goods is a good indicator of a household's socioeconomic status. Furthermore, particular goods have specific benefits. For example, having access to a radio or a television exposes household members to innovative ideas; a refrigerator prolongs food storage; and a means of transport allows greater access to many services away from the local area. As a measure of the overall quality of life apart from incomes and available community-wide basic infrastructures, the proportion of the population with or without the requisite amenities in their dwellings should indicate either a satisfactory situation or otherwise. Valid responses could however, not be gleaned from retrieved questionnaires. Generally, many households could own basic household amenities like telephone (mobile/GSM), electric fan, radio, television and generator especially where facilities to enjoy the amenities, e.g. electricity is readily available. Householders in bigger urban areas are more likely to own household goods than their rural counterparts.

Knowledge of HIV/AIDS

Most respondents during the focus group discussion in the communities have heard of HIV/AIDS but knowing how it's usually contacted was observed to be very low. There is need to carry out awareness campaign to educate members of the communities on HIV/AIDS. There is a need to keep educating the public on the preventive measure of these deadly diseases.

Household Food

Common foods eating by the Utapate Field project communities include garri, plantain, loiloi, rice, and yam. Others eaten at lesser levels include fish, vegetables, beans, milk, eggs and meat. Malnutrition is a major health problem in Nigeria and provides an overall picture of the health status of the population. Children who are malnourished are at a greater risk of falling sick and dying than children who are not malnourished.

Three standard indices of child growth are used to describe nutritional status, Height-For-Age (stunting), Weight-For-Height (wasting) and Weight-For-Age (underweight). To ensure that the results obtained in this study are comparable on an international scale, they are expressed in terms of Z scores. The Z score gives indication in units of standard deviation how far from the reference value a given value lies. The standard used here is based on the National Canter for Health Statistics (NCHS) growth references as recommended by the World Health Organisation (WHO).

An assessment of the nutritional status of 190 children in the surveyed community, aged 0-5 years, was carried out Table 4.48. The indices of malnutrition recorded showed that 26.7% were underweight, 32% were stunted and 13.4% were wasted. A child with a significantly low height-for-age ratio is considered to be stunted or short for his age. This is generally the result of a failure to receive adequate nutrition over an extended period of time and is also affected by recurrent episodes of chronic illness. Children whose Weight-For-Height (W/H) ratio is significantly low are defined as wasted or thin for their age. One in ten surveyed children was classed as wasted. Stunting and wasting are both most severe in the second year of life. This pattern is likely to be due to poor weaning diets (with breast milk offering significant protection in the first year) and infected sources of water resulting in acute illnesses from diarrhoea mainly in the second, third and fourth years of life.

Table 4.48: Weight and height for age of pre-school children in the studied communities

Age (months)	Mean Weight (kg)	Mean Height (m)	Weight for age (Normal range) kg
0 – 11	6.73	0.54	3.5 – 9.4
12 – 23	9.17	0.76	9.5 – 12.4
24 – 35	11.45	0.91	12.5 – 14.4
36 – 47	12.60	0.94	14.5 – 17.4
48 – 60	13.98	1.02	17.5 – 19.4

Mortality Rate

The mortality figures from questionnaire survey are grossly unreliable. The indigenes tend to give exaggerated values when asked about mortality cases may be to lend credence for their demand for more government presence. Inadequate records on mortality rates from the local government level where cases of death are supposed to be registered were also noted. The common causes of mortality in the project area especially in children includes; diarrhoea, malnutrition, malaria, respiratory tract infections, and measles as well as other vaccine preventable diseases. These illnesses were prevalent in the area from the hospital record.

Morbidity Rate

Mortality rates between the ages of 0-5 and maternal mortality rates are said to be low in Utapate Field communities. This was observed during the focus group discussion with the communities. It was said that women dies during pregnancy and childbirth, and that this doesn't happen often but at most once in five years in the communities. The causes of the maternal death that happened in the communities in the last five years according to the respondents are attributed to prolonged labour, and abortion.

Health system

The resident population in the Utapate Field study communities have access to functional primary health care services. Functional and effective public (government health care facilities) primary healthcare (PHC) facilities and services are available at Okorote, the local government headquarter, Okorombokho, Iko, Amadaka, Akpabom and Amauka. There are also private clinics/maternities in the bigger communities like Okorote which have public (government) health establishments including a general hospital and a maternity health centre and 1 private clinics.

Traditional and Herbal Medicine Practices

Traditional medical practice is available in the community. Their practice commonly involved the use of herbs derived from medicinal plants. Several medicinal plants abound in the area. Some of the medicinal plants used in the traditional medical practice in this study area and their uses are given in Table 4.49.

Table 4.49: Common Medicinal Plants and their Uses in the Area

Common/local names	Botanical Names	Medicinal Uses
Pawpaw leaves	Carica papaya	Treatment of malaria
Alligator pepper plant	Afromomum melegueta	Galactogogue, purgative, sore throat, malaria, used by herbalists for consulting their oracles
Lemon orange	Citrus aurantium	Abdominal upset, and as a base for other herbs in treatment of malaria
Cashew fruit, leaf and bark	Anarcadium occidentale	Treatment of diarrhoea and menstrual problems
Mango leaves and bark	Mangifera indica	Treatment of malaria
Banana plant	Musa spp	Treatment of fever
Guava tree leaves and bark	Psidium guajava	Treatment of malaria, diarrhoea and menstrual disorders

5 CHAPTER

CHAPTER FIVE

ASSOCIATED POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Introduction

There are a number of approaches for the prediction and evaluation of impacts. The ISO 14001 method is simple to apply and provides a high level of detail and also relies on limited data, unlike the other methods that require the availability of large historical data. The ISO 14001 method, therefore, is selected for the identification and evaluation of impacts for the proposed Utapate Field Development Project.

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5.2 Impact Identification and Evaluation

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:

- Impact identification
- Impact qualification
- Impact rating
- Impact description

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 potential impacts during the different phases of the project are listed in Table 5.1.

Table 5.1: Identified Project Impacts in Utapate Field Development Project

Impacts	Project Phases			
	Pre-Construction	Construction	Operation/ Maintenance	ning /Abandonme
Acceleration of erosion	√	√		
Acidification of soil and water		√		
Alteration of local hydrology and drainage patterns		√		
Alteration of local topography				
Alteration of natural drainage pattern	√	√		
Alteration of river bed bathymetry		√		
Alteration of soil profile		√		
Availability of fuel wood	√			
Blockage of waterways		√		
Burns/ injuries from welding sparks		√		√
Change in local topography		√		
Contamination of groundwater	√	√	√	√
Contamination of soil and water from rust accumulation				
Contamination of surface water/ soil and sediment	√	√	√	√
Damage to archaeological artifacts		√		
Destruction of assets and properties from oil spill/fire.			√	√
Destruction of subsurface infrastructure		√		
Disruption of fisheries activities	√	√		√
Disturbance of spawning ground for fish and shrimps				
Encroachment on culturally sensitive sites	√			
Exposure of workers to wildlife attack	√	√		√
Habitat fragmentation	√			
Impact on fisheries from pipeline breach and oil spillage			√	√
Impairment of air quality	√	√	√	√
Improved health status/quality of life	√	√	√	√
Incidence arising from accidental contact with power cables		√		√

Impacts	Project Phases			
	Pre-Construction	Construction	Operation/ Maintenance	ning /Abandonme
and other underground infrastructure				
Increase in access for poaching and illegal lumbering				
Increase in incidence of STI's including HIV		√		
Increase in noise and vibration levels	√	√		√
Increase in social vices	√	√		√
Increase in surface water turbidity	√	√		√
Increased opportunity for business and employment	√	√	√	√
Influx of migrant workers and camp-followers				
Injuries and death from blowouts				
Injuries and deaths	√	√		√
Injuries/fatality of workforce	√	√	√	√
Interference with water transport	√	√		√
Legacy issues	√			
Loss of biodiversity				
Loss of employment/ income				√
Loss of wildlife habitat	√			
Mental stress and illness	√			√
Opportunities for business and employment		√		
Opportunity for income generation	√	√	√	√
Pirate attacks and kidnappings	√	√	√	√
Pollution from drill cuttings and mud		√		
Protein-Energy Malnutrition	√	√		
Radiation burns from radioactive emissions		√		
Reduction of access to land and its resources	√			
Sexually transmitted infections including HIV/AIDS	√	√		
Smothering of flora and fauna by dredge spoils		√		
Surface water contamination	√	√	√	√

Impacts	Project Phases			
	Pre- Construction	Construction	Operation/ Maintenance	ning /Abandonme
Temporary blockage of waterways				
Third party agitations	√	√	√	√
Visual impairment from high intensity welding flash		√		√
Waste generation	√	√	√	√
Water traffic accidents	√	√	√	√
Work site accidents	√	√	√	√

5.2.2 Impact Qualification

The identified impacts of the project were qualified based on the following four criteria:

- Positive or Negative
- Short-term or long-term
- Reversible or Irreversible
- Direct or indirect

Negative impacts are those that impact negatively on the biophysical, health, and social environments, while positive impacts are those which enhance the quality of the environment. For this study, short term means a period of time less than 3 months while any period greater than three months is considered long term. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated.

The outcome of the qualification of the identified impacts is shown in Tables 5.7a-5.7c.

5.2.3 Impact Rating

This stage involves evaluation of the impact to determine whether or not it is significant. The quantification scale of 0, 1, 3 and 5 was used. The ratings are as described below and are adapted from The International Organization for Standardization ISO 14001–

Environmental Management System Approach. The criteria and weighting scale used in evaluating significance are as follows:

- Legal/regulatory requirements (L)
- Risk factor (R)
- Frequency of occurrence of impact (F)
- Importance of impact on an affected environmental components (I), and
- Public perception/interest (P).

5.2.3.1 Legal /Regulatory Requirements (L)

This asks the question 'is there a legal/regulatory requirement or a permit required?' The scoring is as follows:

0= There is no legal/regulatory requirement

3= There is legal/regulatory requirement

5= There is a legal/regulatory requirement and permit required

The legal/regulatory requirements were identified based on national laws/guidelines/standards (FMenv and DPR) relating to the project activity.

5.2.3.2 Risk (R)

This uses a matrix based on the interaction of the probability of occurrence of the impact (Table 6.2) against consequences (Table 5.3). The matrix (Figure 5.1) is referred to as the Risk Assessment Matrix (RAM). Five probability categories are interacted against four groups of consequences. The resultant outcomes are given scores with colour-coding. High-risk categories are red; intermediate risks, yellow and low risks, green as follows:

1=Low risk (green)

3=Intermediate risk (yellow)

5=High risk (red)

Table 5.2: Probability of Occurrence

Probability Category	Definition
A	Possibility of Repeated Incidents
B	Possibility of Isolated Incidents
C	Possibility of Occurring Sometime
D	Not Likely to Occur
E	Practically Impossible

Table 5.3: Consequence Categories

Consequence Category	Considerations			
	Safety / Health	Public Disruption	Environmental Aspects	Financial Implications
I	Fatalities / Serious Impact on Public	Large Community	Major/Extended Duration/Full Scale Response	High
II	Serious Injury to Personnel / Limited Impact on Public	Small Community	Serious / Significant Resource Commitment	Medium
III	Medical Treatment for Personnel / No Impact on Public	Minor	Moderate / Limited Response of Short Duration	Low
IV	Minor Impact on Personnel	Minimal to None	Minor / Little or No Response Needed	None

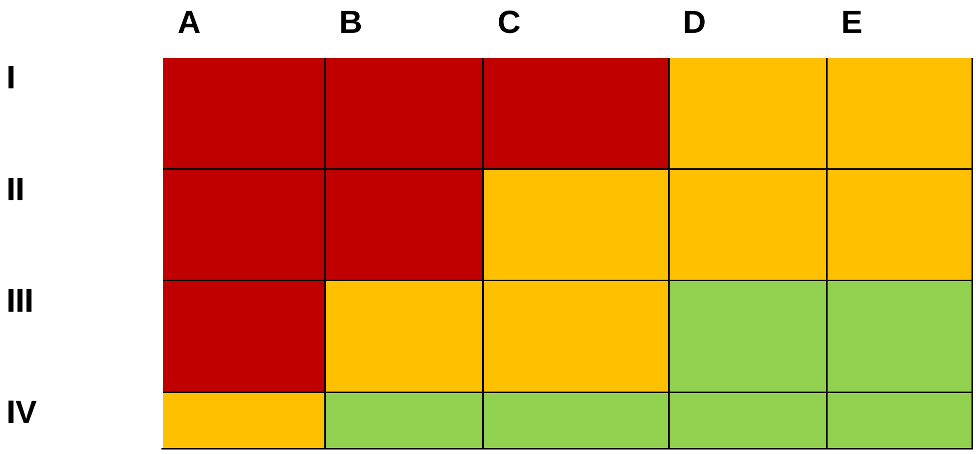

Figure 5.1: Risk Assessment Matrix

5.2.3.3 Frequency of Impact (F)

Frequency of impact refers to the number of occurrence of impact. The frequency of impact was determined using historical records of occurrence of impacts, and consultation with experts and local communities. The criteria for rating the frequency of impacts are outlined in Table 5.4.

Table 5.4: Frequency Rating and Criteria

Frequency	**Rating**	**Criteria**
High	5	Very likely to happen throughout the project lifespan
Medium	3	Likely to happen ≥ 5 years
Low	1	Rare, not likely to happen within project lifespan

5.2.3.4 Importance of Affected Environmental Component and Impact (I)

The importance of the affected environmental components was determined through consultation and consensus of opinions. This was also further facilitated by information on experiences on the impacts of already existing facilities in the proposed project area. The rating of the importance of impacts is shown in Table 5.5.

Table 5.5: Importance Criteria

Importance	Rating	Criteria
High	5	• Highly undesirable outcome (e.g., impairment of endangered, protected habitat, species) • Detrimental, extended animal behavioural change (breeding, spawning, moulting) • Major reduction or disruption in value, function or service of impacted valued ecosystem resource • Impact during environmentally sensitive period • Continuous non-compliance with existing statutes
Medium	3	• Negative outcome • Measurable reduction or disruption in value, function or service of impacted resource • Potential for non-compliance
Low	1	• Imperceptible outcome • Insignificant alteration in value, function or service of impacted resource • Within compliance, no controls required

5.2.3.5 Public Perception (P)

The consensus of opinions among the project stakeholders was used to determine the public perception on the potential impacts and the following criteria were applied (Table 5.6):

Table 5.6: Public Perception Criteria

Public Perception	Rating	Criteria
High	5	• Elevated incremental risk to human health, acute and/or chronic • Possibility of life endangerment for residents, abutting communities • Major reduction in social, cultural, economic value

		• Continuous non-compliance with statute • Any major public concern among population in study area
Medium	3	• Limited incremental risk to human health, acute and/or chronic • Unlikely life endangerment for residents, abutting communities • Some reduction in social, cultural, economic value • Possibility of adverse perception among population • Potential for non-compliance
Low	1	• No risk to human health, acute and/or chronic • No possibility of life endangerment for residents, associated communities • Minor reduction in social, cultural, economic values • Unlikely adverse perception among population

The combination of the five impact rating weights forms the basis for judging the level of significance of each impact. A matrix displaying the combination based on the ISO 14001 tool is shown in Figure 5.2.

Impact value	**Cut off values**	**Impact Rating**
L+R+F+I+P	≥15	**High**
F + I	>6	
P	= 5	
L+R+F+I+P	≥8 but <15	**Medium**
L+R+F+I+P	<8	**Low**
Positive		**Positive**

Figure 5.2: Impact Value and Rating Colour Code

The final ratings of the identified impacts are presented in Tables 5.7a-5.7c. In this report, medium and high significant negative impacts were judged to require mitigation, and all positive impacts required enhancement.

Table 5.7a Potential and Associated Impacts of Proposed Utapate Field Development Project(Pre-Drilling and Pre-Construction Phases)

Project Activity	Description of Impact	Impact Qualification: Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	Impact Quantification: R	F	I	P	Total	F+I	Impact Rating
Pre-Drilling Phase																	
Land acquisition and survey	Reduction of access to land and its resources		√	√			√	√		3	5	3	3	5	19	6	H
	Third party agitations		√		√		√	√		3	5	5	5	5	23	10	H
	Legacy issues		√		√		√	√		3	5	5	5	5	23	10	H
	Exposure of workers to wildlife attack		√	√			√	√	√	0	5	1	1	1	9	2	M
	Opportunity for income generation	√			√	√		√		-	-	-	-	-	-	-	P
	Improved health status/quality of life	√			√	√		√		-	-	-	-	-	-	-	P
Mobilization of equipment	Interference with water transport		√	√		√		√		5	3	1	1	3	13	2	M
	Impairment of air quality		√	√		√		√		3	1	1	5	5	15	6	H

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
& personnel to site	Increase in noise vibration/levels		√	√			√	√		3	1	3	1	3	11	4	M
	Surface water contamination		√	√		√		√		3	1	1	1	1	7	4	L
	Water traffic accidents		√	√		√	√	√	√	3	5	3	5	5	21	8	H
	Disruption of fishing activity		√	√		√		√		3	3	3	3	5	17	6	H
	Pirate attacks and kidnappings		√		√	√	√		√	3	5	3	5	5	21	8	H
	Increase in incidence of STI's									0	3	3	5	5	16	8	H
Site Preparation (vegetation clearing)	Habitat Fragmentation		√	√		√		√		0	3	3	1	1	8	4	L
	Loss of biodiversity		√	√		√		√		3	1	3	1	1	9	4	M
	impairment of air quality		√	√		√		√		3	1	3	3	3	13	6	M
	Acceleration of erosion		√	√			√		√	0	1	1	1	1	4	2	L
	Work site accidents.		√	√		√		√		3	1	1	3	1	9		M
	Influx of migrant workers and camp-followers		√	√		√			√	0	3	3	1	1	8	4	M
	Increase in access for poaching and illegal lumbering		√	√			√		√	0	1	1	3	1	6	4	L
	Increase in social vices		√	√			√	√	√	3	3	3	3	5	17	6	H

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Increased opportunity for business and employment.	√		√		√		√		-	-	-	-	-	-		P
	Availability of fuel wood	√		√		√		√		-	-	-	-	-	-		P
	Smothering of flora and fauna by dredge spoils		√	√		√		√		0	3	1	1	1	6	2	L
	Alteration of local topography									0	1	1	1	1	4	2	L
Dredging	Increased in surface water turbidity		√	√		√		√		3	3	3	3	5	17	6	H
	Exposure of workers to wildlife attack		√	√		√		√		3	5	1	3	3	15	4	H
	Acidification of soil and water		√	√		√		√		0	3	3	3	3	12	6	M
	Interference with water transport		√	√		√		√		3	3	3	3	3	15	5	H
	Disruption of fishing activities		√	√		√		√		3	3	3	3	5	17	6	H
	Alteration of local hydrology and drainage patterns		√	√		√		√		1	1	1	1	3	7	4	L
Drilling rig movement to	Interference with water transport		√	√		√		√		5	3	3	3	3	17	6	H
	Impairment of air quality		√	√		√		√		3	1	1	1	1	7	2	L

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
site	Increase in noise and vibration levels		√	√			√	√		3	1	1	1	1	7	2	L
	Surface water Contamination		√	√		√		√		3	3	1	1	1	9	2	M
	Disturbance of spawning ground for fish and shrimps		√	√		√		√		0	1	1	1	1	4	2	L
	Pirate attacks and kidnappings		√		√	√	√		√	0	5	3	5	5	18	8	H

Table 5.7b Potential and Associated Impacts of Proposed Utapate Field Development Project(Drilling and Construction Phases)

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
Drilling Phase																	
Drilling of	Injuries and death from blowouts		√	√		√			√	3	3	1	3	3	13	6	M

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
proposed well	Opportunities for business and employment	√		√		√		√									P
	Increase in social vices		√	√		√		√		0	5	5	3	3	16	6	H
	Third party agitation		√	√			√	√		0	3	3	3	3	12	6	M
	Contamination of surface water/ soil and sediment		√	√		√		√		3	3	3	3	3	15	6	H
	Impairment of air quality		√	√		√		√		3	3	3	3	3	15	6	H
	Increase in noise and vibration levels		√	√			√	√		3	3	1	1	1	9	2	M
	Contamination of groundwater		√	√			√	√		3	3	1	1	1	9	2	M
	Pollution from drill waste (drill cutting and mud)		√	√		√		√		3	3	3	3	3	15	6	H
Flowline Construction Phase																	
Excavation of flowline route	Damage to archeological artefacts		√	√			√		√	3	1	1	1	1	7	2	L
	Change in the local topography		√	√		√		√		0	1	1	1	1	4	2	L
	Increase in turbidity of surface		√	√		√		√		3	3	3	3	5	17	6	H

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
	water																
	Alteration of local hydrology and drainage patterns		√	√		√		√		0	1	3	1	1	6	4	L
	Acceleration of erosion		√	√			√	√		0	1	3	1	1	6	4	L
	Increase in noise and vibration levels		√	√		√		√		3	3	3	3	3	15	6	M
	Interference with water transport		√	√		√		√		3	3	3	3	3	15	6	M
	Alteration of soil profile		√	√			√		√	0	1	3	1	1	6	4	L
	Impairment of air quality		√	√		√		√		3	1	3	1	1	9	4	M
	Destruction of subsurface infrastructure		√	√		√		√		0	1	1	1	1	4	2	L
	Alteration of river bed bathymetry		√	√			√	√		0	1	3	1	1	6	4	L
Flowline welding/ stringing	Visual impairment from high intensity welding flash		√	√		√		√		0	3	3	3	1	10	6	M
	Burns/ injuries from welding sparks		√	√		√		√	√	3	1	1	3	3	11	4	M
NDT	Radiation burns from radioactive		√	√			√		√	5	5	3	5	5	23	8	H

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
	emissions																
Laying of flowline	Temporary Blockage of waterways		√	√		√		√		5	3	3	3	3	17	6	H
Backfilling	Increase in surface water turbidity		√	√		√		√		3	3	3	3	3	15	6	H
	Disruption of fisheries activities		√	√		√		√		0	1	3	3	3	10	6	M
	Impairment of air quality		√	√		√		√		3	5	3	3	3	17	6	H
	Increase in noise and vibration levels		√	√		√		√		3	1	3	3	3	13	6	M
	Alteration of soil profile/river bathymetry		√	√			√		√	0	3	1	1	1	6	2	L
Cathodic protection	Contamination of soil and water from rust accumulation		√	√		√		√		3	3	1	1	1	9	2	M

Table 5.7c Potential and Associated Impacts of Proposed Utapate Field Development Project(Operation/Maintenance Phases)

Project Activity	**Description of Impact**	**Impact Qualification**									**Impact Quantification**						
		Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Rating**
Operation/ Maintenance of flow line	Air contamination due to gas leakage		√	√		√		√		0	1	1	3	3	8	4	M
	Increased revenue generation for NPDC and Nigerian Government	√		√			√		√	-	-	-	-	-	-	-	P
	Injury/fatality of workforce		√	√	√	√	√	√	√	3	1	1	1	1	7	2	M
	Business opportunities/economic enhancement	√		√	√	√	√		√	-	-	-	-	-	-	-	P
	Surface/ground water contamination		√	√		√	√	√		3	1	1	3	1	9	4	M

Table 5.7d Potential and Associated Impacts of Proposed Utapate Field Development Project(Decommissioning/Abandonment Phases)

Project Activity	Description of Impact	Impact Qualification								L	Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
Movement of personnel and equipment from site	Interference with water transport		√	√		√	√	√	√	5	3	1	1	3	13	2	M
	Impairment of air quality		√	√		√		√		3	1	1	5	5	15	6	H
	Increase noise and vibration levels		√	√		√		√		3	1	3	1	3	11	4	M
	Surface water contamination		√	√		√		√		3	3	3	1	3	13	4	M
	Water traffic accidents		√	√		√		√		5	3	1	5	3	17	6	H
	Disruption of fishing activity		√	√		√		√		3	3	3	3	5	17	6	H
	Pirate attacks and kidnappings	√		√		√		√		3	5	3	5	5	21	8	H
	Increase in incidence of STI's		√	√		√		√		0	3	3	5	5	16	8	H
	Disturbance of spawning ground for fish and shrimps		√		√	√	√		√	0	3	3	3	3	12	6	H
Dismantling and Site	Increase in surface water turbidity		√	√		√		√		3	3	3	5	5	19	8	H
	Disruption of fisheries activities		√	√		√		√		3	3	3	5	5	19	8	H

Project Activity	Description of Impact	Impact Qualification									Impact Quantification						
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Rating
Clean-Up	Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
	Increase in noise and vibration level		√	√		√		√		3	3	3	5	5	19	8	H
	Contamination of surface water/ soil and sediment		√	√		√		√		3	3	3	5	5	19	8	H
	Increased opportunity for business and employment.	√		√		√		√		-	-	-	-	-	-	-	P
	Third party agitation		√	√		√		√		3	3	5	5	5	21	10	H
	Loss of employment/ income		√	√		√		√		3	1	5	5	5	19	10	H
Rehabilitation of site	Employment and income generating opportunity	√		√		√		√		-	-	-	-	-	-	-	P
	Restoration of aesthetic value of the environment	√		√		√		√		-	-	-	-	-	-	-	P

5.3 Description of Impacts

The major and moderate negative impacts for the project are described below:

5.3.1 Mobilization Phase

5.3.1.1 Mobilization of equipment and personnel to site

Interference with water transport

The equipment and personnel will be transported by road and water during mobilization. The Iko Rivers will provide access route for most of the marine movement. Waterways are important means of transportation for all the settlements in the project area. There is high likelihood that when moving these equipment and personnel along these waterways, the transport activities of the community could be disrupted and this could have impact on the socio-economic activities of the community.

Impairment of air quality by emissions of air pollutants including GHG

Barges are known to produce obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2). These pollutants, which are air toxic are known to degrade air quality. Since barges and other marine vessels would be moving both equipment and personnel, much concentration of these gases would be released into the air and this will possibly have high impact on the environment. This impact was rated high

Increase in noise/vibration levels

Increased water craft activities that would occur during the mobilization of equipment and personnel could likely lead to increased noise level above the ambient level. This could have some short term impact on people living along the coast. Also, the noise and vibration would adversely affect the fishes and other sound sensitive animals. In this report the impact is rated medium.

Surface water contamination

Surface water contamination resulting from accidental spill of fuel from marine vessels is considered to have high probability of occurrence on the premise that the movement would involve the use of water crafts, which could release refined products especially diesel and lube oil into the river. This could have considerable impact on the aquatic flora and fauna, and even the source of drinking water of the locals. It is rated medium.

Water traffic accidents

Private operators of water crafts rarely keep to the regulation regarding maritime safety. These routes are also used by the locals for intra-community transport. They are however, mostly used by companies. There still remains the possibility of traffic accidents involving NPDC boats alone or NPDC and third party boats during mobilization.

Disruption of fishing activities

Fishing activities could be disrupted during the mobilization of personnel, materials and equipment to project site. Along the Iko Rivers, there are many fishing camps where fisher folks live and engage extensively in fishing activities. Moving these equipment and personnel along these waterways would likely result in the destruction of fishing activities. Fisheries activities that could be disrupted include trap setting, fishing gears, disturbance of water causing the migration of fish, thereby affecting the fish catch per effort. The impact this might cause to the socio-economic livelihood of the fisher folks is therefore rated high.

Pirate attacks and kidnappings

Attacks by pirates and armed bandits and kidnappings are among the major security concerns in the Niger Delta especially in the coastal communities. During movements like this mobilization involving large materials and personnel both company and contractor asset and personnel may be victim. The impact is therefore rated high.

5.3.1.2 Land acquisition and survey

Reduction of access to the acquired land and its resources

About 1,987m^2 of land would be taken for the entire project. This size of land once acquired by the project proponents will become inaccessible to the locals. These lands are currently used as fishing grounds and for mangrove resources.

Third party agitation

Third party agitation is common during the land take in the Niger Delta. Land acquisition by Oil Company arouses interest and sometimes negative publicity among the people which may result in serious agitation. This impact is rated high. There is usually community agitations over compensations paid for acquired land in the Niger Delta. All these may arise in the course of this project execution.

Legacy issues

Unfulfilled promises to host communities commonly referred as legacy issues, is a common source of conflict with host communities. Oil bearing communities in the Niger Delta usually accuse oil companies of not abiding by the terms agreed upon during negotiation for land take. It is a recurrent issue even when land has been legally acquired from the communities. Therefore, given limited land and its sensitive nature in the region, similar issues in the project communities will have high impact.

Opportunity for income generation

Monetary compensation shall be paid for every land acquired for this project. This is an opportunity for communities to enhance their income. This is a windfall income and there are chances that the money will be used for other income generating ventures.

5.3.1.3 Site Preparation (Vegetation Clearing)

Loss of biodiversity

When there is disturbance on the natural habitat due to human activity, there is likelihood that some flora and fauna would be destroyed. Site clearing will lead to loss of species diversity and abundance, including soil organisms, fungi, invertebrates, bacteria etc. It will also lead to loss of food sources, fauna habitat, breeding grounds and nesting sites. The mangrove species present in the area, mostly *Rhizophora racemosa* and *Rhizophora mangle,* will be lost during the project lifetime. Some of these losses are irreversible.

Exposure of workers to wildlife attack

The mangrove/rain forest such as found in part of the project area is known to provide habitat for dangerous animals like snakes, scorpions and bees etc. Some dangerous snakes such as black cobra, spitting cobra and green mamba have been reported in the area. Field workers engaged in vegetation clearing could be exposed to attack by these animals. These attacks could result in injuries, poisoning or even death. The impact is therefore rated medium.

Impairment of air quality

Swamp buggies and other heavy equipment that will be used in vegetation clearing are known to be the mobile sources of obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2). These pollutants, which are air toxics are known to degrade air quality.

Encroachment on and damage to culturally sensitive sites

Land clearing of the acquired land may encroach on culturally sensitive sites. Okpukpo, Ngalage and Ukan are deities in the project area with shrines scattered in the communities. There is a possibility that the flowline route or the well site clearing could lead to the destruction of the shrines.

Work site accidents

The frequency and incidence of occupational hazards rise with increasing use of machines. Site clearing is typically done using both heavy and light equipment such as dredgers, swamp buggies, bulldozers etc. In the process of the clearing there could be injuries and possibly fatalities among the workforce. This could constitute source of legal and financial claims.

Influx of migrant workers and camp-followers

The need to earn income is a driving force behind upsurge of migrant workers and camp-followers at worksites. The increasing number of skilled and unskilled labour is a common phenomenon in such situation. This will create situation of high population density and in this case it is rated medium. Specifically, pressure on existing infrastructure such as health care, housing, recreational and other social amenities could arise due to increased migration of workers, potential workers and camp followers to project locations. Most communities in the swamp has few or no social infrastructure, hence the migration of large number of people to the area during construction could over stretch the few available social facilities within the communities.

Increased opportunity for business and employment

Both skilled and unskilled labour would be hired to carry out site preparation and by this some youths would be gainfully employed. In compliance with NPDC local content policy, this could create opportunity for employment, contracting and increase in income for the communities. Also, with the influx of people to the project sites, many women and youths would be involved in petty trading and service rendering to the field workers. This is beneficial to the community.

Availability of fuel wood

Rain forest and mangrove trees are source of fuel wood in the project area but it is always difficult for the women to gather them. Site clearing for the project will generate fuel wood which the women in the communities could avail themselves of. One of the positive impacts of site preparation is therefore, the availability of wood for cooking fuel and other uses.

5.3.1.4 Site Preparation (Dredging)

Increased in surface turbidity

River bed sediments could be disturbed during dredging, which could cause increase in turbidity. Host communities are becoming aware of the impacts of increased turbidity on fishing and other water use activities. This impact is therefore rated as high.

Acidification of soil and water

Exposure of mangrove soil and sediments during site preparation could lead to oxidation of pyrites causing acidification. The acidification of the swamp could cause several environmental impacts including vegetation dieback, destruction of fisheries, and corrosion of oil and gas installation. The impact is rated medium.

Interference to water way transport

There is high likelihood that dredging during site preparation could have impact on the socio-economic activities of the communities. It could cause temporary disruption of water way transport. It is rated medium.

Disruption of fishing activities

Fishing activities could be disrupted when the water ways are dredged. Dredging may result to the migration of fish, thereby affecting the fish catch per effort. The effect this could have on the socio-economic livelihood of the fisher folks is significant and therefore impact is rated high.

Local hydrological impacts with possible death of mangrove

Dredging and sand filling within the project area could lead to alteration in the local topography and hence hydrology of the area leading to deaths of plants. Loss of mangrove has become a global sensitive issue hence the impact is rated medium

5.3.2 Drilling Phase

5.3.2.1 Drilling of proposed well

Injuries and death from blowouts

System failures and human error during the drilling of the proposed wells could results in blowouts, which could cause serious fatalities/injuries to the personnel and oil spills to the environment. It is however a rare occurrence in the oil and gas industry in Nigeria.

Contamination from drill Waste

Water based mud cuttings and psuedo-oil based mud cuttings will be processed with solids control equipment to reduce mud on cuttings. If the volume of drill waste is not handled properly, it could constitute a significant contamination of the environment.

Opportunities for business and employment

Drilling of the proposed wells would require recruitment of field labour. These labour are usually natives of the project area. Also, with the influx of people to the project sites, many people from the communities would be involved in petty trading and provision of services to the field workers. This is beneficial to the community.

Increase in social vices

The increase in population and earnings arising from project execution could lead to social vices like violence, alcoholism, attraction of Commercial Sex Workers (CSW), substance abuse, teenage pregnancies etc. This could in turn lead to increase in sexually transmissible diseases (HIV/AIDS, syphilis, etc).

Contamination of soil and surface and subsurface waters

Surface water contamination resulting from accidental spill from oil well is considered to have probability of occurrence. Pits must have an impermeable lining and be large enough to contain all fluids. In spite of these precautions, accidental leaking and overflow can occurred. This would have considerable impact on the aquatic flora and fauna, and even the source of drinking water of the locals could be polluted. During drilling the infiltration of the drilling mud into the aquifer may cause degradation of the ground water quality.

Impairment of air quality

Drilling rig are mobile sources of obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2). These pollutants, which are air toxics are known to degrade air quality, thus the impact is rated high.

Increase noise level/vibration

Drilling rigs produce sounds that can lead to increased noise level above the ambient level. This could have some short-term impact on people living along the project site. Also, the noise and vibration could adversely affect the fishes and other sound sensitive animals.

5.3.3 Flowline Construction Phase

5.3.3.1 Excavation of flowline route

Increase in turbidity of surface water

Trenching by bucket dredger could cause the loosening of the sediments in the water bringing a huge amount of materials into suspension. The suspended materials could thus increase the turbidity of the water over a stretch of the river. The increased turbidity can cause potential problems for both aquatic flora, which depend on light transmission through the water column for growth, and fauna which feed on the submerged vegetation. It can also smother and suffocate benthic communities.

Increase noise and vibration levels

Heavy machines used during trenching for the laying of flow lines produce sounds that can lead to increased noise above the ambient level. This could have some short term impact on people living within the project area of influence. The degree to which noise can impact the human environment ranges from levels that interfere with speech and sleep (annoyance and nuisance) to levels that cause adverse health effects (hearing loss and psychological effects). Also, the noise and vibration could adversely affect the fishes and other sound sensitive animals. Ground-borne vibration levels rarely affect human health. High levels of ground-borne vibration may damage some of the fragile buildings or interfere with equipment that is highly sensitive to ground-borne vibration.

Impairment of air quality

Heavy equipment used to carry out trenching and laying of the flow lines is known to be the mobile sources of obnoxious gas that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2). These pollutants, which are air toxics are known to degrade air quality.

5.3.3.2 Flow line welding/stringing

Burns/ injuries from welding sparks

Welding sparks are potential source of injuries to work force. In the process of flow line welding and stringing there could be injuries among the workforce if adequate safety precautions are not adhered to.

5.3.3.3 Non Destructive Testing

Radiation burns from radioactive emissions

The integrity of the welded pipeline joint will be checked visually and by 100% radiography. Radioactive materials emitted during radiography could affect the health of the welders/radiographers especially in the long run with a possibility of genetic mutations. The impact is rated high

5.3.3.4 Laying of flow line

Temporary Blockage of waterways

The whole length of the flow line would be welded on land and then pulled into the excavated area as one piece. This activity could temporarily lead to blockage of the waterways to other users. Considering the magnitude of socio-economic disruption that the blockage might cause the other users, the associated impact is rated high.

5.3.3.5 Backfilling

Increase in surface water turbidity

The backfilling of excavated area in the water using the dredged spoil materials could increase the turbidity of the river.

Disruption of fishing activities

Fishing activities could be disrupted during backfilling. Fishing activities that could be disrupted include trap setting, destruction of fishing gears, disturbance of water causing the migration of fish, thereby affecting the fish catch per effort.

Impairment of air quality

Reduction in air quality could arise as a result of the continued operation of heavy duty construction equipment, and dust from backfilling activities.

Noise nuisance from machinery

Noise arising from the use of heavy equipment for backfilling such as dredgers, swamp buggies, bulldozers, excavators etc could affect the workers, host communities and scare wildlife.

5.3.3.6 Cathodic protection

Contamination of soil and water from rust concentration

Anodic corrosion as a result of cathodic protection could lead to release of heavy metals into the soil and water environment. It is rated medium

5.3.4 Operation/Maintenance Phase

Air contamination due to gas leakage

Gas leakage due to corrosion or sabotage has potential to contaminate the air and this will possibly have high impact on the environment. This impact was rated medium.

Increased revenue generation for NPDC/PARTNERS and Nigerian Government

The additional gas shall be exported and the proceeds shall add to NPDC*/PARTNERS* and the government income in accordance with the JV agreement.

Surface/ground water contamination

Condensate spill could cause the pollution of surface water and/or percolate through the soil profile over a period of time and pollute the groundwater. In addition, the hydrological flow and dynamics of groundwater could cause the pollutants to be widespread. This is impact is considered to be moderate.

Injury/fatality of workforce

There is the potential for work related injuries/fatalities (drowning, well blowout etc) during surveillance and well head/pipeline maintenance works. The severity of the injury would be dependent on the type and duration of impact and the resultant effect on the individual. Additionally, major work related accidents could also affect community members.

Business opportunities/economic enhancement

Part of the strategy to safeguard the gas supply is to maintain surveillance over the pipeline. This surveillance shall be provided by the communities. This is beneficial to the communities.

5.3.5 Demobilization Phase

5.3.5.1 Dismantling and Site Clean Up

Decommissioning phase would be after 35 years when the entire well and flowline design life would have expired.

Loss of job opportunity

The end of the project will bring about loss of job for the project workers. This will translate to loss in income and business opportunities.

Interference with water transport

The equipment and personnel will be transported by road and water during mobilization. The Iko and Ibom Rivers will provide access route for most of the marine movement. Waterways are important means of transportation for all the settlements in the project area. There is high likelihood that when moving these equipment and personnel along these waterways, the transport activities of the communities could be disrupted and this could have impact on the socio-economic activities of the communities.

Impairment of air quality

Marine vessels barges are known to produce obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2). These pollutants, which are air toxic are known to degrade air quality. Since barges and other marine vessels would be moving both equipment and personnel, much concentration of these gases would be released into the air and this will possibly have high impact on the environment. This impact was rated high

Increase in noise and vibration levels

Increased water craft activities that would occur during the decommissioning of equipment and personnel could likely lead to increased noise level above the ambient level. This could have some short term impact on people living along the coast. Also, the noise and vibration would adversely affect the fishes and other sound sensitive animals. In this report the impact is rated medium.

Surface water contamination

Surface water contamination resulting from accidental spill of fuel from marine vessels is considered to have high probability of occurrence on the premise that the movement would involve the use of water crafts, which could release refined products especially diesel and lube oil into the river. This could have considerable impact on the aquatic flora and fauna, and even the source of drinking water of the locals. It is rated medium.

Water traffic accidents

Private operators of water crafts rarely keep to the regulation regarding maritime safety. These routes are also used by the locals for intra-community transport. They are however, mostly used by companies. There still remains the possibility of traffic accidents involving NPDC boats alone or NPDC and third party boats during mobilization.

Disruption of fishing activities

Fishing activities could be disrupted during the mobilization of personnel, materials and equipment to project site. Along the Iko and Ibom Rivers, there are many fishing ports where fisher folks live and engage extensively in fishing activities. Moving these equipment and personnel along these waterways would likely result in the destruction of fishing activities. This movement will take place in phase and the impact will be prolonged. Fisheries activities that could be disrupted include trap setting, fishing gears, disturbance of water causing the migration of fish, thereby affecting the fish catch per effort. The impact this might cause to the socio-economic livelihood of the fisher folks is therefore rated high.

Pirate attacks and kidnappings

Attacks by pirates and armed bandits and kidnappings are among the major security concerns in the Niger Delta especially in the coastal communities. After decommissioning, the personnel and equipment will be evacuated from the site. This is usually the time pirates and militants always want to have the last sloth and this increases the risk.

5.3.5.2 Rehabilitation

Employment and income generating opportunity

Site rehabilitation could demand for employment of labour (both skilled and unskilled). Payments for such labour are a good source of income to persons who might be employed.

Restoration of aesthetic value of the environment

Proper restoration of the environment through maintenance and management would improve the aesthetic value of the environment.

6 CHAPTER

CHAPTER SIX
MITIGATION

6.1 Introduction

The actions and measures that NPDC intend to take to reduce (or eliminate) negative impact and promote positive Environmental, Social and Health impacts of the proposed Project are presented in this chapter. In this mitigation measures, emphases are placed on those negative impacts rated as significant. These 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. Significant negative impacts are expected to be mitigated through effective implementation of Health, Safety and Environment (HSE) policies put in place during the different phases of the project.

The mitigation measures proposed are in keeping with the following:

- Department of Petroleum Resources guidelines and standards;
- Environmental laws at national, regional and internal levels
- FMEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management.
- Akwa Ibom State Ministry of Environment policies;
- Best Available Technology for Sustainable Development;
- Social wellbeing; and
- Concerns of stakeholders.

The following criteria were used to define mitigation measures for the identified associated and potential impacts:

Prevention – Exclude significant potential impacts and risks by design and management measures.

Reduction – Minimise the effects or consequences of those significant associated and potential impacts that cannot be prevented to a level as low as reasonably possible by implementing operational and management measures.

Control – Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practical.

6.2 Selected Control Measures

A summary of the mitigation measures is presented In Table 6.1. These measures are recommended to ameliorate all the significant associated and potential impacts identified for the proposed Project.

Table 6.1a Mitigation measures for Utapate Field Development Project (Pre-Drilling and Pre-Construction Phases)

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
Land acquisition and survey	Reduction of access to the acquired land and its resources	H	• NPDC shall ensure: • minimization of land take by following existing RoW • thorough assessment of land requirements before additional land take • proper consultation to be carried out. • appropriate compensation is paid for any additional land take • provision of alternative means of livelihood e.g. micro credit scheme.	L
	Third party agitation	H	• NPDC shall ensure: • management of public expectations by engaging NGOs and CBOs • regular/periodic dialogue sessions with active NGOs and CBOs • adoption of appropriate community entry strategies;	M

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• commitment to transparent adherence to G-MoU programmes and projects. • improvement of company-media relation	
	Legacy issues	H	• NPDC shall identify and settle all outstanding legacy issues within the project area	M
	Exposure of workers to wildlife attack	M	• NPDC shall provide and enforce usage of PPE by field workers. • NPDC shall provide First aid/Anti venom and insect repellant on site. • NPDC shall create awareness among site workers and nearby communities on the likelihood of exposure to wildlife	L
Movement of personnel and equipment to site	Interference with water transport	M	• NPDC shall minimize movement at the peak hours of water transportation • NPDC shall notify the community of the movement on the waterways	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
	Impairment of air quality	H	• NPDC shall use only pre-mobed boats . • NPDC shall ensure that there is controlled use of all vessels and that their engines are turned off when not in use.	L
	Increase in noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/vessels • vessels are turned off when not in use • Vehicles/vessels engines are fitted with effective silencers.	L
	Road/Water traffic accidents	H	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on road/water and the need for extra precautions through public enlightenment • compliance with NPDC journey management policy for road and water transport • marine boat quarter master training for boat drivers	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• road and water borne crafts are pre-mobed and pre mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites. • the use of PPEs at sites. • daily pep talk • carry out job hazard analysis	
	Disruption of fishing activities	H	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear. • make provision for fishing gears and fingerlings.	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• scheduling of project activities to minimize disruption of fisheries activities.	
	Pirate attacks and kidnappings	H	• NPDC shall make adequate security arrangements. • NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M
	Increase in incidence of STI's	H	• NPDC shall ensure: • regular medical check-up are conducted for project work force • condoms are provided for workers • restriction of workers to the camp	M
Site Preparation (vegetation clearing)	Loss of biodiversity	M	• NPDC shall limit clearing and all earth digging activities to necessary areas • NPDC shall carry out the re-vegetation of cleared area.	L
	Increase in Social vices	H	▪ NPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers.	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			▪ that contractor enforces the alcohol and drug policy for staff. ▪ regular medical check-up are conducted for project work force ▪ condoms are provided for workers.	
	Impairment of air quality	M	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that the engines are turned off when not in use.	L
	Work site accidents	M	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water • compliance with NPDC journey management policy for land and water transport • Marine boat quarter master training for boat drivers • that all road and water borne crafts are pre-mobed and pre-mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• the provision of First Aid facilities in all land and water borne crafts sites. • compensation for proven project-induced injuries, accidents and fatalities • enforcement of the use of PPEs at sites. • daily pep talk are conducted • shall carry out job hazard analysis	
	Influx of migrant workers and camp-followers	M	NPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pr-existing facilities • ensure that there is site and camp base clinics/first aid and personnel. • ensure that local workforce be employed from the project communities in line with Nigerian Content	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			Development (NCD) directives.	
Site Preparation: (Dredging)	Increase in surface water turbidity	H	NPDC shall: • ensure the rapid completion of the water crossing to minimize turbidity • compensate all affected fisher folks • supply potable water to the affected communities during crossings	L
	Acidification of soil and water	M	NPDC shall ensure: • liming of dredge spoil • regular monitoring of leachates from dredge spoil dumps	L
	Interference with water transport	H	NPDC shall: • minimize river crossing time • proactively engage the community prior to any blockages of the waterways	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
	Disruption of fishing activities	H	NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear. • make provision for fishing gears and fingerlings. • schedule of project activities to minimize disruption of fisheries activities.	L
Drilling rig movement to site	Interference with water transport	H	NPDC shall • minimize river crossing time. • proactively engage the community prior to any blockages of the waterways	L
	Surface water Contamination	M	• NPDC shall treat all effluents to regulatory limits before discharging into the environment.	L
	Risks of pirates/militant attack	H	• NPDC shall make adequate security arrangements.	M

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	

Table 6.1b Mitigation measures for Utapate Field Development ProjectProject (Drilling and Construction Phases)

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
Drilling of proposed well	Injuries and death from blowouts	M	NPDC shall • ensure the use of adequate mud density during drilling • regular monitoring sub surface pressure • install blowout preventers	L
	Increase in social vices	H	NPDC shall ensure: • intensive enlightenment campaign and health education. • that contractor enforces the alcohol and drug policy for staff.	M

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
	Third party agitation	M	NPDC shall ensure the • Management of public expectations by engaging NGOs and CBOs; • Periodic dialogue sessions with active NGOs and CBOs ; • Adoption of proper community entry strategies; • Commitment to transparent adherence to MoU programmes and projects. • Improvement of company-media relations.	M
	Contamination of soil, surface water and sediment	H	NPDC shall • treat all effluents to regulatory limits before discharging into the environment. • treat drill mud and cuttings according to regulatory standards • carry out sediment studies six (6) months after laying of the flowlines. • Implement recommendations from the soil/ sediment	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
			study. • mitigation measures put in place to reduce leakages include; i. thickness of the pipes ii. polyethylene coating of the pipes, iii. extensive surveillance of the flow lines and signages (markers).	
	Impairment of air quality	H	• NPDC shall use only pre-mobbed equipment. • NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	M
	Increase noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/vessels • vehicles/vessels are turned off when not in use • combustion engines are fitted with effective silencers. • regular maintenance of machines and equipment. • machinery covers and panels are closed and well fitted at	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
			all times • equipments with low noise level are used. • NPDC shall provide appropriate PPEs	
	Contamination of Ground water	M	• NPDC shall treat all effluents to regulatory limits before discharging into the environment.	L
	Pollution from drill waste (drill cutting and mud)	H	NPDC shall: • process the waste by separating the cutting into solid and liquid phases using shaker. • re-injected cuttings in dedicated approved re-injection wells • recycle mud	L
Excavation of flowline route	Increase in surface water turbidity	H	▪ NPDC shall ensure the rapid completion of the decommissioning to minimize turbidity ▪ NPDC shall compensate all affected fisher folks ▪ NPDC shall supply potable water to the affected communities during river crossing	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
	Increase in noise and vibration levels	M	NPDC shall ensure: ▪ machines are turned off when not in use ▪ combustion engines are fitted with effective silencers. ▪ regular maintenance of machines and equipment. ▪ machinery covers and panels are closed and well fitted at all times ▪ appropriate PPEs are provided	L
	Interference with water transport	M	NPDC shall ensure: • quick completion of the excavation work • Inform the community about the excavation ahead of time	L
	Impairment of air quality	M	▪ NPDC shall use only pre-mobbed equipment. ▪ NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	L
Flowline welding/ stringing	Burns/ injuries from welding sparks	M	• NPDC shall ensure the use of appropriate PPEs by all the welders • NPDC shall engage certified and competent welders	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
			• NPDC shall use certified welding equipment	
	Burns/ injuries from welding sparks	M	NPDC shall ensure: • that all personnel for welding related operations shall have certificate of proficiency • the provision of First Aid facilities at sites. • NPDC shall enforce the use of PPEs at sites. • daily pep talk are conducted • shall carry out job hazard analysis	L
NDT	Radiation burns from radioactive emissions	H	NPDC shall ensure: • that all personnel for operations involving the use of radioactive material shall have certificate of proficiency • the provision of First Aid facilities at sites. • enforce the use of PPEs at sites. • daily pep talk are conducted • shall carry out job hazard analysis	L
Laying of flow line	Temporary Blockage of waterways	H	• NPDC shall minimize river crossing time • NPDC shall proactively engage the community prior to	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
			any blockages of the waterways	
Backfilling	Increase in surface water turbidity	H	NPDC shall: • ensure the rapid completion of the water crossing to minimize turbidity • compensate all affected fisher folks • supply potable water to the affected communities during crossings • regular compliance monitoring	L
	Disruption of fisheries activities	M	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • make provision for fishing gears and fingerlings. • scheduling of project activities to minimize disruption of fisheries activities.	L
	Impairment of air quality	H	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all	L

Project Activity	Description of Impact	Rating	Mitigation measures	Rating after
			equipment and that equipment engines are turned off when not in use.	
	Increase in noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/vessels • vehicles/vessels are turned off when not in use • combustion engines are fitted with effective silencers. • selection of equipment with low noise level	L
Cathodic protection	Contamination of soil from rust concentration	M	NPDC shall ensure timely replacement of the anode	L

Table 6.1c Mitigation measures for Utapate Field Development ProjectProject (Operation/Maintenance Phases)

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
Operation/Maintenance Pipeline/Well	Air contamination from accidental discharge of gas	M	▪ deployment of NPDC emergency response procedure, which includes shut-in of the well	L
	Surface/ground water contamination	M	▪ deployment of NPDC spill emergency response procedure which includes clean up and remediation of the impacted site	L
	Injury/fatality of workforce	M	▪ NPDC shall ensure toolbox talks are conducted before the commencement of the job ▪ NPDC shall ensure adequate precautions are taken before work commences on the line ▪ NPDC shall ensure appropriate PPEs are used by the workers	L

Table 6.1d Mitigation measures for Utapate Field Development ProjectProject (Decommissioning/Abandonment Phases)

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
Movement of personnel and equipment from site	Interference with water transport	M	• NPDC shall minimize movement at the peak hours • NPDC shall notify the community of the movement on the waterways	L
	Impairment of air quality	H	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	L
	Increase in noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/vessels • vehicles/vessels are turned off when not in use • combustion engines are fitted with effective silencers. • regular maintenance of machines and equipment. • machinery covers and panels are closed and well fitted at all times • equipments with low noise level are used. • NPDC shall provide appropriate PPEs	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
	Surface water contamination	M	• NPDC shall use only pre-mobed boats. NPDC shall ensure that there is controlled use of all vessels and that their engines are turned off when not in use.	L
	Road/Water traffic accidents	H	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on road /water and the need for extra precautions through public enlightenement • compliance with NPDC journey management policy for water transport • marine boat quarter master training for boat drivers • vehicles/water borne crafts are pre-mobed and pre-mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency • the provision of First Aid facilities in all vehicles and water borne crafts at sites. • the use of PPEs at sites.	L

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			• daily pep talk • carry out job hazard analysis	
	Disruption of fishing activities	H	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear. • make provision for fishing gears and fingerlings. • scheduling of project activities to minimize disruption of fisheries activities.	L
	Pirate attacks and kidnappings	H	• NPDC shall make adequate security arrangements. • NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M
	Increase in incidence of STI's including HIV	H	• NPDC shall ensure: • regular medical check-up are conducted for project work	M

Project Activity	Description of Impact	before	Mitigation measures	Rating after mitigation
			force • condoms are provided for workers • restriction of workers to the camp	
	Disturbance of spawning ground for fish and shrimps	H	• NPDC shall ensure: • adequate compensation for affected fishermen that would take care of lost income • timing of activities to avoid known seasons of spawning and fry development of commercial fish in the area.	L

7

CHAPTER

CHAPTER 7
ENVIRONMENTAL MANAGEMENT PLAN

7.1 Introduction

Environmental management plan is the tool for managing the predicted environmental impacts of a project. It provides the means whereby the mitigation measures developed for reducing the effects of moderate and major impacts to *as low as reasonably practicable* (ALARP) are implemented and monitored throughout the project lifecycle.

The Environmental Management Plan (EMP) shall be employed as a tool for the management of both the predicted environmental, social and health potential impacts. The EMP provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' impacts to as low as reasonably practicable, (ALARP), prior to and through the life cycle of the proposed project. The methodology used for the impacts identification and evaluation considered that impacts of 'Low' significance would be eliminated by standard industrial practises and by the implementation of the NPDC's Health, Safety and Environment Management Systems. Hence, impacts that were considered not significant were not mitigated in the subsequent table.

7.2 Objectives of EMP

The EMP has the following specific objectives:

- The adoption of a systematic procedure to ensure that the Project activities are executed in compliance with all applicable legislations and NPDC HSE (and other) policies and guidelines;

- Demonstrate that mitigation measures for all impacts and effects have been put in place and that the measures shall be adhered to throughout the project development life cycle;

- Demonstrate that effective recovery measures for managing 'lost control' situations throughout the Project life cycle;

- Establish a structure that will ensure compliance by NPDC and its Contractors with the EMP.

In order to accomplish the above targets, the EMP has considered each environmental, social and health impacts from the point of view of the Valued Ecosystem and Social Component(s) (VEC/VSC) to be monitored, as well as the parameters for their monitoring (Table 7.1a – 7.1c). It also specifies the responsible party/parties for each action.

In developing this EMP, NPDC recognises that sound environmental management of the proposed project can only be guaranteed through the integration of the provisions of the plan as an integral part of business quality management. To this end NPDC shall put in place measures to enforce compliance by the project team on a daily basis throughout the duration of the project.

Table 7.1a Environmental Management Plan (EMP) for Utapate Field Development Project (Pre-Drilling and Pre-Construction Phases)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
Land acquisition and survey	Reduction of access to land and its resources	H	NPDC shall ensure: ▪ thorough assessment of land requirements before additional land take;. ▪ appropriate compensation is paid for any additional land take; provision of encourage adoption of alternative means of livelihood e.g. micro credit scheme	M	• Site inspection report. • Map of pipeline RoW. • Post-construction RoW dimensions. • Evidence of disbursement of compensation Evidence of provision of alternative means of livelihood.	Once before, during and after construc tion.	NPDC Project Manager.
	Third party agitations	H	NPDC shall ensure: ▪ management of public expectations by engaging the communities	M	• Records of public engagement sessions. • Records of minutes of meetings.		NPDC

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			▪ regular/periodic dialogue sessions with the communities ▪ adoption of appropriate community entry strategies; ▪ commitment to transparent adherence to MoU programmes and projects. ▪ improvement of company-media relation ▪ obtain the Freedom to Operate (FTO)		• Records of Third Party Grievances. • Records of MoU implementation status.	Quarterly	Project Manager.
	Legacy issues	H	▪ NPDC shall identify and settle all outstanding legacy issues within the	M	• Records of legacy issues identified/resolved	Quarterly	NPDC Project Manager.

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			project area				
	Exposure of workers to wildlife attack	M	• NPDC shall provide and enforce usage of PPE by field workers. • NPDC shall provide First aid/Anti venom and insect repellant on site. • NPDC shall create awareness among site workers and nearby communities on the likelihood of exposure to wildlife	L	• Evidence of provision of PPE/first aid facility • Awareness campaign records	Daily	NPDC Project Manager
Mobilization of equipment and personnel to site	Interference with water transport	M	• NPDC shall minimize movement at the peak hours of water transportation	L			

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• NPDC shall notify the community of the movement on the waterways				
	Impairment of air quality	H	• NPDC shall use only pre- mobed vehicles/boats. • NPDC shall ensure that there is controlled use of all vehicles/vessels and that their engines are turned off when not in use.	L	• Monitoring records of the criteria air pollutants • Vehicle/boat maintenance records • Vehicle/boat pre-mob records	Monthly	NPDC Project Manager
	Increase in noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/vessels • vehicles/vessels are	L	• Noise monitoring records • Maintenance records • Vehicle/boat pre-mob	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			turned off when not in use • engines are fitted with effective silencers.		records		
	Road/Water traffic accidents	H	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on road and water and the need for extra precautions through public enlightenment • compliance with NPDC journey management policy for water transport • Marine boat quarter	L	• records of awareness sessions • journey management records; IVMS records • PDC drivers permit/ DEP certificates • First aid box and contents • Maritime accident records • Minutes of pep talk meetings	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			master training for boat drivers • vehicles/water borne crafts are pre-mobed and pre-mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency • the provision of First Aid facilities in all vehicles/water borne crafts & at sites. • the use of PPEs at sites. • daily pep talk		• Site inspection report • Incident reports (injuries / fatalities).		

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• carry out job hazard analysis				
	Disruption of fishing activities	H	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear. • make provision for	L	• Evidence of stakeholder engagement • Evidence of project activities schedules • Site inspection report	Six months	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			fishing gears and fingerlings. • scheduling of project activities to minimize disruption of fisheries activities.				
	Pirate attacks and kidnappings	H	• NPDC shall make adequate security arrangements. • NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M	• State/ company Security/Incident Reports • Evidence of approved security plans • Evidence of staff sensitization sessions	Daily	NPDC Project Manager
	Increase in incidence of	H	• NPDC shall ensure: • regular medical check-up	M	• Enlightenment campaign records	Monthly	NPDC Project

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	STI's		are conducted for project work force • condoms are provided for workers • restriction of workers to the camp		• Evidence of issuance of condoms • Records of regular medical records		Manager
Site Preparation (vegetation clearing)	Loss of biodiversity	M	• NPDC shall limit clearing and all earth digging activities to necessary areas • NPDC shall carry out the re-vegetation of cleared area.	L	Record of vegetation clearing Record of re-vegetation	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Impairment of air quality	M	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that the engines are turned off when not in use.	L	• Monitoring records of the criteria air pollutants • Boat/Vehicle maintenance records • Boat/Vehicle pre-mob records	Monthly	NPDC Project Manager
	Work site accidents.	M	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on water • compliance with NPDC journey management policy for water transport • Marine boat quarter	L	• Records of issuance of PPE • Records of tool box meeting • Evidence of approved JHA • HSE incident records • Drivers certifications • Safety training records	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			master training for boat drivers • that all vehicle/water borne crafts are pre-mobed and pre-mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency • the provision of First Aid facilities in all vehicle/water borne crafts at sites. • compensation for proven project-induced injuries,				

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			accidents and fatalities • enforcement of the use of PPEs at sites. • daily pep talk are conducted • shall carry out job hazard analysis				
	Influx of migrant workers and camp-followers	M	NPDC shall: •provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pr-existing facilities •ensure that there is site and camp base clinics/first aid and personnel. •ensure that local workforce be employed from the project communities in line with Nigerian Content Development (NCD)	L	Evidence of workforce accommodation Employment records	Quarterly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			directives.				
	Increase in Social vices	H	▪ NPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers. ▪ that contractor enforces the alcohol and drug policy for staff. ▪ regular medical check-up are conducted for project	L	• Enlightenment campaign records. • Records of alcohol/drug policy • Evidence of issuance of condoms. Records of regular medical records.	Monthly	NPDC Project Manager.

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			work force condoms are provided for workers.				
Dredging	Increased in surface water turbidity	H	NPDC shall: • ensure the rapid completion of the water crossing to minimize turbidity • compensate all affected fisher folks • supply potable water to the affected communities during crossings	L	▪ Physico- chemical parameters of surface water and sediment in line with DPR requirements ▪ Compensation records	Monthly	NPDC Project Manager
	Exposure of workers to wildlife attack	H	▪ NPDC shall: ▪ provide and enforce usage of PPE by field workers.	L	• Evidence of provision of PPE/first Aid facility • Awareness campaign records	Daily	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			▪ provide First aid/Anti venom and insect repellent on site. ▪ create awareness among site workers and nearby communities on the likelihood of exposure to wildlife/insect attack				
	Acidification of soil and water	M	NPDC shall ensure: • liming of dredge spoil • regular monitoring of leachates from dredge spoil dumps	L	Physico-chemical properties of leachate	Monthly	NPDC Project Manager
	Interference with water transport	H	NPDC shall: • minimize river crossing time • proactively engage the	L	Record of water crossing time Evidence of community engagement	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			community prior to any blockages of the waterways				
	Disruption of fishing activities	H	NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear.	L	• Evidence of stakeholder engagement • Evidence of project activities schedules • Site inspection report	Six months	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• make provision for fishing gears and fingerlings. • scheduling of project activities to minimize disruption of fisheries activities.				
Drilling rig movement to site	Interference with water transport	H	NPDC shall • minimize river crossing time. • proactively engage the community prior to any blockages of the waterways • minimize movement during peak community movement time	L	Record of water crossing time Evidence of community engagement Record of travel time	Daily	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Surface water Contaminatio n	M	• NPDC shall treat all effluents to regulatory limits before discharging into the environment.	L	Effluent monitoring records	Montly	NPDC Project Manager
	Pirate attacks and kidnapping	H	• NPDC shall make adequate security arrangements. • NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M	• State/ company Security/Incident Reports • Evidence of approved security plans • Evidence of staff sensitization sessions	Daily	NPDC Project Manager

Table 7.1b Environmental Management Plan (EMP) for Utapate Field Development Project (Drilling Construction Phases)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
Drilling of proposed well	Injuries and death from blowouts	M	NPDC shall • ensure the use of adequate mud density during drilling • regular monitoring of sub-surface pressure	L	Mud density records Sub-surface pressure monitoring records	Daily	NPDC Project Manager
	Increase in social vices	H	NPDC shall ensure: • intensive enlightenment campaign and health education. • that contractor enforces the alcohol and drug policy for staff.	M	• Enlightenment campaign records • Records of alcohol/drug policy	Monthly	NPDC Project Manager
	Third party agitation	M	NPDC shall ensure the • Management of public	M	▪ Records of Third Party Grievances	Weekly	NPDC Project

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			expectations by engaging NGOs and CBOs; • Periodic dialogue sessions with active NGOs and CBOs • Adoption of proper community entry strategies; • Commitment to transparent adherence to G-MoU programmes and projects. • Improvement of company-media relations.		• Records of work stoppages at locations. • Records of MoU programmes implementation • Minutes of meetings		Manager
	Contamination of water/ soil and sediment	H	NPDC shall • treat all effluents to	L	Effluent monitoring records	Monthly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			regulatory limits before discharging into the environment. • re-inject drill cuttings and mud • treat all effluents to regulatory limits before discharging into the environment. • treat drill mud and cuttings according to regulatory standards • Implement recommendations from the soil/sediment study. • mitigation measures put in		Records of drilling cutting re-injection Carry out soil/sediment studies six (6) months after laying of the flowlines		

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			place to reduce leakages include; i. thickness of the pipes ii. polyethylene coating of the pipes, iii. extensive surveillance of the flow lines and signages (markers).				
	Impairment of air quality	H	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	M	• Monitoring records of the criteria air pollutants • Boat/Vehicle maintenance records • Boat/Vehicle pre-mob records	Monthly	NPDC Project Manager
	Increase noise and vibration levels	M	NPDC shall ensure:	L	• Noise monitoring	Weekly	NPDC Project

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• regular maintenance of Vehicles/ vessels • Vehicles/ vessels l are turned off when not in use • combustion engines are fitted with effective silencers. • regular maintenance of machines and equipment. • machinery covers and panels are closed and well fitted at all times • equipments with low noise level are used. • NPDC shall provide appropriate PPEs		records • Maintenance records • Rig pre-mob records		Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Contamination of Ground water	M	• NPDC shall treat all effluents to regulatory limits before discharging into the environment.	L	Effluenct monitoring records Records of drilling cutting re-injection	Monthly	NPDC Project Manager
	Pollution from drill waste (drill cutting and mud)	H	NPDC shall: • process the waste by separating the cutting into solid and liquid phases using shaker. • re-injected cuttings in dedicated approved re-injection wells recycle mud	L	Drill waste management records	Daily	NPDC Project Manager
Excavation of flowline route	Increase in surface water turbidity	H	▪ NPDC shall ensure the rapid completion of the decommissioning to minimize turbidity	L	▪ Physico- chemical parameters of surface water and sediment in line with DPR	Monthly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			▪ NPDC shall compensate all affected fisher folks ▪ NPDC shall supply potable water to the affected communities during river crossing		requirements ▪ Compensation records		
	Increase in noise and vibration levels	M	NPDC shall ensure: ▪ machines are turned off when not in use ▪ combustion engines are fitted with effective silencers. ▪ regular maintenance of machines and equipment. ▪ machinery covers and panels are closed and well fitted at all times ▪ appropriate PPEs are	L	• Noise monitoring records • Maintenance records • equipment pre-mob records	Daily	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			provided				
	Interference with water transport	M	NPDC shall ensure: • quick completion of the excavation work • inform the community about the excavation ahead of time	L	Record of completion time Record of community engagement	Daily	NPDC Project Manager
	Impairment of air quality	M	▪ NPDC shall use only pre-mobbed equipment. ▪ NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	L	Monitoring records of the criteria air pollutants	Monthly	NPDC Project Manager
Flowline welding/ stringing	Visual impairment from high intensity welding flash	M	• NPDC shall ensure the use of appropriate PPEs by all	L	• Records of issuance of PPE	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			the welders • NPDC shall engage certified and competent welders • NPDC shall use certified welding equipment		• Records of tool box meeting • Evidence of approved JHA • HSE incident records • Welding certifications • Safety training records		
	Burns/ injuries from welding sparks	M	NPDC shall ensure: • that all personnel for welding related operations shall have certificate of proficiency • the provision of First Aid facilities at sites.	L	• Records of issuance of PPE • Records of tool box meeting • Evidence of approved JHA • HSE incident records	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• NPDC shall enforce the use of PPEs at sites. • daily pep talk are conducted • shall carry out job hazard analysis		• welding certifications • Safety training records		
NDT	Radiation burns from radioactive emissions	H	NPDC shall ensure: • that all personnel for operations involving the use of radioactive material shall have certificate of proficiency • the provision of First Aid facilities at sites. • enforce the use of PPEs at sites.	L	• Records of issuance of PPE • Records of tool box meeting • Evidence of approved JHA • HSE incident records • radiation certifications • Safety training	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• daily pep talk are conducted • shall carry out job hazard analysis		records		
Laying of flowline	Temporary Blockage of waterways	H	• NPDC shall minimize river crossing time • NPDC shall proactively engage the community prior to any blockages of the waterways	L	Record of water crossings Evidence of engagement of community prior to blockage	Weekly	NPDC Project Manager
Backfilling	Increase in turbidity	H	NPDC shall: • ensure the rapid completion of the water crossing to minimize turbidity • compensate all affected	L	▪ Physico- chemical parameters of surface water and sediment in line with DPR requirements ▪ Compensation records	Monthly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			fisher folks • supply potable water to the affected communities during crossings • regular compliance monitoring				
	Disruption of fisheries activities	M	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • make provision for fishing gears and fingerlings. • scheduling of project	L	• Evidence of stakeholder engagement • Evidence of project activities schedules • Site inspection report	Six months	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			activities to minimize disruption of fisheries activities.				
	Impairment of air quality	H	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use.	L	• Monitoring records of the criteria air pollutants • equipment maintenance records • equipment pre-mob records	Monthly	NPDC Project Manager
	Noise nuisance/vibration	M	NPDC shall ensure: • regular maintenance of vehicles/ vessels	L	• Noise monitoring records • Maintenance records	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• Vehicles/ vessels are turned off when not in use • combustion engines are fitted with effective silencers. • Selection of equipment with low noise level		• equipment pre-mob records		
Cathodic protection	Contamination of soil and water from rust accumulation	M	NPDC shall ensure timely replacement of the anode	L	Record of anode replacements	Yearly	NPDC Project Manager

Table 7.1c Environmental Management Plan (EMP) for Utapate Field Development Project (Operation/Maintenance Phase)

Project Activity	Description of Impact	before	Mitigation measures	after	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party

Project Activity	Description of Impact	before	Mitigation measures	after	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
Pipeline/Well Operation/maintenance	Air contamination due to gas leakage	M	▪ Deployment of NPDC emergency response procedure, which includes shut-in of the well	L	Air quality monitoring	Quarterly	NPDC Asset Team
	Surface/ground water contamination		▪ Deployment of NPDC spill emergency response procedure which includes clean up and remediation of the impacted site	L	Pre-mob certificate and statistics	Quarterly	NPDC Asset Team
	Injury/fatality of the workforce	M	• NPDC shall ensure toolbox talks are conducted before the commencement of daily tasks • NPDC shall ensure adequate safety measures are taken before work on the line • NPDC shall ensure appropriate PPEs are used by the workers	L	Manual of Operation and Permit to Work Form	6-monthly	NPDC Asset Team

Table 7.1d Environmental Management Plan (EMP) for Utapate Field Development Project (Decommissioning/Abandonment Phase)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
Movement of personnel and equipment from site using barges, and supply vessels	Interference with water transport	M	• NPDC shall minimize movement at the peak hours • NPDC shall notify the community of the movement on the waterways	L	Record of water crossing time Evidence of community engagement Record of travel time	Daily	NPDC Project Manager
	Impairment of air quality	H	• NPDC shall use only pre-mobed equipment. • NPDC shall ensure that there is controlled use of all equipment and that equipment engines are	L	• Monitoring records of the criteria air pollutants • boat maintenance records • Vehicle/boat pre-mob	Monthly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			turned off when not in use.		records		
	Increase noise and vibration levels	M	NPDC shall ensure: • regular maintenance of vehicles/ vessels • vehicles/ vessels are turned off when not in use • combustion engines are fitted with effective silencers. • regular maintenance of machines and equipment. • machinery covers and panels are closed and well fitted at all times	L	• Noise monitoring records • Maintenance records • Vehicle/boat pre-mob records	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			• equipments with low noise level are used. • NPDC shall provide appropriate PPEs				
	Surface water contamination	M	• NPDC shall use only pre-mobed boats . • NPDC shall ensure that there is controlled use of all vessels and that their engines are turned off when not in use.	L	Effluent monitoring records	Weekly	NPDC Project Manager
	Road/Water traffic accidents	H	NPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on road and water and the need for extra		• ecords of awareness sessions • ourney management records; IVMS records	Weekly	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			precautions through public enlightenment • compliance with NPDC journey management policy for water transport • Marine boat quarter master training for boat drivers • Vehicles/water borne crafts are pre-mobed and pre-mobilization/compliance certificate issued. • that all personnel for water related operations shall have certificate of swimming proficiency • the provision of First Aid facilities in all vehicles and		• PDC drivers permit/ DEP certificates • First aid box and contents • Accident records Minutes of pep talk meetings Site inspection report Incident reports (injuries / fatalities).		

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			water borne crafts & at sites. • the use of PPEs at sites. • daily pep talk • carry out job hazard analysis				
	Disruption of fishing activities	H	• NPDC shall: • issue timely information to stakeholders particularly fisher folk on the nature and timing of activities that may interfere with fisheries operations. • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage	L	• Evidence of stakeholder engagement • Evidence of project activities schedules • Site inspection report	Six months	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			to fishing gear. • make provision for fishing gears and fingerlings. • scheduling of project activities to minimize disruption of fisheries activities.				
	Risks of pirates / militant attack	H	• NPDC shall make adequate security arrangements. • NPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M	• State/ company Security/Incident Reports • Evidence of approved security plans • Evidence of staff sensitization sessions	Daily	NPDC Project Manager
	Increase in	H	• NPDC shall ensure:	M	• Enlightenment	Monthly	NPDC

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	incidence of STI's		• regular medical check-up are conducted for project work force • condoms are provided for workers • restriction of workers to the camp		campaign records • Evidence of issuance of condoms • Records of regular medical records		Project Manager
	Disturbance of spawning ground for fish and shrimps	H	• NPDC shall ensure: • adequate compensation for affected fishermen that would take care of lost income • timing of activities to avoid known seasons of spawning and fry development of commercial fish in the	L	Record of timing of activities Compensation records	Daily	NPDC Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			area.				

CHAPTER 8

CHAPTER EIGHT
CONCLUSIONS

This EIA report was prepared to assess the potential impacts of the Utapate Field Development Project on the environment. The need to identify and predict the adverse and beneficial impacts of the proposed Utapate Field Development Project on the biophysical environment and the socio-economic and health status of the people and thus provide necessary data/evidence that will form the Environmental Impact Statement (EIS) of the project necessitated NPDC to carry out an EIA of the proposed project. This study was carried out in accordance with relevant local and international regulations. The methodology applied for the study involved desktop studies, reviews of existing data and fieldwork including community consultations.

To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various ecological components of the project area using extensive literature, two season field sampling, measurements/testing as well as quantitative and qualitative analysis. Consultations with the project communities were also carried out and these would continue throughout the project life cycle. These consequently established the environmental characteristics of the proposed project area with respect to climate, air quality, soil, surface water, groundwater, socio-economic and health environment, among others.

The EIA on the Utapate Field Development Project has considered the environmental impacts of the various project activities in relation to the ambient environmental conditions (baseline) that are likely to be affected. The magnitude of the impacts of these activities anticipated on air, water, soil, sediment, vegetation, fauna, fishery, socio-economics and health were evaluated in line with the proposed project activities (site preparation, construction, drilling, flowline construction, production and decommissioning).

The EIA of the project shows that it would have a significant beneficial impact on both regional and national economy. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the mitigation recommended measures are adhered to.

Further, an Environmental Management Plan has been developed to ensure effective implementation of prescribed mitigation measures and for proactive environmental management throughout the drilling, flowline construction and operational life of the project facilities. The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components.

It can be concluded that the project will not cause serious damage to the environment if executed in accordance with plans and programmes in this EIA. The approval of this EIA report for the execution of the proposed project is hereby recommended in accordance with the contents of this EIA to enhance project and environmental sustainability.

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APPENDIX 1

SOCIAL SURVEY QUESTIONNAIRE FOCUS GROUP DISCUSSION (FGD)/KEY INFORMANT INTERVIEW

FOCUS GROUP DISCUSSION (FGD)/KEY INFORMANT INTERVIEW (KII) GUIDE FOR ENVIRONMENTAL EVALUATION STUDY

*This **Guide** is to assist the researcher obtain qualitative data from respondents in an interactive manner. The discussions should be recorded by a **Note Taker** and later transcribed. **Photos** of the discussion sessions should be taken with due permission of the discussants. This should be included in the report.*
NOTE A: (1) FGD should be conducted with adult male & female groups, youths-male & female groups and any other group that could be impacted by the proposed project. (2) Number of discussants in the FGD should be 5-10. (3) At least 2 KIIs should be conducted per community (i.e. with 1 male, 1 female). (4) Individual/household questionnaires should not be administered on Focus Group Discussants and Key Informants.
NOTE B: For questionnaire administration, sample size should be determined using the formula [$n = N/1+N(e)^2$]: n = sample size per community, N= population of each community, e = level of precision required (use 0.05).

Demography:
What is the population size and distribution (Probe for distribution in terms of age, gender, ethnic groupings, population density, dependency and sex ratio)? How would you describe the marital status, educational attainment, primary and secondary school dropout rates in the community? Give the history and trend of migration into and out of the area of study, net enrolment ratios for primary and secondary schools, levels of increased pressure on existing infrastructural facilities.

Social Structure and Organisation: Describe settlement history, ethnic groups, social organisation and traditional governance – power and authority structure; history of conflicts and their resolution including the role of women. Have you noticed changes in social organizations and traditional governance, power and authority structure? (Discussants to compare traditional and modern governance structures)

Social Infrastructure: What are the means of transportation (water, land); educational institutions (Primary, Secondary, tertiary) water supply, electricity, communication, recreational facilities, waste management facilities, housing (type, pattern and quality).

Cultural Properties: Describe the value system and social norms in the community. Name the location and spatial distribution of historical sites, archaeological sites and artefacts, shrines, sacred forests/scenic areas that exist in the community. Which religion, plants/animal species of cultural value, festivals, marriage practices, cultural calendar, and cultural organisations are found in the community? [Probe for changes (if any) and reasons for the changes].

Livelihood: Describe the income distribution and consumption patterns, employment status, occupation, occupational mobility and adjustment, poverty profile in the community. Describe the land use and tenure system, and other economic activities, traditional market systems in your community (Probe for changes that have taken place in the livelihoods in the community).

Natural Resources and Land Use: Describe the natural resources in the community, their **v**alues and use including rights over private, rental, common ownership and access to resources – especially with respect to women (access to and use of farm land); local conservation practices (closed seasons/closed locations).

The role of women and children: Are there specific roles for women and children in the community? Do they have specific rights and privileges, contribution to socio-economic development? Are there incidents of women trafficking and child labour? Describe the activity systems, political organisation and cooperatives in the community.

Vehicular Traffic Analysis: Describe the vehicular volume count (road and water), origin and destination survey, incidence and records of motoring accidents in the community. Have there been changes in vehicular volume and incidence of motoring accidents. (Probe for the direction of changes and possible causes).

Perception of the study area: In what ways has your community benefitted from SEEPCO activities in your community? Are there negative impacts from SEEPCO's operations? Name them. (Probe for respondents' perception of associated risks and impacts on quality of life). How would you rate/describe the relationship of SEEPCO with the community?
Is there other oil and gas company operating in your community? How would you describe the community's relationship with it? What are your reasons for your assessment?

SOCIAL SURVEY QUESTIONNAIRE

1. NEIGHBOURHOOD/COMMUNITY/SETTLEMENT
1.1 Name of interviewer: --
1.2 Date of interview:--
1.3 Neighborhood /comm./settle:------ --
1.4 Local Govt. Area:---
1.5 State:---
2. RESPONDENTS PERSONAL INFORMATION
2.1 Sex (Male./Female):--
2.2 Age:
2.3 How would you describe yourself in this community/neighbourhood?
(i) Indigene (ii) Settler (iii) Visitor (iv) Tenant
2.4 If you are a visitor/ settler, where is your hometown?
____
2.4 How long have you lived in this community/neighbourhood?
(i) less than 5 years (ii) 6-10 years (iii) 11-15 years (iv) 16-20 years (v) above 20 years
2.5 Marital Status (i) Single (ii) Married (iii) Divorced (iv) Widow/widower
2.6 What position do you hold in this community (i) Traditional ruler (ii) Religious leader
2.7 (iii) Family head (iv) Chairman, Social club (iv) Others (specify)………………………………..
2.8 What is your level of Education? (i) Primary (ii) Secondary (iii) Tertiary (iii) No formal education.
3. DEMOGRAPHIC CHARACTERISTICS
3.1 Family size (Husband, wife/wives and children) (i) 1-3 (ii) 4-6 (iii) 7-10 (iv) 11-15 (v) above 15
3.2 Sex: How many are:
3.2.1 Males---
3.2.2 Females:---
3.3 How many births in your family in the last 12 months? (i) 0 (ii) 1 (iii) 2 (iv) 3 (v) 4
3.4 How many deaths in your family in the last 12 months? (i) 0 (ii) 1 (iii) 2 (iv) 3 (v) 42
4. ECONOMIC ENVIRONMENT
4.1 What is your occupation? (i) Farming (ii) Fishing (iii) Hunting (iv) Civil servant (v) Trading (vi) Business (vii) Industrial worker (viii) Other (specify):--------------------------
4.2 If farmer, what crops do you grow? ………………………………………………...
4.2.1 Yearly quality of farm produce in the last 5yrs …………………………………………
4.2.2 If fisherman, name some fishes ………………………………………………………...
4.3.1 Yearly quality of fish caught in the last 5yrs……………………………………….…
4. 3 How long have you been in the occupation? (i) 0-5 years (ii) 6-10 years (iii) 11-20 years (iv) 21-30 years (v) above 30 years.
4.4 How many members of your household are employed in crude oil related companies operating in this area? (i) None (ii) 1 (iii) 2 (iv) 3 (v) 4 (vi) 5

4.5 Please state the Number of your household who have attained 18 years and above but are not employed. (i) None (ii) 1 (iii) 2 (iv) 3 (v) 4 (vi) 5 (vii) 7 (viii) Others (specify)--------------------

4.5 Does any of the persons above have any form of technical training related to the operations of oil companies in the area? If yes how many? (i) 1 (ii) 2 (iii) 3 (iv) 4 (v) 5
4.6 Please briefly specify the nature of the training and indicate the number of persons who have such training
(i)--- (ii)--
(iii)--- (iv)--

4.7 How much do you realise from fishing in a week? (i) N0.0-N250.00 (ii) N250.00-N500.00 (iii) N501.00-N750.00 (iv) N751.00-N1000.00 (v) N1001.00-N1,500.00 (vi)N1,501.00-N1,750.00 (vii) N1,751.00-N2,000.00 (viii) Above N2,000.00

4.8 How much do you realise from other activities/sources in a week? (i) N0.00-N500.00 (ii) N501.00-N1000.00 (iii) N1001.00-N1,500.00 (iv) N1,501.00-N2,000.00 (v) Others--------

4.9 What is your annual income? (i) N11,000-N20,000 (ii) N21,000-N30,000 (iii) N31,000-N40,000 (iv) N41,000-N50,000 (v) N51,000-N60,000 (vi) N61,000-N70,000 (vii) N71,000-N80,000 (viii) 81,000-N90,000 (ix) N91,000-N100,000 (x) Other range------------------------

4.10 How much do you spend on your family a week? (i) N250.00-N500.00 (ii) N501.00-N1000.00 (iii) N1,001.00-N1,500.00 (iv) N1,50100-N2,000.00 (v) 2,500.00-N3,000.00 (vi)N3,001.00-N3,500.00 (vi) Other range --

4.11 How much do you spend on? (i) Food items (ii) Household item (iii) Clothing (iv)Education of Children (v) Medical care (vi) Transport (vii) Others (specify)------------------

4.12 How much are your able to save in a year? (i) No savings (ii) N10,000.-N20,000.00 (iii)N21,000.00-N30,000.00 (iv) N31,000.00-N40,000.00 (v) N41,000.00-N50,000.00 (vi) N51,000.00-N60,000.00 (vii) Other range--

4.13 Which of these properties do you own? (i) Bicycle (ii) Motor cycle (iii) Motor vehicle (iv)Out board engine boat (v) Canoe (vi) Others (specify)---

4.14 Do you own any land in the community? If yes, what is the size in hectares? (i) 0-1 (ii) 2-3 (iii) 4-5 (iv) 6-7 (v) above 7

4.15 What is the nature of land ownership? (i) Personal (ii) Family (iii) Communal (iv) Lease hold (v) Free hold (vi) Others (specify):--

4.16 Do you have a house in the neighbourhood/ community? (i) Thatch roof/mud (ii) Zinc roof block (iii) Zinc roof /book (iv) Zinc roof/wooden (v) Others (specify)--------------------------

5 SOCIAL/CULTURAL ENVIRONMENT

5.1 What is your religion? (i) Christianity (ii) Islam (iii) Traditional (iv) Others (specify)-------

5.2 Which of the following do you have around this neighbourhood /community: (Please show us the location) (i) Shrines (ii) Sacred ground/forest (iii) Historical / archaeological site (iv) Religious houses (v) Others (Special)----------------------------

5.3 What of these social problems do you have in your neighbourhood?
(i) Youth /juvenile delinquency/unrest (ii) Land dispute (iii) Chieftaincy problem (iv) Inter-village problem (v) Inter-family problem (vi) Unemployment (vii) Others (specify) (viii) None of the above

5.4 What is your source of water supply? (i) Pipe-borne water (ii) Hand dug well (iii) Streams (iv) Rainfall (vi) Others (please specify)

5.5 What are your sources of energy? (i) Wood (ii) Kerosene (iii) Gas (iv) Petrol (v) Coal (vi) Electricity

5.6 What are you fears about this proposed project? (i) Loss of land (land acquisition) (ii)Damage of agricultural land (iii) Cultural interference (iv) Noise nuisance from working equipment (v) Pollution of fishing ground (vi) Others (specify)

5.7 What benefits do you expect from SEEPCO in course of the execution of this project and subsequent operations in the area? Please rank them in order of importance by placing 1 against the most important, 2 against next important etc.
(i) Employment of indigenes (ii) Scholarship for indigenes (iii) Electricity (iv) Primary school (v)Water project (vi) Health centres (vi) Others (specify):--------------------------------

6.0 SOCIAL STATISTICS (For interviewer only) Note and record the following:

6.1 School statistics (i) Primary school enrolment data Primary 1 to IV (ii) Secondary school enrolment data JSS 1-3, SSS 1-3 (iii) Other educational institutions

6.2 What are the common environmental problems in the neighbourhood/community?
(i) Flooding (ii) Shoreline erosion (iii) Deforestation

6.3 State of infrastructure (i) Roads (ii) Building materials (iii) Sanitation (iv) Others (specify):--------------------------------------- (v) No idea

7 FISHERY AND WILDLIFE

7.1 Where do you usually fish? (i) Within a few nautical miles from the village (ii) Open Sea fishing (iii) Fish pond

7.2 Please list the types of fish you normally catch.
(i)-- (ii)---
(iii)-- (iv)---
(v)-- (vi)---
(vii)-- (viii)---

(ix)-- (x)---
7.3 In the last 5 years has your annual production of fish been: (i) Increasing (ii)The same (iii) Decreasing
7.4 If decreasing what do you think is responsible? (Record answer verbatim).
(i)-- (ii)---
(iii)-- (iv)---
7.5 Please list the type of wild animal and birds you normally see or catch in this area
(i)-- (ii)---
(iii)-- (iv)---
(v)-- (vi)---
7.6 In the last five years have you noticed any changes in the population of animals and birds in the forest? What are the changes? (i) Increasing (ii) The same (iii) Decreasing
7.7 If decreasing what so you think is responsible (record answer verbatim) ---
7.8 In the last 5 years have you noticed any changes in the types of animal and birds in the forest? Yes / No
7.9 If your answer to question 7.8 is yes, what are the changes (record answer verbatim).
(i)-- (ii)---
(iii)-- (iv)---

In the last five years have you noticed any changes in the ways trees in the forest and around the village have been growing? What are the changes? :---

FORM D: HEALTH FACILITY SURVEY CHECKLIST

The objectives of the health facility survey are to:
Assess the current capacity of the health facility to meet the health needs of the people.

Proposed Project____
Local Government Area _______________________________________
Community ____
Facility name ____
Date____

2. Facility type: ☐ Primary ☐ Secondary ☐ Tertiary
3. Ownership ☐ Government ☐ Private ☐ Mission ☐ Others

B. **Health Personnel**

S/N	Personnel	Number	Qualification	Years of Experience
1	Doctors			
2	Nurses/Midwifes			
3	Pharmacist			
4	Lab Scientists			
5	Radiographers			
6	Anesthetists			
7	Community Health Officers (CHOs)			
8	Community Health Extension Workers (CHEW)			
9	Record Clerk			
10	Others			

C. **Equipment**

- Sterilizer
- Refrigerators

- Medical waste disposal methods
- ECG
- Ultrasound
- Pharmacy
- Weighing Scale
- Sphygmomanometer
- Ambulance

D. Consumables

- Disposable needless and syringes
- Disposable suture kits
- Essential Drug List Available
- Are all Drugs on the list available?
- Vaccines

F Health Infrastructures

FEATURES	Adequate	Inadequate
Clean consultation room		
Clean waiting room		
Treatment/minor procedures room		
Privacy rooms		
Clean running water/hand washing facilities		
Toilet		
Good light		
Good ventilation (or AC)		
Insect screens		
Catering facilities		
Operating theatre		
X-ray facilities		
Laundry facilities		
Consulting table and chairs		
Examination couch		
Laboratory facilities		
No of beds		

E. **Administration**

FEATURES	YES	NO
Appointment system		
Health records		
Security		
Confidentiality		
Scale of changes		
Cleaning and maintenance routine		

F. **Logistics**

- Accessibility of the health Institution (average radial distance of the center from the members of the community) ____
- Communications Telephone/radio

G. Administration/Records

- Average daily clinic attendance:
- Common diseases treated:
- How many days in a week is the facility opened?
- How many days per week are services provided for
  - a. Sick children aged less than 5 years?
  - b. Pregnant women?
  - c. General outpatient?
  - d. VCT/Anti retroviral Screen? ____________________
  - e. TB Clinic? ____________________
  - f. Other services3? ____________________

H Referral Services

1. Where do you refer severely ill patients?
   - ☐ Government hospital specify name
   - ☐ Private hospital
   - ☐ Others ______________________

2. How long will it take for a patient to get to the referral centre using the most common means of transport that is available in the community? _________

3. Has there been an occasion when the facility tried to refer a severely ill patient but was unable to do so? ☐ Yes ☐No

4. Are the health records kept for
   - a. In-patients? ☐ Yes ☐No
   - b. Out-patients? ☐ Yes ☐No
   - c. Ante-natal visits? ☐ Yes ☐No
   - d. Immunizations? ☐ Yes ☐No
5. Does the record include diagnosis of patients who attend? ☐ Yes ☐No

6. Is the record collated for use at the health facility or higher levels? ☐ Yes ☐No

7. Review records and collate attendances and admission for the last 1 year

Month	Male			Female			Total
	Out-p	In-p	Total	Out-p	In-p	Total	
Jan							
Feb							
Mar							
Apr							
May							
June							
July							
Aug							
Sep							
Oct							
Nov							
Dec							
Total							

FOCUS GROUP DISCUSSION

Name of Town/Village ……………………………………………………

Lifestyle/habits

1. What are the common types of food eaten in the community……………
2. Is there any food taboos Yes / No
3. What is the average life span (expectancy) in your community?…………………….

(a) Male…………………………… (b) Female…………………………………

4. What are the common health problems in your community?……………………………

………………………………………………………………………………………

5. When are these health problems common during the year

S/No	Disease	**RAINY SEASON**	**DRY SEASON**

6. Which of these health problems pose the greatest threat to your community
7. (5 diseases to be listed in order of frequency)…………………………………………

……

……………………………………………

8. What are the most important causes of death in your community? Among :
9. Children under 5 years …………………………………………………………
10. Adults ……………………………………………………………………………..
11. How many deaths in the last one year among:

(i) Whole community ……………………………………

(i) Children under 5 years ……………………………..

(ii) Adults (Women of child bearing age) …………

12. What refuse do you generate? …………………………………………………………
13. How do you store your refuse ……………………………………………………...
14. How do you dispose your refuse? ……………………………………………………
15. What is your method of sewage disposal? …………………………………………….
16. Do you have drainage in your community? ……………………………………………
17. Does your community get flooded or water logged? …………………………………
18. What is the source of the flooding?…………………………………………………….
19. What is the source of your drinking water? ……………………………………………
20. Do you treat your water before drinking? ………………………………………………
21. Do you wash your hands before eating/ ……………………………………………….
22. Do you wash your hands after defaecating? (Toileting)………………………………...
23. What are health facilities in your communities ………………………………………..
24. Do you think this project would cause any health problem in your community? Yes: ☐ No: ☐

If yes, what are the problems…………………………………………………

25. How do you think these problems can be minimized? ………………………………..
26. What do you think are the most important five health needs of your community?

……………………………………………………………………………………………………

27. Do you have the followings in your community
    (a) House Fly/cockroach/Mosquito/Lice/Black fly/Tsetse fly/and rats.
    (b) What diseases could these insects cause/transmit?

Thank you.

COMMUNITY HEALTH QUESTIONNAIRE

Please be informed that your response/s to the above questions is for a study that will be of interest to the community and shall therefore be treated in strict confidence. We will appeal to you to be as honest as possible.

1. Name of Respondent
2. Age: ……………………………………………………………………
3. Sex: ……………………………………………………………………
4. LGA: …………………………………………………………………
5. Religion: ………………………………………………………………
6. Level of Education: ………………………………………………………
   - No formal Education: ……………………………………………………
   - Functionally Literate: …………………………………………………
   - Primary: ………………………………………………………………
   - Secondary: ……………………………………………………………
   - Tertiary: ………………………………………………………………
   - Others: ………………………………………………………………...
   -
7. Marital Status: Married ----, Single ----, Divorced ----, Separated -----

8. Number of Children Male ---------- Female -------------
9. No. of other Dependents Male ---------- Female -------------
10. Total no. of people in Household; Male -------- Female -------------
11. Residential Status ------------- Tenant ------------, Landlord -------------
12. Health Institution:
    (a) Location ……………………………………………………….
    (b) Type:
    (i) Primary Health Centre

    (ii) General Hospitals

    (iii) Teaching Hospitals
    (iv) Private Clinics
    (v) Pharmacy Shops
    (vi) Patent Medicine stores
    (vii) Traditional / Herbal homes.
13. Staffing:
    (a) No. of Doctors: ………………………………………………..
    (b) No. of Nurses: …………………………………………………
    (c) No. of Auxiliaries: ……………………………………………
    (d) Others: ………………………………………………………
14. Would you say that these Health institutions are easily accessible?
15. Which of the following do you have in this community and what is the condition of the facility if present?
16.

S/No	Facility	Availability Yes / No	Condition Poor/Fair/Good	If not present. How far is the nearest facility
1 2	Access Road Pub. Transport			

3 4 5 6 7	Primary School Portable Water Electricity Market Others specify			

16. In the Health Institutions mentioned above would you say the equipment is:-

(i) Adequate (ii) Inadequate

17. Quality of service rendered?

(i) Poor (ii) Fair (iii) Good (iv) Excellent

18. Population Served? : ……………………………………………………

19. Level of attendance ……………………………………………………………

20. TYPES OF CASES % INCIDENCE
(i) Malaria ……………………………… ………………………….
(ii) Typhoid ……………………………… ……………………………
(iii) Diarrhea……………………………… ………………………….
(iv) Dysentery……………………………… ..…………………………
(v) Respiratory problems / Chest infections … …………………………
(vi) Visual disturbances …………………….. ..…………………………
(vii) Restlessness/Confession/Sleeplessness or Insomnia ………………….
(viii) Others specify ………………………………………………….

21. What are the most serious ailments encountered in the past 3 years?................
22. Are there changes noticed over the years?...
23. Any seasonal variations? ……………………………………………………..
24. Have you recorded any Epidemics in recent times? If so………………………
25. What was the cause of the Epidemics? ……………………………………...
26. What is the yearly mortality Rate?...
27. What is the birth Rate?...
28. What constitutes your main diet?...
29. What is your refuse disposal method?...
(a) into the Stream/River
(b) open refuse dumps
(c) refuse bins
(d) incinerators
(e) isolated areas
(f) dump pits

30. What is your sewage disposal method?

(a) septic tank
(b) pit latrine
(c) into the Stream/ River
(d) others

31. From which of the following sources is your water supply?

a) Rain -
b) River -
c) Stored run off
d) Pipe borne water -
e) Borehole -
f) Well

32. How is water from each of these sources treated before use? ………………….
…………………………………………………………………………

33. What do think is the main source of water pollution in your community?

(a) industrial wrote
(b) untreated waste
(c) domestic waste
(d) herbicides
(e) fertilizers
(f) petroleum products

34. What do you think is the main source of air pollution in your community?

(a) dump sites
(b) industrial discharge
(c) gas flaring
(d) smoke
(e) others/specify)

35. Do you think pollution in the area has affected your health? Yes........... No………… if yes how?...

36. Has there been any out break of food poisoning in your community?

(a) Yes…………… (b) No …………………..

37. How do you avoid the sources of pollution mentioned earlier?
38. Where do you treat major illness?
39. Where do you treat minor illness?
40. Have you suffered or benefited individually or as a community from the presence of an industrial company in your area? E.g. SPDC
If yes what are the benefits?
If not, why?
41. What do you think is your role in environmental protection?
42. How do you protect your family from environmental hazards?
43. What are some of these hazards Animals - Snakes?

Rats

Flies and Cockroaches
Chemical Agents - Specify
Physical Agents - Specify

Appendix 2

STUDY APPROACH AND METHODOLOGY

General

Fieldwork was conducted between 19th September to 2nd October 2019 for the wet season and January 26th to 31st, 2020 for the dry season. The multi-disciplinary field study involved data acquisition on meteorology, air quality and noise, soil, vegetation, Surface water, wildlife/invertebrate fauna, hydrogeology (groundwater) as well as the health status and socio-economic structure of the communities within the study area.

Table 1.1: Environmental Component and Method of Sample Collection

Environmental Component	Method of collection
Soil/Land use	Dutch stainless steel hand auger, Core samplers, Interviews, and Direct observation
Surface Water	Water Samplers
Sediment	Sediment Grab sampler
Hydrobiology/Fisheries/ benthos	Collection with Van Eckmann Grab, Collection with Plankton Net and sieves.
Vegetation	Transects, key Informant Interviews, Use of Binoculars, Direct Observation and sample collection
Wildlife	Direct Observation, Key Informant Interviews and indirect count method
Geology/Hydrogeology	Percussion drilling of boreholes and ground water sampling
Air Quality and Noise	Electronic air quality monitor, Aeroqual air quality kit, Met-One Particulate sampler, Noise meter
Meteorology	Literature Survey, Field Studies with Thermograph, Wind Vane
Socio-economics/ Health	Interviews, questionnaires, focus group discussions, publications

Sampling Design

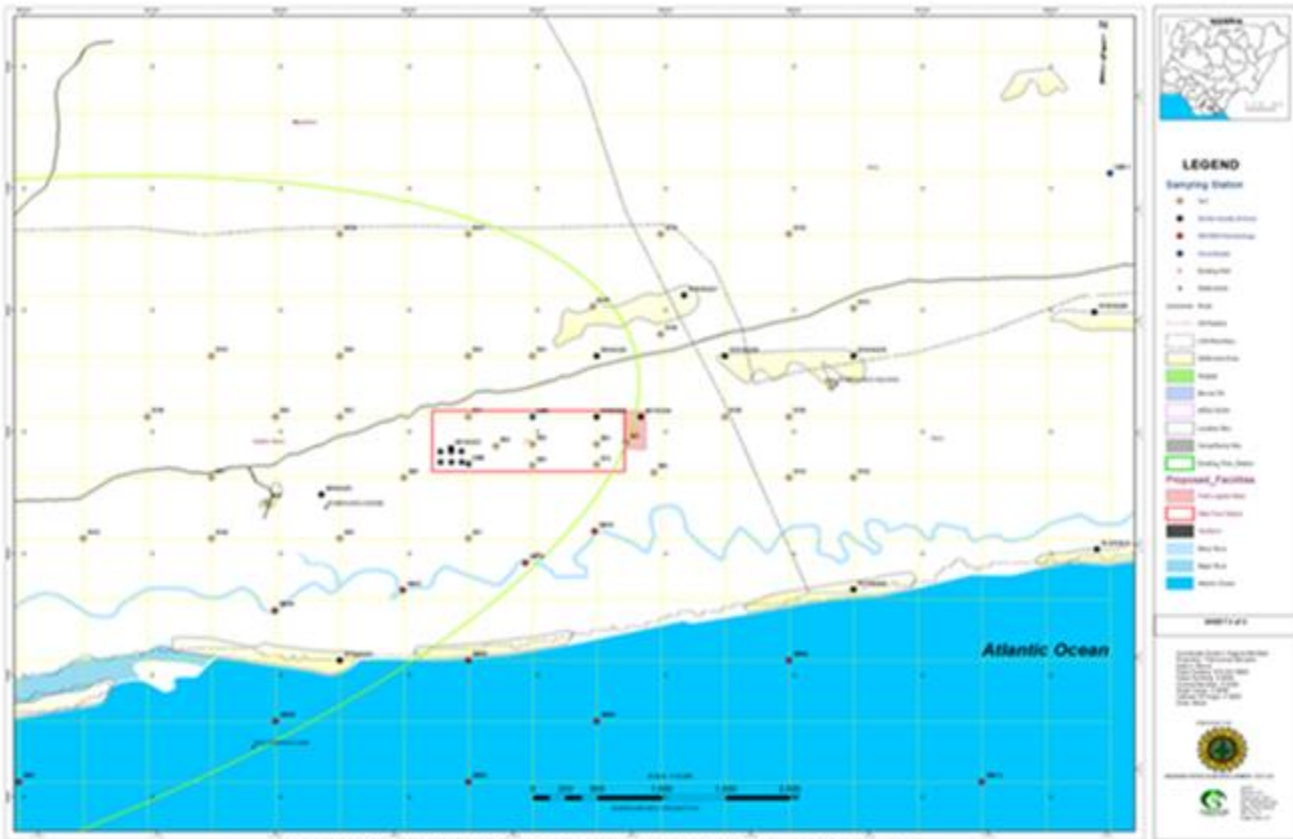
The sampling design is as indicated in the table/map including the control sampling points.

Table 1.2: Summary of Sample Stations

S/N	Environmental Component	No. of Station	Control Station	Total
1.	Soil	176	2	178
2.	Air Quality	53	2	55
3.	Noise	53	2	55
4.	Meteorology	53	2	55
5.	Groundwater	8	2	10
6.	Surface Water	62	2	64
7.	Sediment	62	2	64
8.	Benthos	62	2	64
9.	Phytoplankton	62	2	64
10.	Zooplankton	62	2	64
11.	Vegetation	30 Transects	30 Transects	-
12.	Socio-Economics/ Health	All concern 29 Communities	All concern 29 Communities	
TOTAL				**673**

EES SAMPLING MAP FOR UTAPATE FIELD IN OML 13

EES SAMPLING MAP FOR UTAPATE FIELD IN OML 13



EES SAMPLING MAP FOR UTAPATE FIELD IN OML 13

Fig.1.1: Sampling Map of the Study Area

Detailed Method of Sample Collection

The number and types of samples collected from the different environmental components are summarized in Table 2.1.

Air Quality

Methods of Sample Collection

Ambient air sampling was conducted in accordance with ASTM D5111-99.
At each station, the prevailing wind direction and speed were determined with ambient air monitoring instruments.

Sampling and measurements of the chemical constituents of atmospheric pollutants were carried out in-situ using the hand-held air quality monitoring equipment described below:

(a) Suspended Particular Matter (SPM): AEROCET 531 MET ONE High Volume Gravimetric sampler was used to collect airborne particulate matter.
(b) Aeroqual 500 series portable air quality meter for NO_2, SO_2, H_2S, CO, VOC, and CH4 was used.
(e) Wind speed and Direction, Humidity, Temperature A SKYMASTER Byrotech combined wind vane and Anemometer was used.

Noise Level Measurement
The noise levels in different locations of the study area were determined at several locations using a pre-calibrated BK precision 732 sound level meters.

Plate 1.1: Picture Showing Air Quality Consultants at Work.

Soils
Soil samples were collected as part of the environmental Audit studies of Anieze facilities. This was to examine and ascertain the condition of the soils with regards to the anthropogenic activities in the study area. The soil sample points were predetermined and spread randomly to effectively cover the study area. The points were located by navigating in the field using a hand held GPS however, where the predetermined point was not accessible; the nearest possible point was sampled and geo-referenced accordingly. A total of 20 soil samples were collected at ten (10) different points which included one (1) controls point.

Standard scientific methods were used to collect soil samples in the field. The samples were collected with the aid of a soil auger two different depths which were the surface (0 -15cm) and the subsurface (15 – 30 cm) depths. The samples were appropriately rapped in aluminum foil and put in a well labeled polythene bag and properly packaged for transit to the lab. Soil samples for microbiology were sub sampled from the main samples and preserved in ice packs before taken to the laboratory.

Plate 1.2: Picture Showing Soil Consultants at Work.

Land Use

For land use, a thorough field survey of the study sites were undertaken by the use of topographic map of the area provided. Eight (8) land use/land cover classes were identified in all the study sites/communities. The various land use classes were built-up area, cultivated land, shrubs/open grass land, oil palm, water body, jetty, oil pipelines, and oil wells. The identified land uses are of varying degrees and coverage.

Aquatic Studies

Aquatic studies covered the following components specified below:

a. Water Quality
b. Sediment Physico-chemistry
c. Phytoplankton Ecology
d. Zooplankton Ecology
e. Macrobenthic fauna Ecology
f. Fisheries Studies

A total of sixty-four (64) stations were covered for surface water studies of the above listed parameters respectively.

Sampling Methodology

Phytoplankton*:*
Phytoplankton was collected within the aquatic systems within the project area. Plankton net with a mesh size of 55µ to which a vial was attached at the bottom was used in sampling. The net was first lowered to a depth of 2-3m and slowly towed vertically for about 2 minutes. A horizontal tow was achieved by lowering the net to a depth of about 1m and towed at a speed of about 2 knots/hr for two minutes were applicable. The contents of the vial attached at the bottom of the plankton net was emptied into plastic vials and preserved in 4% formalin.

Zooplanktons:
Zooplankton was collected using plankton net with a mesh size of 55µ to which a vial was attached at the bottom. To achieve the objective, the net was first lowered to a depth of 2-3m and slowly towed vertically for about 2 minutes. A horizontal tow was achieved by lowering the net to a depth of about 1m and towed at 2 knots/hr for two minutes were applicable. The contents of the vial attached at the bottom of the plankton net was emptied into plastic vials and preserved in 4% formalin.

Benthos:
Eckman Grab was deployed into each of the sample point within the project area to sample for sediments. The Grab was deployed using an appropriate length of clean polypropylene rope. A composite of three successful grab samples were removed from the Grab using an acid washed plastic scoop, and placed in appropriately labeled, acid washed plastic or glass containers.

Benthic macro fauna were sampled by sieving 0.01 cm^3 of sediments through a 1.0mm mesh sieve in the field, using water. The samples were preserved in 2% formalin solution, and stored in sterilized plastic containers at room temperature and transported to the laboratory.

A summary of the biological samples that were collected from the aquatic medium is presented in Table below

Table 1.3: Summary of biological samples collected

Sample	Preservation technique	No. of samples.
Phytoplankton	2% formalin	8
Zooplankton	2% formalin	8
Benthos	2% formalin	8


1.3 Surface water/ Plankton Sampling:

An Eckman Grab was deployed at each station to sample for sediment. About 500gm of sediment was collected in cellophane bags for physic-chemistry, 5gms of sediment were collected into cellophane bags for microbiological analysis and another 200gm for THC and heavy metal analysis were collected into aluminum

Fishing activity was assessed by counting the number of fishermen at work at the time of sampling. The types of gear used by fishermen were observed and their catch examined for types of fish. Fishermen were also interviewed to obtain further information on the attributes of the fisheries of the areas under study.

1.4 Sediment / Benthos Sampling

Vegetation

Vegetation study was carried out at the established sampling points using random quadrat methods. A quadrat delimits an area, with ease of study in mind; for which vegetation cover can be estimated, plants counted, or species listed (Cox, 1990). The sizes of the quadrats (plots of a standard convenient size) used were 100m2 for trees, 5m2 for shrubs and 1m2 for herbaceous species. Standard error of two thirds of all quadrats was used to make accurate estimations (Babour *et al*., 1987). Numerical estimations were done in number of species per Ha.

1 hectare = 10, 000 square meters.

Where Density = [Sum total # of species 'A' in all the quadrats x] 2

Due to tree density, large quadrat size was achieved by the use of marine ropes and a 30 meter measuring tape. Pegs and tree trunks were used as pillars to establish the four corners of the quadrat bounded by rope perimeter. Sub units, consistent with the tree quadrat unit size, is further achieved by creating grid meshwork of ropes crisscrossing the outer frame. For each of the three plant habit categories listed above, five squares were chosen randomly and species within each were identified, enumerated, density established, tree girth (at breast height) and height accessed, and used to estimate the vegetation characteristics of the larger population at each location. This information was pooled together and used to describe the entire vegetation cover in terms of the relevant parameters assessed. Plants that could not be identified on site were sampled and incorporated into a plant press for herbarium studies. The profile of the vegetation cover was observed over a distance to establish the structure of the vegetation as well as profiles documented in pictures. The profile that best represents the habitat was selected. Pictures were obtained using a hand held digital camera. An analysis of the life-form structure of the habitat was carried out according to the Raunkiaer (1934) life-form classification. The dominant species composition, physiognomy and structure of the vegetation as well as the topography and hydrology are used to describe the ecological unit / habitat type. Information on the important ethno-botanical plants and utilisation patterns of the flora was compiled from oral interviews, chance observations, and existing literature.

Plant Pathology

The health status of the vegetation was visually assessed. The state of health of crops and vegetation were noted while infected crops and vegetation were collected and kept in moistened polythene bags and transported to the laboratory for further studies. Laboratory studies included isolation and characterization of pathogenic fungi and bacteria from infected plant materials.

Wildlife

Sampling Procedure

Interviews

Field based interviews were conducted to collect wildlife biodiversity data by discussing with local hunters and farmers. The people had earlier been briefed of the purpose of the survey and the benefits to the community. They provided names of birds, reptiles, amphibians and mammals in their local vernacular.

Transect surveys (Observations)

In each transect of about 50 meters apart, the survey team walked through transect recording animals sighted. The presence of animals was also inferred from indices like dung, burrows, footprints, claw marks, nests and feathers where available.

Calls

On each plot, the survey team stood quiet for some minutes, listened and recorded bird and animal calls. The identification was aided by local knowledge.

Geology/ Hydrogeology

Ten (10) boreholes were drilled within the study area. The dept to water levels of the boreholes were obtained using an electronic dip meter. The pH, DO, conductivity and Temperature values of the water were also recorded insitu. GPS coordinates were recorded for all sample locations.

Plate 1.5: Groundwater sampling during the field work

Socio-economic Studies

Socio-economic Data Acquisition Approach/Methodology

Acquisition of relevant socioeconomic characteristics of an area is a necessary condition without which environmental assessment process is incomplete. Social and economic field data provides vital information on the existing human environmental quality in which industrial activities and facilities have been on-going for some time or are planned to be undertaken. It is also useful for addressing adverse identified sensitive socioeconomic indicators as well as proffering measures to enhance effects found positive in the operating social environment.

The socio-economic study was planned to include the use of extensive literature materials and field data collection, using the interviews and the survey methods. Administration of structured questionnaires, key informants interviews and focus group discussions (FGDs) are the requisite tools to generate the necessary data.

The field study was supervised by the relevant regulatory agencies, and carried out between Tuesday 19th to Monday, 23rd September, 2019 and the identified and recognized communities visited are Atabrikang I, Okorombokho, Okoroiti, Okoroete, Iko, Elile, Amadaka, Kwampa, Edowink, Elekpo-Okoroete, Emerioke I & II, Okwanaobolo, Otuenene, Emeriemen, Akpabom, Bethlehem, Isotoyo, Amanglass, Okoromeobolo, Ayama, Okorobilom, Amangbuiji, Ozoubo, Amauka, Okoroinyang, Iwofe, Nkonta, Obianga, and Engwewe in Eastern Obolo LGA of Akwa-Ibom State.

Community Interaction/Focus Group Discussions (FGDs) & Questionnaire Administration, and Sampling Rationale/Technique

Effective socio-economic baseline data collection involves the use of several techniques and methods, including using interview schedules, questionnaire administration, Focus Group Discussion (FGD) and key informant interviews (KIIs). Community interactions and the above mentioned techniques are participatory rural appraisal (PRA) techniques used for the socioeconomic data collection. A mix of the PRA techniques (SSI, FGD and KII) has over the years yielded better results when appropriately utilized according to Akpofure and Ojile 1999.

Both qualitative and quantitative study techniques were employed for socioeconomic data collection. As a primary technique of data collection, community consultations and focus group discussions (FGDs) were employed and participants included. The socioeconomic team led by NPDC/Sterling Community Liaison Officer (CLO) entered the communities with prior notice/information and members were gathered and addressed by both the CLO (introduction) and the SIA team lead; on reasons of visit and sought participants cooperation to achieve study aim and objectives.

Thereafter, a community-wide focus group discussions (FGDs) were conducted. As an FGD approach, probing questions on relevant socio-economic elements were raised and answers solicited from the participants according to their relative positions in the community and level of knowledge (***See attached Plate***).

The administration of structured copies of the questionnaire is a conventional method of data collection in the social sciences. As a survey instrument and primary data collection method, the questionnaire is structured to incorporate socioeconomic, community and environmental issues and included binary, optional and open-ended questions that solicited relevant information from the householder. In consideration of the population and physical size of the affected communities, copies of the questionnaire were administered… four hundred and fifty (450) were administered at the communities and out of which 325 questionnaires were adequately completed for analysis, giving a response rate of 72.2%. Ground-truthing was also undertaken to identify, inventories and verify existing social infrastructures, their functionality, and capacity/adequacy. These were subsequently photographed where necessary to aid report preparation. The secondary source of data collection shall also be used extensively during report preparation.

Plate 1.5a: Stakeholders forum session at Eden Hotel, Eket

Plate1.5b: Stakeholders snapshot after the session at Eden Hotel, Eket

Plate 1.5c: Fieldwork kick-off session at Marylyn Hotel, Eket

Plate 1.5d: Few of Consultation/Interactive session with the Utapate Field host communities

Health Studies

Because of regulatory requirements, emphasis was placed on the use of rapid appraisal methods for the collection of the data. The methods used are:

- Focal Group Discussion
- Key informant interviews; and
- On-the-spot observations

These rapid appraisal methods were complemented by the use of a self-administered, semi-structured questionnaire. The anthropometric measurements of under-five children were also taken during the field study.

The Focus Group Discussions were conducted using the standard methods, in the houses of community leaders and other convenient places. The discussion sessions were held using a discussion guide (please find attached).

The key informant interviews were held with:

- Key opinion leaders of the communities

- Community health workers posted to the health centers that serve the communities
- Traditional medicine practitioners in the communities
- Owners of private health facilities in the communities; and
- Other opinion leaders in the community, chosen for their ability to provide the needed information
- Women

The interviews were held in all the communities visited; and were conducted in an environment that guarantees valid responses.

The interviews of the opinion leaders in the communities were to get a detail view of:

- The living conditions in the communities
- Presence of risk factors in the communities
- Health seeking behaviour; and
- To explore the interviewee's view on the possible health impact of the SPCD facilities on the respondent's community/ies.

The interviews of health workers and traditional medicine practitioners in the area were to assess the quality of health services in the communities, and the health seeking behaviour of members of the communities.

Direct observations were used to assess:

- The quality of health services in the health facilities that serve the community, using a checklist
- The practices of patent medicine dealers and Traditional Birth Attendants in the community; and
- The environmental health conditions in the community, especially:
    i. The layout of the buildings
    ii. The source of drinking water
    iii. Method of refuse disposal
    iv. Sanitation facilities

The HIA/SIA team, assisted by a local guide moved round the community, taking note of these and taking photographs where possible.

Efforts were also made during the field study to ensure that the health-specific parameters of surface water, ground water and air quality are carried out by the relevant bio-physical teams, according to the required standards. The results of these would be used for the final assessment of the possible health impacts.

Laboratory Analytical Methods and Procedure for Water, Sediment, and Soil Analysis
Laboratory Analysis

The methods of analyses used in this study were those specified in EGASPIN (2018 Revised) and other internationally accepted analytical procedures. Also, in order to ensure the reliability and integrity of the data obtained, *in-situ* measurements of some surface and ground water properties were carried out in the field. Heavy metals were analysed using Atomic Absorption Spectrophotometer (AAS).
Details of analyses of the parameters studied are as follows:

i. Phosphate: Phosphate was determined by the stannous chloride method (APHA, 1992). Phosphate in water reacts with ammonium molybdenum blue complex in the presence of stannous chloride. The intensity of colour was measured at 690 nm using a spectronic 20 spectrophotometer.

ii. Sulphate: Sulphate was determined by the turbidimetric method (APHA, 1992). The sulphate was reacted with barium ion in the presence of sodium chloride-hydrochloric acid solution containing glycerol and ethyl alcohol. This resulted in the formation of colloidal barium sulphate, which was measured at 420 nm with a spectronic 20 spectrophotometer.

iii. Total alkalinity: Total Alkalinity was determined by titrating water samples (100 ml) with 0.02 N sulphuric acid solution using methyl orange as indicator (APHA, 1992).

iv. Ammonium nitrogen: This was determined by the phenol-hypochlorite method (APHA, 1992). Alkaline phenol and hypochlorite catalysed by sodium nitroprusside, reacted with ammonia to form indophenol blue complex. The intensity of the colour was measured at 630 nm using a spectronic 20 spectrophotometer.

v. Suspended solids: This was measured by the gravimetric method (APHA, 1992). Water samples (200 ml) were filtered through pre-weighed 0.5μ membrane filters. The filters were then dried to constant weight in an oven.

vi. Chloride: Chloride was measured titrimetrically (Argentometric Method) in slightly alkaline solution with silver nitrate ($AgNO_3$) solution in the presence of potassium chromate as indicator (APHA, 1992).

vii. Oil: Oil in water was measured, after pre-extracting 100 ml sample with 10ml xylene, using a Horiba Oil Content Analyzer (OCMA-200, range 0-100 ppm).

viii Heavy Metals: Heavy metals were analysed using Unicam Atomic Absorption Spectrophotometer Model 929.

ix. Biochemical Oxygen Demand (BOD): The standard test involves seeding with river water, or effluent, and incubating at 20^oC, for five days. The dissolved oxygen in the sample was determined before and after incubation.

Two sets of samples were collected; one set for immediate dissolved oxygen (DO) determination and the other for incubation for 5 days at 20^oC. Prior to titration, each of the samples (250 ml) was fixed with 2 ml of Winkler I and II reagents. 2ml of concentrated H_2SO_4 was also added to aid liberation of iodine equivalent to the original DO content in the sample. The samples were then titrated with a standard solution of 0.025 M thiosulphate. The difference between initial and 5 day DO gave the BOD values in mg l^{-1} of Oxygen.

Soil Mechanical and Physical Properties.

Particle size distribution was determined by the methods of Bougoueus as described by Day (1967) which involves dispersing the soil with sodium hexametaphosphate (CALGON), followed by saturation and hydration of particles with sodium hydroxide. Temperature readings as well as hydrometer readings to determine the water content were taken at specific intervals. Textural classes were then obtained from the texture analysis and expressed as % clay, % silt and % sand.

Soil Chemical Analyses

i) pH: This was measured in 1:1 soil to water suspension with a glass electrode pH meter. Similar measurement was also made in a 1:1 soil to 1.0 M KCl suspension. The pH meter used was bench CIBA Corning/Kent/EIL 7055 (1990) with a sensitivity of $\pm$ 0.01.

ii) Electrical Conductivity (EC): This was measured in the 1:1 soil to water suspension after the pH measurement using a bench/field Corning portable conductivity meter-(1990) with a sensitivity of $\pm$ 0.5%, 0.2 µSat 5 mg/l ionic strength. The results were expressed in micro-siemens (µS) per cm.

iii) Organic Carbon: This was determined using ground soil sample by the chromic acid wet oxidation method of Walkley and Black (1973).

iv) Total Nitrogen: Ground samples of the soil were digested by the modified Kjeldahl method using a BD20/40 Tecator block digestor with concentrated H_2SO_4 and Selenium catalyst. The nitrogen content in the digest was determined on a bench Technicon-Auto-Analyser II.(1980/1985) with a sensitivity of 0.001 ppm.

Nutrient/Fertility Analysis.

v) Available Phosphate: The available phosphate in the soil was extracted with Brain P1 solution (NH_4F 0.03N + HCl 0.02 N) and analysed using the ascorbic acid- molybdenum blue colour method of Murphy and Ritney (1972) on a bench Technicon-Auto-Analyser II (1980/1985) with a sensitivity of 0.001 ppm

vi) NO_3^-, NO_2^-, and NH_4^+ Nitrogen forms: The NO_3^-, NO_2^-, and NH_4^+ nitrogen forms in the soils were determined by shaking 5.0g of representative soil sample with 50ml of 1.0 N K_2SO_4 and extracted, using Morgan's reagent. The NO_3^-N forms were assayed using the Brucine method of Greweling and Peech (1964). Likewise, the NO_2^-N and the NH_4^+ N forms were assayed using the alpha naphthol method and the alkaline phenate method respectively. A bench Technicon-Auto Analyser II (1980/1988) with a sensitivity of 0.001 ppm was also used.

vi) Sulphate (SO_4^{2-}): The sulphate in the soil was extracted with a 500ml solution of potassium orthophosphate and the sulphate determined by $BaCl_2$. $2H_2O$ Gelatic turbidimetric method.

viii) Exchangeble Cations (Na^+, K^+, Ca^{++}, Mg^{++}): The exchangeable cations of the soil were extracted by equilibrating/shaking in neutral ammonium acetate. Calcium and magnesium ions concentrations were determined volumetrically by titration with EDTA while Na^+ and K^+ were determined by flame photometry using a digital bench Gallenkamp flame photometer (1990) with a sensitivity of 3 ppm.

vii) Exchangeable Acidity (H^+ and Al^{3+}): Exchangeable H^+ and Al^{3+} were determined by extraction with 1.0M KCl solution. The extract was first determined for exchangeable acidity (H^+ + Al^{3+}) by filtration with 0.05N HCl using phenolphthalien as indicator. Al^{3+} was only determined with 0.05N HCl after addition of 10 ml NaF solution (Mclean, 1965).

x) Effective Cation Exchange Capacity (ECEC): The effective cation exchange capacity (ECEC) was taken as summation of exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and exchange acidity ($Al^{3+} + H^{+}$) (Black *et al.,* 1965**)**.

xi Heavy Metals Analyses: The heavy metals (Fe, Mn, Zn, Cu, Cr, Cd, Ni, V, Pb, Hg) were extracted using a mixture of equal volumes of analytical grade of a 1:10 soil to water ratio, shaken for 1h and followed by filtration. Fe, Mn, Zn, Cu, Cr, Cd, Ni, V, Pb and Hg were determined by Flame Atomic Absorption Spectrometer (AAS) using air-acetylene flame. Vanadium by AAS, but using nitrous oxide-acetylene flame.

Hg was analysed by the flameless AAS using the cold vapour mode.

xii) Total Hydrocarbon Content: Five (5) grammes of the representative soil samples were weighed into 100ml volumetric flask. 10ml of xylene was added and mixed by swirling for 5 minutes and filtered through Whatman No 1. filter paper. The filtrate obtained was placed in the sample cell and measured in the UV spectrophotometer (Bench CECIL absorbance 303/393, sensitivity is $\pm$ 0.01 ppm). The concentration of hydrocarbon was obtained from standard calibration curve and the results were reported in mg/kg.

xiii) Planktons: The phytoplankton species were identified using a Leitz Orthoplan Universal Wide-Field Research Microscope equipped with tracing and measuring devices. Enumeration of cells per m^3 was computed using the following formula:

Number of cells/m^3 = [N X 1000]/[Initial volume of water filtered]

where N = Cells counted per sample. That is;

$$\frac{\textbf{Counts x Fraction}}{\textbf{No. of fields counted}} \times \frac{\textbf{1}}{\textbf{Volume of Chamber}} \times \frac{\textbf{100}}{\textbf{1}}$$

Sorting and identification of the zooplankton were performed using a Wild-Lietz Stereo Zoom dissecting microscope and an Olympus Universal Vanox Research microscope with drawing attachment. Representative specimens were mounted in 100% glycerine after dissection of relevant taxonomic parts. Identifications were made to the lowest possible taxonomic level using relevant identification keys. Individuals of each identified taxon in each sample were enumerated using the counting chamber, and the zooplankton density expressed in numbers per m^3 using the formula:

Number of individuals/m^3 = [N X 1000]/[Initial volume of water filtered]

Where, N = total number of zooplanktons per sample.

Where Subsamples from the original 100ml concentrated samples were used, 'N' was first computed from the original sample before estimating the density.

xiv) Benthos: Benthic analysis was carried out using the Binocular Dissecting Microscope and the compound microscope for sorting, dissecting, slide preparation, identification and counting.

Faunal densities were computed in numbers per m^2 by multiplying the counts in the bank-root biotope by 4 and those of the bottom sediment by 44.4.

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

(1) Margalef's index (d) of taxa richness where $\mathbf{d} = \frac{\mathbf{S-1}}{\mathbf{lnN}}$

S = number of taxa, and N = total number of individuals/cell.

(2) Shannon-Wiener index (H) of general diversity: where $\mathbf{H} = \frac{\mathbf{N \log N - f_i \log f_i}}{\mathbf{N}}$

N = total number of individuals/cell and f_i = Number of individuals/cell in species 'i'.
(3) Evenness Index (E), where $E = H/ H_{max}$; where $H_{max} = \log S$.
Evenness measures the degree of uniformity in the distribution or spread of individuals among the species (Odum 1971, Zar 1983).

xv) Microbiology: Soil microorganisms were estimated by the soil dilution plate method in which serial dilution of all the soil samples in sterile normal saline were plated on a surface agar medium. 10 g of each sample was aseptically added to 90ml of sterile normal saline and shaken vigorously to give a 10-fold dilution (10^{-1}). Transferring 1ml of the soil suspension to 9ml of the diluents, 10-fold serial dilutions were made. Up to 10^{-4} aliquots (0.1ml) of appropriate dilutions were then spread/plated in duplicate on surface nutrient agar (Oxoid cm 13), MacConkey agar (Oxoid cm 7) and Sabouraud dextrose agar (SDA). The nutrient agar and MacConkey agar plates were incubated at 37^{o}C for 24 hours, while the Sabouraud agar plates were incubated at ambient temperature (28-30^{o}C) for 3 - 7 days. Chloramphenicol was added to differentially isolate fungi. The plates with soil extract were incubated at 30^{o}C for 96 hours for fungi species.
Population counts of hydrocarbon degrading bacteria and fungi were carried out using the methods of Mills *et al.,* (1978). The prepared media were autoclaved at 121^{o}C for 15 minutes. Each inoculated plate was inverted over sterile filter paper, which was moistened with Bonny light blend crude oil, placed in the lid of the Petri dish for 4 days. The resulting hydrocarbon biodegrading bacteria and fungi were recorded and their counts expressed as a percentage of the total heterotrophic bacteria or fungi.
Diseased plant/crop parts were aseptically collected using a sharp knife into sterilized polythene bags for further pathological studies in the laboratory. Photographs of the dominant vegetation types as well as other features of interest were taken. A total of 27 vegetation sampling sites were studied.

xvi) Plant Tissue Analysis: Mature leaves samples collected from the field were oven-dried at 70^{o}C and milled to pass through a 2 mm mesh sieve. Sub-samples of these milled samples were then dry-ashed or wet-ashed (in some cases) and analysed to estimate their chemical composition.

Dry-ashing of plant materials was carried out by placing 1g of the finely ground plant material in silica dish and placed in a muffle furnace and burnt to ash at 550 ^{o}C for 4 hours. It was then cooled and the ash dissolved in 5 ml of 2N HNO_3,, filtered into a 50 ml volumetric flask and diluted to volume with distilled water. Determinations of K, Ca, Mg, Mn, Fe, Zn, Cu, Cr, Pb, Ni, V, Cd and Hg were then carried out with a flame photometer, Auto Analyser, and Atomic Absorption Spectrophotometer. For the determination of phosphorous, the milled samples were also dry-ashed, only that the plant materials were treated with about 5ml of a 50% solution of hydrated magnesium nitrate ($Mg (NO_3)_2 . 6H_2O$) and heated at low temperature on a water bath until completely dried, before being burnt to ash in a muffle furnace at 550 ^{0}C for four hours, after which it was allowed to cool. Determination of nitrogen in plant samples was by using Kjeldahl's method with 0.5g of plant material.

xvii) Identification of Disease Pathogens: Diseased plant specimens were where necessary, washed with clean water before sterilization with 0.1% of $HgCl_2$ for one minute. Sterilized plant materials were then washed in sterile distilled water to remove traces of the sterilant. These were then cut into small bits (2 mm x 2 mm) and plated in nutrient medium following the methods of Wadel and Weber (1963) and Emua and Fajola (1982).

Three media were used in the isolation of pathogenic organisms, viz.: Yeast Extract Agar (YEA), Potato Dextrose Agar (PDA) as well as a decoction of the respective plant material. While the YEA and PDA were prepared following standard methods, the decoctions were each prepared as follows:
A 250g of plant material was chopped and boiled in 500 ml distilled water for one hour. This was allowed to cool and the supernatant carefully filtered through a laboratory test sieve (2 mm aperture). A 10g laboratory nutrient broth and 20g agar-agar were then added. This was then made up to one litter, mixed and dispensed at 200 ml into 250 ml conical flasks for sterilization. All media were sterilized in the autoclave at 1 kg/cm^2 for 15 minutes.
Specimens were inoculated into media plates and incubated at 25^{o}C $\pm$ 1^{o}C until adequate growth of organisms was obtained. Colonies so formed were examined under the microscope, counted and correctly identified using specific texts (Barneth and Hunter 1972, Street 1969).

Appendixes 3

LABORATORY RESULTS

Soil Laboratory Results

FIRST SEASON: Sample Location Mean- Top (0-15cm) and bottom Soil(0-30cm)

A. **Anions:**

Sample Code	Longitude	Latitude	Nitrate	Ammonia	Phosphate	Sulphate	Chloride
OML13/UTP/SS1	7.746622	4.512974	21.00	0.25	0.40	8.28	428.87
OML13/UTP/SS2	7.748224	4.513378	11.75	0.14	0.36	4.86	581.07
OML13/UTP/SS3	7.760141	4.51182	8.50	0.69	1.32	17.22	2330.53
OML13/UTP/SS4	7.764648	4.511824	10.00	0.00	0.40	6.99	518.87
OML13/UTP/SS5	7.766093	4.515153	20.00	0.16	0.38	10.05	581.07
OML13/UTP/SS6	7.765385	4.519561	38.75	0.76	2.05	20.64	518.59
OML13/UTP/SS7	7.76267	4.516345	28.00	0.32	0.40	10.09	549.83

OML13/UTP/SS8	7.759575	4.518565	23.00	0.18	2.33	14.54	737.27
OML13/UTP/SS9	7.751355	4.515127	24.40	0.42	0.93	16.63	674.79
OML13/UTP/SS10	7.746618	4.516329	26.25	0.23	1.04	6.92	1268.36
OML13/UTP/SS11	7.742812	4.514534	27.38	0.32	0.84	13.16	437.36
OML13/UTP/SS12	7.737606	4.516319	23.20	0.53	2.16	6.96	699.78
OML13/UTP/SS13	7.737601	4.520842	58.65	0.44	0.45	11.39	1049.67
OML13/UTP/SS14	7.742108	4.520846	11.75	0.46	0.71	5.40	487.35
OML13/UTP/SS15	7.746513	4.52175	15.38	0.00	0.39	0.00	612.31
OML13/UTP/SS16	7.75112	4.520856	20.38	0.39	1.22	11.25	518.59
OML13/UTP/SS17	7.757063	4.520766	80.75	0.18	0.44	2.34	487.35
OML13/UTP/SS18	7.763581	4.529484	4.38	0.09	0.41	6.27	456.11
OML13/UTP/SS19	7.767206	4.52636	17.38	0.09	0.44	9.95	581.07
OML13/UTP/SS20	7.769144	4.520874	33.75	0.60	1.24	20.47	331.15
OML13/UTP/SS21	7.728603	4.507264	18.88	0.52	0.58	0.67	393.63
OML13/UTP/SS22	7.696755	4.509897	8.88	0.30	2.32	3.46	374.88
OML13/UTP/SS23	7.702915	4.511759	20.74	0.53	1.98	15.88	3736.34
OML13/UTP/SS24	7.756213	4.513744	8.50	0.35	0.79	5.10	518.59
OML13/UTP/SS25	7.750558	4.514029	20.13	0.35	1.19	25.69	374.88
OML13/UTP/SS26	7.751631	4.513697	38.00	0.28	0.56	13.40	393.63
OML13/UTP/SS27	7.75021	4.515694	31.38	0.21	2.82	14.58	299.91
OML13/UTP/SS28	7.754523	4.513733	17.50	0.44	0.60	19.29	443.61
OML13/UTP/SS29	7.755244	4.514653	27.75	0.71	0.54	15.46	706.03
OML13/UTP/SS30	7.755237	4.513039	14.75	0.39	0.26	5.03	593.57
OML13/UTP/SS31	7.760903	4.514462	46.00	0.48	2.10	9.89	612.31
OML13/UTP/SS32	7.757298	4.514458	48.50	0.41	1.50	12.72	837.24
OML13/UTP/SS33	7.764112	4.514811	9.50	0.18	1.83	4.99	581.07
OML13/UTP/SS34	7.749781	4.519774	29.63	0.14	1.02	6.64	643.55
OML13/UTP/SS35	7.751807	4.520022	24.50	0.46	2.18	11.94	768.51
OML13/UTP/SS36	7.7505	4.518359	17.38	0.00	1.04	4.01	493.60
OML13/UTP/SS37	7.754	4.526	22.38	0.12	0.96	5.19	331.15
OML13/UTP/SS38	7.729207	4.510056	59.00	0.41	1.15	2.96	456.11
OML13/UTP/SS39	7.727048	4.513107	23.00	0.55	1.68	1.61	443.61
OML13/UTP/SS40	7.723265	4.509723	29.88	0.60	0.87	12.57	412.37
OML13/UTP/SS41	7.715088	4.504714	7.00	0.30	1.18	9.03	487.35
OML13/UTP/SS42	7.689953	4.505031	11.38	0.21	2.53	4.26	312.40
OML13/UTP/SS43	7.687989	4.510796	7.00	0.42	1.94	7.91	443.61
OML13/UTP/SS44	7.685022	4.504473	15.00	0.25	1.81	5.08	462.36
OML13/UTP/SS45	7.674529	4.509259	10.00	0.32	2.09	5.04	462.36
OML13/UTP/SS46	7.674541	4.498159	20.25	0.09	3.87	5.77	456.11
OML13/UTP/SS47	7.670028	4.505224	37.50	0.00	2.50	8.75	331.15
OML13/UTP/SS48	7.664601	4.517961	60.00	0.35	1.63	6.01	481.10
OML13/UTP/SS49	7.657674	4.518288	20.00	0.33	1.58	10.16	518.59
OML13/UTP/SS50	7.64748	4.520171	17.75	0.28	0.98	7.72	618.56
OML13/UTP/SS51	7.746609	4.525374	35.00	0.51	1.13	0.49	306.16
OML13/UTP/SS52	7.75909	4.525314	12.38	0.45	0.57	7.53	706.03
OML13/UTP/SS53	7.749717	4.533069	14.00	0.28	1.26	6.65	768.51
OML13/UTP/SS54	7.748213	4.534178	12.38	0.20	1.19	0.49	581.07

OML13/UTP/SS55	7.742093	4.534415	13.75	0.51	3.37	16.34	768.51
OML13/UTP/SS56	7.710325	4.536499	14.50	0.60	2.23	9.21	324.90
OML13/UTP/SS57	7.706049	4.529853	21.13	0.18	2.60	3.13	306.16
OML13/UTP/SS58	7.692559	4.526639	6.25	0.50	2.88	10.04	362.39
OML13/UTP/SS59	7.737583	4.538933	10.88	0.14	3.41	6.65	368.64
OML13/UTP/SS60	7.753925	4.514576	27.25	0.42	0.87	14.60	487.35
OML13/UTP/SS61	7.754002	4.513983	37.88	0.39	0.49	5.00	524.84
OML13/UTP/SS62	7.753649	4.513475	19.63	0.28	1.04	6.47	443.61
OML13/UTP/SS63	7.753968	4.510249	16.63	0.42	0.62	11.22	331.15
OML13/UTP/SS64	7.758431	4.510609	51.25	0.62	1.66	17.57	962.20
OML13/UTP/SS65	7.7591	4.515364	31.38	0.47	1.87	11.49	518.59
OML13/UTP/SS66	7.7582	4.514439	40.13	2.55	1.27	12.12	674.79
OML13/UTP/SS67	7.760002	4.514441	57.50	0.25	3.01	4.01	318.65
OML13/UTP/SS68	7.759102	4.513564	51.00	0.47	2.27	6.25	874.73
OML13/UTP/SS69	7.759099	4.516269	11.00	0.30	1.76	5.77	674.79
OML13/UTP/SS70	7.759094	4.521696	4.19	0.09	1.05	6.65	324.90
OML13/UTP/SS71	7.761427	4.515605	15.13	0.30	0.66	5.00	418.62
OML13/UTP/SS72	7.74212	4.508869	12.00	0.42	1.39	2.75	706.03
OML13/UTP/SS73	7.755631	4.516338	33.75	0.00	1.98	5.03	1237.12
OML13/UTP/SS74	7.758146	4.529962	18.50	0.50	1.44	6.25	643.55
OML13/UTP/SS75	7.760114	4.538956	102.50	0.00	2.99	5.00	674.79
OML13/UTP/SS76	7.769131	4.534443	20.25	0.12	0.51	7.10	393.63
OML13/UTP/SS77	7.805181	4.534478	15.75	0.00	1.22	2.38	343.64
OML13/UTP/SS78	7.814194	4.534487	23.50	0.16	0.89	7.50	1387.07
OML13/UTP/SS79	7.814197	4.530921	12.50	0.18	1.46	8.42	1393.32
OML13/UTP/SS80	7.809691	4.530845	14.75	0.32	0.51	4.89	549.83
OML13/UTP/SS81	7.803966	4.532134	8.75	0.32	1.54	12.67	343.64
OML13/UTP/SS82	7.809689	4.532457	31.50	0.23	0.76	5.20	474.85
OML13/UTP/SS83	7.814196	4.532438	21.25	0.28	1.76	6.31	374.88
OML13/UTP/SS84	7.807136	4.532305	14.13	0.14	1.97	8.77	318.65
OML13/UTP/SS85	7.816258	4.532579	9.50	0.32	1.68	7.53	356.14
OML13/UTP/SS86	7.818229	4.530359	11.75	0.14	1.58	9.30	206.19
OML13/UTP/SS87	7.817296	4.53449	14.75	0.25	0.98	7.50	374.88
OML13/UTP/SS88	7.800679	4.529951	14.13	0.23	0.71	4.89	499.85
OML13/UTP/SS89	7.794886	4.528698	9.38	0.63	1.53	10.00	631.05
OML13/UTP/SS90	7.791662	4.534465	17.50	0.39	2.28	6.92	574.82
OML13/UTP/SS91	7.78716	4.529938	20.00	0.27	1.46	8.83	343.64
OML13/UTP/SS92	7.796164	4.538992	15.00	0.58	0.51	7.06	349.89
OML13/UTP/SS93	7.796169	4.534469	19.25	0.55	1.02	13.78	487.35
OML13/UTP/SS94	7.805177	4.539001	22.50	0.00	1.20	5.77	456.11
OML13/UTP/SS95	7.809683	4.539005	13.13	0.35	0.76	3.63	599.81
OML13/UTP/SS96	7.814189	4.539009	30.75	0.31	0.26	8.61	406.12
OML13/UTP/SS97	7.80519	4.525433	9.38	0.23	0.91	11.25	612.31
OML13/UTP/SS98	7.791076	4.528126	28.38	0.09	0.96	2.99	612.31
OML13/UTP/SS99	7.796177	4.525424	7.13	0.76	0.34	11.96	624.81
OML13/UTP/SS100	7.78265	4.534456	15.00	0.74	0.13	6.25	612.31
OML13/UTP/SS101	7.787152	4.538983	28.63	0.60	0.06	12.20	581.07

OML13/UTP/SS102	7.787165	4.525415	24.50	0.46	0.16	13.20	393.63
OML13/UTP/SS103	7.778153	4.525406	76.25	0.47	0.40	16.04	581.07
OML13/UTP/SS104	7.813927	4.542686	23.00	0.48	0.05	10.97	424.87
OML13/UTP/SS105	7.820344	4.543538	33.25	0.17	0.09	22.92	549.83
OML13/UTP/SS106	7.818694	4.540633	17.00	0.27	2.72	7.50	474.85
OML13/UTP/SS107	7.823202	4.539018	16.25	0.24	1.44	5.51	924.71
OML13/UTP/SS108	7.823206	4.534495	15.00	0.29	1.65	3.63	213.18
OML13/UTP/SS109	7.827713	4.534499	13.25	0.15	1.98	4.14	518.59
OML13/UTP/SS110	7.832215	4.539026	13.00	0.00	1.35	5.76	1074.67
OML13/UTP/SS111	7.830677	4.536695	3.75	0.09	0.92	10.00	624.81
OML13/UTP/SS112	7.832223	4.529981	3.25	0.39	1.66	17.50	387.38
OML13/UTP/SS113	7.832212	4.54257	17.38	0.00	3.73	4.88	324.90
OML13/UTP/SS114	7.827717	4.529977	17.88	0.10	1.81	12.82	893.47
OML13/UTP/SS115	7.818687	4.548059	4.75	0.00	1.18	11.25	449.86
OML13/UTP/SS116	7.796155	4.548038	3.75	0.06	1.10	7.55	474.85
OML13/UTP/SS117	7.805168	4.548046	18.38	0.33	2.32	6.48	481.10
OML13/UTP/SS118	7.849135	4.542309	19.13	0.30	0.98	20.05	293.66
OML13/UTP/SS119	7.8277	4.548068	20.38	0.30	1.70	4.01	456.11
OML13/UTP/SS120	7.733305	4.512159	2.88	0.00	2.62	0.58	324.90
OML13/UTP/SS121	7.734207	4.511236	12.25	0.25	1.77	10.04	287.41
OML13/UTP/SS122	7.733346	4.510351	21.00	0.44	2.81	1.04	231.18
OML13/UTP/SS123	7.732405	4.511234	27.63	0.41	2.37	5.03	487.35
OML13/UTP/SS124	7.733304	4.513064	12.25	0.42	3.08	4.25	518.59
OML13/UTP/SS125	7.735108	4.511257	21.25	0.25	2.32	7.53	462.36
OML13/UTP/SS126	7.731503	4.511253	16.25	0.00	2.98	3.13	706.03
OML13/UTP/SS127	7.733311	4.506732	7.00	0.40	2.72	3.30	518.59
OML13/UTP/SS128	7.726096	4.51119	7.88	0.14	1.89	10.03	293.66
OML13/UTP/SS129	7.733282	4.533868	16.25	0.09	1.44	6.26	362.39
OML13/UTP/SS130	7.724073	4.529873	10.13	0.19	2.63	6.07	393.63
OML13/UTP/SS131	7.728584	4.525355	5.75	0.36	0.52	5.01	581.07
OML13/UTP/SS132	7.737592	4.529887	12.25	0.14	4.13	3.13	362.39
OML13/UTP/SS133	7.72857	4.538923	13.50	0.21	3.30	7.20	431.12
OML13/UTP/SS134	7.708158	4.505773	21.75	0.21	1.14	6.65	362.39
OML13/UTP/SS135	7.709059	4.504849	11.25	0.00	1.54	9.35	474.85
OML13/UTP/SS136	7.708159	4.503963	28.75	0.28	1.28	6.67	349.89
OML13/UTP/SS137	7.707258	4.504847	23.25	0.23	0.93	5.77	393.63
OML13/UTP/SS138	7.708157	4.506677	27.50	0.54	1.96	6.65	518.59
OML13/UTP/SS139	7.709961	4.50487	21.50	0.18	1.18	4.51	418.62
OML13/UTP/SS140	7.708161	4.503059	17.75	0.00	1.39	5.07	487.35
OML13/UTP/SS141	7.706356	4.504866	30.13	0.23	0.79	2.58	456.11
OML13/UTP/SS142	7.708154	4.509391	32.50	0.47	1.45	9.99	549.83
OML13/UTP/SS143	7.712664	4.504783	24.25	0.12	1.39	5.77	424.87
OML13/UTP/SS144	7.711939	4.502406	20.63	0.21	0.69	4.89	393.63
OML13/UTP/SS145	7.704944	4.501698	5.25	0.30	0.93	8.78	424.87
OML13/UTP/SS146	7.703654	4.504773	5.00	0.46	1.62	7.49	331.15
OML13/UTP/SS147	7.708151	4.512104	7.63	0.63	1.13	14.09	331.15
OML13/UTP/SS148	7.700949	4.504803	24.38	0.30	2.20	10.58	515.59

OML13/UTP/SS149	7.708147	4.515722	30.63	0.64	1.58	19.08	456.11
OML13/UTP/SS150	7.718681	4.507373	20.88	0.09	1.46	4.01	487.35
OML13/UTP/SS151	7.723796	4.505333	24.75	0.67	1.28	3.86	387.38
OML13/UTP/SS152	7.697344	4.504856	16.25	0.14	0.31	10.21	549.83
OML13/UTP/SS153	7.702794	4.526183	21.13	0.35	3.90	4.89	287.41
OML13/UTP/SS154	7.719572	4.525345	5.00	0.25	2.03	3.80	268.27
OML13/UTP/SS155	7.719586	4.511777	20.75	0.14	1.99	14.01	643.55
OML13/UTP/SS156	7.68692	4.497321	99.00	0.69	1.37	5.07	487.35
OML13/UTP/SS157	7.688055	4.501934	22.00	0.09	2.54	8.13	456.11
OML13/UTP/SS158	7.669787	4.501406	20.38	0.18	1.46	4.01	487.35
OML13/UTP/SS159	7.679042	4.502687	13.00	0.35	2.64	8.43	443.61
OML13/UTP/SS160	7.679032	4.511733	19.50	0.18	2.29	6.27	237.43
OML13/UTP/SS161	7.674521	4.51625	15.39	1.13	1.67	7.54	424.87
OML13/UTP/SS162	7.69254	4.520793	12.50	0.07	0.80	8.81	337.40
OML13/UTP/SS163	7.715061	4.529863	18.75	0.29	4.77	3.13	362.39
OML13/UTP/SS164	7.71956	4.536161	2.88	0.40	4.00	12.75	737.27
OML13/UTP/SS165	7.703011	4.533354	5.00	0.50	0.23	8.94	374.88
OML13/UTP/SS166	7.685381	4.523373	18.75	0.47	2.33	8.66	337.40
OML13/UTP/SS167	7.659853	4.508103	21.88	0.21	0.60	11.62	549.83
OML13/UTP/SS168	7.67001	4.520768	36.25	0.39	2.50	7.69	612.31
OML13/UTP/SS169	7.653856	4.514489	25.25	0.42	3.61	2.34	549.83
OML13/UTP/SS170	7.660994	4.523616	22.13	0.00	1.85	4.01	231.18
OML13/UTP/SS171	7.651982	4.523605	20.50	0.26	2.53	4.93	631.05
OML13/UTP/SS172	7.796186	4.516378	7.00	0.24	2.05	6.49	387.38
OML13/UTP/SS173	7.832231	4.521651	11.50	0.36	2.81	5.19	231.18
OML13/UTP/SS174	7.746543	4.538958	3.50	0.40	2.58	4.94	549.83
OML13/UTP/SS175	7.751184	4.525779	39.13	0.22	0.61	6.59	424.87
OML13/UTP/SS176	7.755651	4.53687	14.75	0.33	1.66	8.66	449.86

B. Organic Compounds

Sample Code	Longitude	Latitude	TOC	Oil & Grease	THC	TPH	PAH	BTEX
OML13/UTP/SS1	7.746622	4.512974	1.39	0.42	ND	ND	ND	ND
OML13/UTP/SS2	7.748224	4.513378	0.72	0.32	ND	ND	ND	ND
OML13/UTP/SS3	7.760141	4.51182	1.36	0.45	0.11	0.04	ND	ND
OML13/UTP/SS4	7.764648	4.511824	1.48	1.04	ND	ND	ND	ND
OML13/UTP/SS5	7.766093	4.515153	1.60	0.59	ND	0.02	ND	ND
OML13/UTP/SS6	7.765385	4.519561	0.91	0.14	0.41	0.25	0.02	ND
OML13/UTP/SS7	7.76267	4.516345	0.82	6.08	ND	ND	ND	ND
OML13/UTP/SS8	7.759575	4.518565	1.16	0.22	ND	ND	ND	ND
OML13/UTP/SS9	7.751355	4.515127	1.01	0.54	ND	ND	ND	ND
OML13/UTP/SS10	7.746618	4.516329	1.17	0.74	0.41	ND	ND	ND
OML13/UTP/SS11	7.742812	4.514534	1.49	1.23	ND	ND	ND	ND
OML13/UTP/SS12	7.737606	4.516319	1.53	0.36	0.09	0.09	ND	ND
OML13/UTP/SS13	7.737601	4.520842	1.26	0.57	ND	ND	ND	ND
OML13/UTP/SS14	7.742108	4.520846	1.75	0.17	0.38	0.38	ND	ND
OML13/UTP/SS15	7.746513	4.52175	1.63	0.52	0.34	0.34	ND	ND
OML13/UTP/SS16	7.75112	4.520856	0.52	0.00	0.44	0.44	ND	ND
OML13/UTP/SS17	7.757063	4.520766	1.53	0.49	0.52	0.52	ND	ND

OML13/UTP/SS18	7.763581	4.529484	1.33	0.50	ND	ND	ND	ND
OML13/UTP/SS19	7.767206	4.52636	0.81	0.00	ND	ND	ND	ND
OML13/UTP/SS20	7.769144	4.520874	1.27	0.15	ND	ND	ND	ND
OML13/UTP/SS21	7.728603	4.507264	2.19	0.74	0.23	0.23	ND	ND
OML13/UTP/SS22	7.696755	4.509897	1.52	0.33	0.20	0.20	ND	ND
OML13/UTP/SS23	7.702915	4.511759	1.80	0.71	0.21	0.21	ND	ND
OML13/UTP/SS24	7.756213	4.513744	1.98	0.40	0.16	0.16	ND	ND
OML13/UTP/SS25	7.750558	4.514029	2.20	0.70	ND	ND	ND	ND
OML13/UTP/SS26	7.751631	4.513697	0.49	0.00	0.17	0.17	ND	ND
OML13/UTP/SS27	7.75021	4.515694	0.70	0.44	0.23	0.23	ND	ND
OML13/UTP/SS28	7.754523	4.513733	1.74	0.58	0.22	0.22	ND	ND
OML13/UTP/SS29	7.755244	4.514653	1.30	0.49	0.08	0.08	ND	ND
OML13/UTP/SS30	7.755237	4.513039	1.42	0.74	0.30	0.30	ND	ND
OML13/UTP/SS31	7.760903	4.514462	1.66	0.80	0.58	0.19	0.03	ND
OML13/UTP/SS32	7.757298	4.514458	1.31	0.36	0.27	0.08	ND	ND
OML13/UTP/SS33	7.764112	4.514811	0.70	0.35	ND	ND	ND	ND
OML13/UTP/SS34	7.749781	4.519774	1.54	0.28	0.06	ND	ND	ND
OML13/UTP/SS35	7.751807	4.520022	1.09	0.55	ND	ND	ND	ND
OML13/UTP/SS36	7.7505	4.518359	1.26	0.00	0.30	0.04	ND	ND
OML13/UTP/SS37	7.754	4.526	1.99	0.48	ND	ND	ND	ND
OML13/UTP/SS38	7.729207	4.510056	0.83	0.79	0.45	0.18	ND	ND
OML13/UTP/SS39	7.727048	4.513107	1.20	0.00	0.35	0.12	ND	ND
OML13/UTP/SS40	7.723265	4.509723	1.74	0.49	0.15	ND	ND	ND
OML13/UTP/SS41	7.715088	4.504714	1.73	0.79	0.65	0.22	ND	ND
OML13/UTP/SS42	7.689953	4.505031	0.63	0.87	0.38	0.36	ND	ND
OML13/UTP/SS43	7.687989	4.510796	2.52	0.45	0.97	0.15	0.60	ND
OML13/UTP/SS44	7.685022	4.504473	0.67	0.00	0.45	ND	ND	ND
OML13/UTP/SS45	7.674529	4.509259	0.98	0.08	0.06	0.05	ND	ND
OML13/UTP/SS46	7.674541	4.498159	1.93	0.05	0.28	0.10	ND	ND
OML13/UTP/SS47	7.670028	4.505224	1.74	0.51	0.09	ND	ND	ND
OML13/UTP/SS48	7.664601	4.517961	1.28	0.33	0.28	0.08	ND	ND
OML13/UTP/SS49	7.657674	4.518288	1.21	0.27	0.35	0.09	ND	ND
OML13/UTP/SS50	7.64748	4.520171	1.28	0.00	0.56	0.09	0.01	ND
OML13/UTP/SS51	7.746609	4.525374	2.31	0.78	0.86	ND	ND	ND
OML13/UTP/SS52	7.75909	4.525314	2.01	0.32	0.74	0.15	0.01	ND
OML13/UTP/SS53	7.749717	4.533069	1.01	0.28	0.31	0.09	ND	ND
OML13/UTP/SS54	7.748213	4.534178	1.37	0.65	0.26	0.05	ND	ND
OML13/UTP/SS55	7.742093	4.534415	0.73	0.10	ND	ND	ND	ND
OML13/UTP/SS56	7.710325	4.536499	2.01	0.46	0.34	0.07	ND	ND
OML13/UTP/SS57	7.706049	4.529853	1.29	0.00	0.31	0.01	ND	ND
OML13/UTP/SS58	7.692559	4.526639	0.87	0.11	0.04	ND	ND	ND
OML13/UTP/SS59	7.737583	4.538933	2.39	1.31	0.56	0.20	0.01	ND
OML13/UTP/SS60	7.753925	4.514576	0.92	0.76	0.28	0.03	ND	ND
OML13/UTP/SS61	7.754002	4.513983	2.09	0.71	0.39	0.04	ND	ND
OML13/UTP/SS62	7.753649	4.513475	1.98	0.65	0.84	0.09	0.01	ND
OML13/UTP/SS63	7.753968	4.510249	1.61	0.70	0.14	0.01	ND	ND
OML13/UTP/SS64	7.758431	4.510609	2.27	1.32	0.59	0.06	ND	ND
OML13/UTP/SS65	7.7591	4.515364	1.41	0.51	0.09	ND	ND	ND
OML13/UTP/SS66	7.7582	4.514439	1.03	0.07	0.36	0.04	ND	ND
OML13/UTP/SS67	7.760002	4.514441	1.30	1.29	0.53	0.05	0.02	ND
OML13/UTP/SS68	7.759102	4.513564	1.49	0.19	0.05	ND	ND	ND
OML13/UTP/SS69	7.759099	4.516269	1.14	1.13	0.29	0.12	ND	ND
OML13/UTP/SS70	7.759094	4.521696	1.24	0.30	0.14	0.01	ND	ND
OML13/UTP/SS71	7.761427	4.515605	1.42	0.96	0.68	0.14	0.04	ND
OML13/UTP/SS72	7.74212	4.508869	1.28	2.33	0.99	0.16	ND	ND

OML13/UTP/SS73	7.755631	4.516338	1.51	1.80	0.96	0.26	0.06	ND
OML13/UTP/SS74	7.758146	4.529962	1.89	0.53	0.85	0.14	ND	ND
OML13/UTP/SS75	7.760114	4.538956	1.98	1.69	0.89	0.28	0.04	ND
OML13/UTP/SS76	7.769131	4.534443	1.36	2.15	0.69	0.11	ND	ND
OML13/UTP/SS77	7.805181	4.534478	1.85	1.16	1.33	0.37	ND	ND
OML13/UTP/SS78	7.814194	4.534487	1.73	0.64	0.62	0.05	ND	ND
OML13/UTP/SS79	7.814197	4.530921	1.59	2.06	1.14	0.17	0.02	ND
OML13/UTP/SS80	7.809691	4.530845	1.14	0.28	0.67	0.25	ND	ND
OML13/UTP/SS81	7.803966	4.532134	1.50	1.47	1.04	0.07	0.01	ND
OML13/UTP/SS82	7.809689	4.532457	1.64	1.90	0.88	0.16	0.07	ND
OML13/UTP/SS83	7.814196	4.532438	1.99	1.80	0.96	0.10	0.06	ND
OML13/UTP/SS84	7.807136	4.532305	1.95	0.53	0.85	0.16	0.03	ND
OML13/UTP/SS85	7.816258	4.532579	1.98	0.00	1.10	0.07	0.02	ND
OML13/UTP/SS86	7.818229	4.530359	1.36	2.15	1.51	0.47	0.08	ND
OML13/UTP/SS87	7.817296	4.53449	1.85	1.16	1.11	0.37	ND	ND
OML13/UTP/SS88	7.800679	4.529951	1.73	0.64	0.81	ND	ND	ND
OML13/UTP/SS89	7.794886	4.528698	1.20	0.34	1.00	0.09	0.02	ND
OML13/UTP/SS90	7.791662	4.534465	1.43	0.07	0.50	0.01	ND	ND
OML13/UTP/SS91	7.78716	4.529938	1.90	0.65	0.02	ND	ND	ND
OML13/UTP/SS92	7.796164	4.538992	1.14	2.48	0.15	0.02	ND	ND
OML13/UTP/SS93	7.796169	4.534469	1.08	1.91	0.25	ND	ND	ND
OML13/UTP/SS94	7.805177	4.539001	1.33	1.95	0.41	0.01	ND	ND
OML13/UTP/SS95	7.809683	4.539005	0.69	2.13	0.23	0.04	ND	ND
OML13/UTP/SS96	7.814189	4.539009	1.03	0.55	0.25	0.03	ND	ND
OML13/UTP/SS97	7.80519	4.525433	2.59	0.17	1.33	0.08	ND	ND
OML13/UTP/SS98	7.791076	4.528126	0.99	1.78	0.22	0.09	0.02	ND
OML13/UTP/SS99	7.796177	4.525424	2.25	1.24	ND	ND	ND	ND
OML13/UTP/SS100	7.78265	4.534456	1.36	0.29	ND	ND	ND	ND
OML13/UTP/SS101	7.787152	4.538983	1.25	0.84	0.15	0.01	ND	ND
OML13/UTP/SS102	7.787165	4.525415	2.36	0.95	0.89	0.04	ND	ND
OML13/UTP/SS103	7.778153	4.525406	0.96	0.16	0.28	ND	ND	ND
OML13/UTP/SS104	7.813927	4.542686	2.06	0.80	0.60	0.22	0.03	0.01
OML13/UTP/SS105	7.820344	4.543538	1.05	0.90	ND	ND	ND	ND
OML13/UTP/SS106	7.818694	4.540633	1.26	1.37	0.75	ND	ND	ND
OML13/UTP/SS107	7.823202	4.539018	1.06	0.31	0.26	0.04	ND	ND
OML13/UTP/SS108	7.823206	4.534495	2.05	0.99	0.20	0.04	ND	ND
OML13/UTP/SS109	7.827713	4.534499	2.25	1.24	ND	ND	ND	ND
OML13/UTP/SS110	7.832215	4.539026	2.29	0.83	1.29	0.17	0.01	ND
OML13/UTP/SS111	7.830677	4.536695	1.59	0.86	0.52	0.14	0.06	ND
OML13/UTP/SS112	7.832223	4.529981	2.36	1.44	0.92	0.05	0.01	ND
OML13/UTP/SS113	7.832212	4.54257	1.91	0.36	0.21	ND	ND	ND
OML13/UTP/SS114	7.827717	4.529977	1.91	0.90	0.21	0.08	ND	ND
OML13/UTP/SS115	7.818687	4.548059	1.21	0.45	0.31	0.03	ND	ND
OML13/UTP/SS116	7.796155	4.548038	2.05	0.59	0.78	0.05	ND	ND
OML13/UTP/SS117	7.805168	4.548046	2.16	0.49	ND	ND	ND	ND
OML13/UTP/SS118	7.849135	4.542309	0.71	1.31	0.13	ND	ND	ND
OML13/UTP/SS119	7.8277	4.548068	1.26	1.01	ND	ND	ND	ND
OML13/UTP/SS120	7.733305	4.512159	2.00	1.17	ND	ND	ND	ND
OML13/UTP/SS121	7.734207	4.511236	1.81	0.96	0.39	0.02	ND	ND
OML13/UTP/SS122	7.733346	4.510351	2.20	0.86	0.11	0.08	ND	ND
OML13/UTP/SS123	7.732405	4.511234	1.26	0.08	1.02	ND	ND	ND
OML13/UTP/SS124	7.733304	4.513064	1.61	0.74	0.33	0.05	ND	ND
OML13/UTP/SS125	7.735108	4.511257	2.06	0.84	0.74	0.06	ND	ND
OML13/UTP/SS126	7.731503	4.511253	1.74	1.28	0.84	0.18	0.09	ND
OML13/UTP/SS127	7.733311	4.506732	1.75	1.00	0.29	0.05	ND	ND

OML13/UTP/SS128	7.726096	4.51119	2.14	0.18	0.62	0.04	ND	ND
OML13/UTP/SS129	7.733282	4.533868	1.07	1.06	0.16	0.01	ND	ND
OML13/UTP/SS130	7.724073	4.529873	1.73	1.30	0.36	0.01	ND	ND
OML13/UTP/SS131	7.728584	4.525355	2.13	1.17	0.56	0.06	ND	ND
OML13/UTP/SS132	7.737592	4.529887	1.74	0.77	0.68	0.10	ND	ND
OML13/UTP/SS133	7.72857	4.538923	1.52	0.57	0.14	ND	ND	ND
OML13/UTP/SS134	7.708158	4.505773	1.97	0.80	0.20	ND	ND	ND
OML13/UTP/SS135	7.709059	4.504849	1.64	2.23	0.51	0.03	ND	ND
OML13/UTP/SS136	7.708159	4.503963	1.20	1.00	0.07	ND	ND	ND
OML13/UTP/SS137	7.707258	4.504847	2.17	0.81	1.04	0.03	ND	ND
OML13/UTP/SS138	7.708157	4.506677	1.62	0.99	ND	ND	ND	ND
OML13/UTP/SS139	7.709961	4.50487	1.60	0.54	0.30	0.03	ND	ND
OML13/UTP/SS140	7.708161	4.503059	1.15	1.06	0.31	0.01	ND	ND
OML13/UTP/SS141	7.706356	4.504866	2.07	0.56	0.24	0.08	ND	ND
OML13/UTP/SS142	7.708154	4.509391	1.33	1.13	0.30	0.06	ND	ND
OML13/UTP/SS143	7.712664	4.504783	2.12	1.19	0.09	ND	ND	ND
OML13/UTP/SS144	7.711939	4.502406	1.79	0.91	0.85	0.11	ND	ND
OML13/UTP/SS145	7.704944	4.501698	1.88	1.18	0.28	0.05	ND	ND
OML13/UTP/SS146	7.703654	4.504773	2.13	0.85	0.44	0.05	ND	ND
OML13/UTP/SS147	7.708151	4.512104	1.94	0.00	ND	ND	ND	ND
OML13/UTP/SS148	7.700949	4.504803	1.31	0.44	0.47	0.08	ND	ND
OML13/UTP/SS149	7.708147	4.515722	1.74	0.95	0.61	0.04	ND	ND
OML13/UTP/SS150	7.718681	4.507373	1.35	1.27	0.33	ND	ND	ND
OML13/UTP/SS151	7.723796	4.505333	1.34	0.14	0.06	ND	ND	ND
OML13/UTP/SS152	7.697344	4.504856	1.61	1.46	0.21	0.02	ND	ND
OML13/UTP/SS153	7.702794	4.526183	1.40	2.05	0.83	0.10	ND	ND
OML13/UTP/SS154	7.719572	4.525345	0.74	0.75	0.19	ND	ND	ND
OML13/UTP/SS155	7.719586	4.511777	1.48	0.23	ND	ND	ND	ND
OML13/UTP/SS156	7.68692	4.497321	1.61	1.10	0.27	0.05	ND	ND
OML13/UTP/SS157	7.688055	4.501934	0.87	1.50	0.43	0.03	ND	ND
OML13/UTP/SS158	7.669787	4.501406	1.49	0.00	ND	ND	ND	ND
OML13/UTP/SS159	7.679042	4.502687	2.08	1.51	0.69	0.10	ND	ND
OML13/UTP/SS160	7.679032	4.511733	1.14	0.05	ND	ND	ND	ND
OML13/UTP/SS161	7.674521	4.51625	2.06	0.10	1.30	ND	ND	ND
OML13/UTP/SS162	7.69254	4.520793	2.30	0.17	1.34	ND	ND	ND
OML13/UTP/SS163	7.715061	4.529863	1.94	0.07	1.05	0.03	0.01	ND
OML13/UTP/SS164	7.71956	4.536161	1.75	0.15	0.80	ND	ND	ND
OML13/UTP/SS165	7.703011	4.533354	2.19	0.23	0.39	0.08	0.01	ND
OML13/UTP/SS166	7.685381	4.523373	1.94	1.61	0.90	0.03	ND	ND
OML13/UTP/SS167	7.659853	4.508103	2.01	0.61	0.90	0.14	0.03	ND
OML13/UTP/SS168	7.67001	4.520768	1.20	0.11	1.80	ND	ND	ND
OML13/UTP/SS169	7.653856	4.514489	2.04	0.63	1.39	ND	ND	ND
OML13/UTP/SS170	7.660994	4.523616	1.73	0.74	ND	ND	ND	ND
OML13/UTP/SS171	7.651982	4.523605	1.57	0.86	0.27	0.04	ND	ND
OML13/UTP/SS172	7.796186	4.516378	1.48	0.62	0.10	0.02	ND	ND
OML13/UTP/SS173	7.832231	4.521651	2.23	0.31	0.56	0.08	ND	ND
OML13/UTP/SS174	7.746543	4.538958	1.27	0.31	0.55	0.04	ND	ND
OML13/UTP/SS175	7.751184	4.525779	1.67	1.36	0.76	0.05	0.01	ND
OML13/UTP/SS176	7.755651	4.53687	1.88	1.13	0.42	0.01	ND	ND

Table 1: Surface Water Microbiology - Wet Season

	Total Coliform Count (MPN/100ml)	Faecal Coliform (MPN/100ml)	Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	Total Heterotrophic Fungi Count (x10^1 cfu/ml)

Sample ID	APHA 9221 B	APHA 9221 E	APHA 9215 B	APHA 9610 B
OML13/UTP/SW1	NIL	NIL	7.5 x 10^3	3.0 x10^2
OML13/UTP/SW2	27	NIL	8.6 x 10^3	4.0 x10^2
OML13/UTP/SW3	NIL	NIL	7.9 x 10^3	NIL
OML13/UTP/SW4	NIL	NIL	4.3 x 10^3	4.0 x10^2
OML13/UTP/SW5	11	NIL	7.8 x 10^3	NIL
OML13/UTP/SW6	NIL	NIL	9.4 x 10^3	NIL
OML13/UTP/SW7	NIL	NIL	5.5 x 10^3	NIL
OML13/UTP/SW8	120	20	2.5 x 10^3	8.0 x10^2
OML13/UTP/SW9	NIL	NIL	4.9 x 10^3	6.0 x10^2
OML13/UTP/SW10	NIL	NIL	6.5 x 10^3	5.0 x10^2
OML13/UTP/SW11	16	NIL	9.1 x 10^3	NIL
OML13/UTP/SW12	NIL	NIL	1.06 x 10^4	6.0 x10^2
OML13/UTP/SW13	NIL	NIL	9.0 x 10^2	2.0 x10^2
OML13/UTP/SW14	NIL	NIL	1.64 x 10^4	4.0 x10^2
OML13/UTP/SW15	43	NIL	8.6 x 10^3	9.0 x10^2
OML13/UTP/SW16	NIL	NIL	1.15 x 10^4	3.0 x10^2
OML13/UTP/SW17	11	NIL	1.34 x 10^4	6.0 x10^2
OML13/UTP/SW18	3.6	NIL	2.5 x 10^3	5.0 x10^2
OML13/UTP/SW19	NIL	NIL	2.1 x 10^3	1.1 x10^3
OML13/UTP/SW20	7.2	NIL	6.8 x 10^3	NIL
OML13/UTP/SW21	38	9.2	1.05 x 10^4	NIL
OML13/UTP/SW22	NIL	NIL	6.4 x 10^3	NIL
OML13/UTP/SW23	NIL	NIL	7.5 x 10^3	7.0 x10^2
OML13/UTP/SW24	75	20	9.4 x 10^3	NIL
OML13/UTP/SW25	27	NIL	8.4 x 10^3	5.0 x10^2
OML13/UTP/SW26	NIL	NIL	9.2 x 10^3	2.0 x10^2
OML13/UTP/SW27	7.4	NIL	6.7 x 10^3	9.0 x10^2
OML13/UTP/SW28	NIL	NIL	6.4 x 10^3	6.0 x10^2
OML13/UTP/SW29	120	20	8.3 x 10^3	6.0 x10^2
OML13/UTP/SW30	15	NIL	1.34 x 10^4	8.0 x10^2
OML13/UTP/SW31	11	NIL	1.58 x 10^4	1.5 x10^3
OML13/UTP/SW32	15	NIL	1.18 x 10^4	1.8 x10^3
OML13/UTP/SW33	NIL	NIL	3.0 x 10^3	1.0 x10^2
OML13/UTP/SW34	NIL	NIL	7.6 x 10^3	3.0 x10^2
OML13/UTP/SW35	9	3.6	1.18 x 10^4	4.0 x10^2
OML13/UTP/SW36	NIL	NIL	1.31 x 10^4	6.0 x10^2
OML13/UTP/SW37	23	7	1.48 x 10^4	6.0 x10^2
OML13/UTP/SW38	NIL	NIL	1.54 x 10^4	7.0 x10^2
OML13/UTP/SW39	160	14	3.4 x 10^3	NIL
OML13/UTP/SW40	NIL	NIL	2.6 x 10^3	6.0 x10^2
OML13/UTP/SW41	15	NIL	4.1 x 10^3	NIL
OML13/UTP/SW42	NIL	NIL	5.1 x 10^3	5.0 x10^2
OML13/UTP/SW43	20	NIL	2.7 x 10^3	2.0 x10^2
OML13/UTP/SW44	20	NIL	6.2 x 10^3	NIL
OML13/UTP/SW45	NIL	NIL	3.1 x 10^3	NIL
OML13/UTP/SW46	3	NIL	1.7 x 10^3	6.0 x10^2
OML13/UTP/SW47	NIL	NIL	6.0 x 10^3	NIL
OML13/UTP/SW488	6	NIL	7.5 x 10^3	3.0 x10^2
OML13/UTP/SW49	3.6	NIL	6.4 x 10^3	NIL
OML13/UTP/SW50	NIL	NIL	7.6 x 10^3	4.0 x10^2
OML13/UTP/SW51	16	NIL	9.4 x 10^3	1.1 x10^3
OML13/UTP/SW52	23	3.6	1.22 x 10^4	9.0 x10^2
OML13/UTP/SW53	NIL	NIL	1.9 x 10^3	NIL
OML13/UTP/SW54	6.2	NIL	2.2 x 10^3	NIL

OML13/UTP/SW55	NIL	NIL	7.1 x 10^3	6.0 x10^2
OML13/UTP/SW56	150	11	9.5 x 10^3	3.0 x10^2
OML13/UTP/SW57	20	NIL	2.5 x 10^3	NIL
OML13/UTP/SW58	NIL	NIL	1.5 x 10^3	4.0 x10^2
OML13/UTP/SW59	NIL	NIL	4.6 x 10^3	7.0 x10^2
OML13/UTP/SW60	NIL	NIL	7.2 x 10^3	9.0 x10^2
OML13/UTP/SW61	3	NIL	2.6 x 10^3	4.0 x10^2
OML13/UTP/SW62	NIL	NIL	6.7 x 10^3	3.0 x10^2
OML/UTP/SWC1	NIL	NIL	1.03 x 10^4	NIL
OML/UTP/SWC2	21	NIL	6.8 x 10^3	2.0 x10^2
OML/UTP/SWC3	4	NIL	3.8 x 10^3	NIL

Table 7: Surface Water Microbiology - Dry Season

	Total Coliform Count (MPN/100ml)	Faecal Coliform (MPN/100ml)	Total Heterotrophic Bacteria Count (x10^1 cfu/ml)	Total Heterotrophic Fungi Count (x10^1 cfu/ml)
OML13/UTP/SW1	NIL	NIL	8.3 x 10^3	4.0 x10^2
OML13/UTP/SW2	43	3.6	8.9 x 10^3	2.0 x10^2
OML13/UTP/SW3	NIL	NIL	6.5 x 10^3	NIL
OML13/UTP/SW4	NIL	NIL	5.4 x 10^3	3.0 x10^2
OML13/UTP/SW5	21	NIL	8.3 x 10^3	NIL
OML13/UTP/SW6	NIL	NIL	8.6 x 10^3	NIL
OML13/UTP/SW7	NIL	NIL	6.2 x 10^3	NIL
OML13/UTP/SW8	75	20	6.8 x 10^3	5.0 x10^2
OML13/UTP/SW9	NIL	NIL	5.7 x 10^3	NIL
OML13/UTP/SW10	NIL	NIL	7.5 x 10^3	3.0 x10^2
OML13/UTP/SW11	21	NIL	8.5 x 10^3	3.0 x10^2
OML13/UTP/SW12	NIL	NIL	9.7 x 10^4	6.0 x10^2
OML13/UTP/SW13	14	NIL	9.3 x 10^3	3.0 x10^2
OML13/UTP/SW14	NIL	NIL	1.01 x 10^4	3.0 x10^2
OML13/UTP/SW15	29	NIL	7.7 x 10^3	4.0 x10^2
OML13/UTP/SW16	NIL	NIL	9.5 x 10^4	3.0 x10^2
OML13/UTP/SW17	11	NIL	1.08 x 10^4	4.0 x10^2
OML13/UTP/SW18	7.2	NIL	6.4 x 10^3	5.0 x10^2
OML13/UTP/SW19	NIL	NIL	1.3 x 10^3	1.1 x10^3

	Total Coliform Count (MPN/100ml)	Faecal Coliform (MPN/100ml)	Total Heterotrophic Bacteria Count ($x10^1$ cfu/ml)	Total Heterotrophic Fungi Count ($x10^1$ cfu/ml)
OML13/UTP/SW20	111	NIL	8.6×10^3	2.0×10^2
OML13/UTP/SW21	26	11	1.52×10^4	5.0×10^2
OML13/UTP/SW22	NIL	NIL	7.1×10^3	2.0×10^2
OML13/UTP/SW23	15	NIL	6.4×10^3	2.0×10^2
OML13/UTP/SW24	93	20	6.3×10^3	NIL
OML13/UTP/SW25	16	NIL	9.1×10^3	5.0×10^2
OML13/UTP/SW26	NIL	NIL	9.2×10^3	2.0×10^2
OML13/UTP/SW27	9.4	7.2	1.24×10^4	7.0×10^2
OML13/UTP/SW28	NIL	NIL	7.5×10^3	7.0×10^2
OML13/UTP/SW29	75	21	8.6×10^3	4.0×10^2
OML13/UTP/SW30	9.2	NIL	1.11×10^4	8.6×10^2
OML13/UTP/SW31	NIL	NIL	9.9×10^3	7.0×10^2
OML13/UTP/SW32	NIL	NIL	1.23×10^4	1.5×10^3
OML13/UTP/SW33	NIL	NIL	4.7×10^3	1.0×10^2
OML13/UTP/SW34	NIL	NIL	8.6×10^3	5.0×10^2
OML13/UTP/SW35	NIL	3.6	1.37×10^4	9.0×10^2
OML13/UTP/SW36	NIL	NIL	1.54×10^4	8.0×10^2
OML13/UTP/SW37	36	7.2	1.09×10^4	7.0×10^2
OML13/UTP/SW38	NIL	NIL	1.65×10^4	7.0×10^2
OML13/UTP/SW39	75	14	6.1×10^3	NIL
OML13/UTP/SW40	NIL	NIL	5.62×10^3	4.0×10^2
OML13/UTP/SW41	35	3	5.3×10^3	NIL
OML13/UTP/SW42	6.1	NIL	4.4×10^3	5.0×10^2
OML13/UTP/SW43	21	3	6.8×10^3	4.0×10^2
OML13/UTP/SW44	14	NIL	7.2×10^3	2.0×10^2
OML13/UTP/SW45	NIL	NIL	2.8×10^3	NIL
OML13/UTP/SW46	NIL	NIL	4.3×10^3	4.0×10^2
OML13/UTP/SW47	7.2	NIL	7.5×10^3	2.0×10^2
OML13/UTP/SW48	NIL	NIL	4.0×10^3	3.0×10^2
OML13/UTP/SW49	11	NIL	9.2×10^3	2.0×10^2
OML13/UTP/SW50	NIL	NIL	4.7×10^3	4.0×10^2
OML13/UTP/SW51	29	NIL	1.32×10^4	9.0×10^2
OML13/UTP/SW52	9.4	3.6	1.46×10^4	7.0×10^2
OML13/UTP/SW53	3	NIL	4.5×10^3	2.0×10^2
OML13/UTP/SW54	3	NIL	6.5×10^3	NIL
OML13/UTP/SW55	NIL	NIL	3.2×10^3	7.0×10^2
OML13/UTP/SW56	75	15	7.8×10^3	5.0×10^2
OML13/UTP/SW57	21	NIL	3.3×10^3	NIL
OML13/UTP/SW58	NIL	NIL	1.5×10^3	2.0×10^2
OML13/UTP/SW59	16	NIL	5.1×10^3	1.0×10^2
OML13/UTP/SW60	NIL	NIL	6.6×10^3	6.0×10^2
OML13/UTP/SW61	20	7.2	4.3×10^3	4.0×10^2
OML13/UTP/SW62	NIL	NIL	4.1×10^3	NIL
OML/UTP/SWC1	23	NIL	8.6×10^3	5.0×10^2
OML/UTP/SWC2	NIL	NIL	5.3×10^3	2.0×10^2
OML/UTP/SWC3	16	NIL	7.3×10^3	2.0×10^2

Hydrobiology Results Swamp

Phytoplankton	SWc1	SWc2	SW8	SW9	SW10	SW11	SW13	SW15	SW16	SW17	SW18	SW19	SW20	SW21	SW22	SW23	SW24	SW25	SW26	SW27
Baccillariophyceae																				
Amphora sp	47	0	56	45	0	110	48	0	0	56	61	50	5	48	0	44	0	0	45	10
Amphora ovalis	73	34	0	0	55	0	53	56	6	53	11	0	69	0	59	0	61	0	0	94
Bacillaria paradoxa	34	18	28	7	0	10	0	0	81	10	4	0	0	27	25	12	0	69	0	60
Bacillaria paxillifera	24	34	20	0	0	0	0	0	0	82	54	3	45	11	0	63	0	0	25	17
Bacteriastrum delicatulum	9	0	3	32	66	0	93	0	45	22	57	48	37	20	0	22	10	0	56	10
Biddulphia laevis	27	56	21	45	0	28	15	0	0	18	11	0	0	0	40	0	0	42	8	45
Biddulphia longicruris	38	8	45	0	41	0	45	43	24	60	0	18	20	0	24	0	0	17	32	2
Chaetoceros mulleri	18	8	20	18	10	17	11	15	22	76	28	0	0	0	45	36	0	5	10	15
Cheatoceros decipens	15	28	18	29	10	37	15	20	0	47	81	3	45	10	12	18	0	17	32	0
Cheatoceros didyma	30	0	21	0	0	0	27	25	12	0	0	0	0	7	10	0	45	0	31	0
Cheatoceros emeroli	7	39	11	41	3	45	11	0	63	0	0	29	10	0	32	0	3	0	83	56
Corethrone sp	18	51	42	7	48	37	20	0	22	0	86	32	10	0	10	65	22	0	86	111
Coscinodiscus centalis	5	39	11	43	0	45	9	12	5	0	41	39	0	0	2	0	28	20	0	0
Coscinodiscus concinniformis	19	0	27	0	0	0	0	40	0	9	26	47	0	51	0		0	21	45	0
Coscinodiscus concinnus	24	23	25	16	18	20	0	24	0	28	28	17	89	27	0	0	17	45	0	41
Coscinodiscus radiate	29	43	0	0	0	0	0	45	36	0	18	12	19	20	25	9	37	20	18	10
Coscinodiscus rothii	6	39	11	42	3	45	10	12	2	18	94	0	85	2	81	2	0	18	29	10
Cyclotella meneghianina	39	16	32	0	29	10	0	32	0	21	12	17	0	51	32	2	37	11	41	3
Cyclotella striata	27	9	21	69	32	10	0	10	65	0	0	10	0	35	31	0	45	42	7	48
Cymbella ovalis	0	0	29	36	39	0	0	2	0	12	18	18	16	22	20	0	0	11	43	0
Diatoma hiemale	48	0	21	67	25	95	5	29	45	19	29	45	0	48	5	0	20	27	0	0
Ditylum brightwelli	60	22	85	47	54	0	0	52	53	0	0	2	27	0	31	0	0	25	16	18
Eunotia gracilis	22	34	15	45	19	24	28	0	53	23	2	15	0	0	0	32	45	0	0	0
Fragillariopsis atlantica	83	0	94	21	0	0	56	0	27	35	9	0	28	10	0	0	0	11	42	3
Fragillriopsis oceanica	3	0	19	21	12	6	38	87	43	11	29	0	0	15	39	0	10	9	45	0
Gyrosigma	0	0	20	20	26	0	104	0	42	38	7	56	0	0	0	0	10	32	0	29
Hantzschia amphioxys	0	0	41	0	0	6	28	45	0	22	0	111	91	0	0	5	0	21	69	32
Lauderia borealis	18	12	18	31	27	0	5	19	0	0	24	0	0	0	38	0		29	36	39
Leptocylindricus sp.	26	0	20	0	29	11	32	14	10	28	0	4	0	0		0		21	67	25
Melosia moniliformis	9	0	29	73	41	6	20	0	0	48	0	51	32	0	0	0	93	85	47	54
Navicula bacillum	36	93	32	15	43	0	45	0	0	89	54	35	31	67	0	3	0	15	45	19
Navicula cuspidata	0	15	41	0	49	0	0	0	10	0	43	22	20	24	0	12	0	94	21	0
Navicula gracilis	60	25	65	39	28	0	0	0	0	0	12	48	5	8	0	15	0	19	21	12
Nitzschia closterium	76	63	82	31	0	62	29	0	0	31	14	0	0	3	10	38	28	41	0	0
N. linearis	26	0	20	0	29	10	34	0	94	63	0	10	0	32	0	78	8	18	31	27
N. longissima	0	27	15	15	20	23	28	23	34	62	0	15	39	0	0	0	41	20	0	29
Odontella sinensis	45	21	0	22	13	0	10	6	26	0	0	5	8	0	15	0		29	73	41
Pinnularia appendiculata	52	39	47	73	53	0	46	0	4	0	5	0	0	0	0	0	0	32	15	43
P. interrupta	10	0	0	45	2	45	10	0	9	24	21	0	0	0	0	0	0	41	0	49
Planktonella sol	0	48	43	12	7	0	13	39	18	0	72	0	0	0	0	0	0	15	5	25
Pleurosigma angulatum	32	0	28	9	21	11	0	28	0	12	27	0	31	0	0	15	40	42	31	0
P. elongatum	45	10	48	0	38	2	43	43	67	36	0	0	0	25	17	0	51	32	0	0

Rhizosolenia erensis	43	0	34	0	0	0	0	94	28	0	0	10	0	56	10	0	35	31	67	0
Rhizosolenia habetata	61	0	33	46	75	16	59	69	46	28	63	21	25	25	18	16	22	20	24	0
Rhizosolenia longiseta	0	44	4	47	0	51	0	6	0	36	39	0	42	8	45	0	48	5	8	0
R. simlpex	49	65	43	17	89	27	0	56	10	49	19	0	17	32	2	27	0	31	32	75
R. styliformis	26	0	0	12	19	20	25	24	19	0	0	0	5	10	15	0	0	0	3	10
Skeletonmema sp	54	0	0	0	85	2	81	79	31	14	43	0	17	32	0	28	10	0	32	0
Surirella caproni	0	69	0	60	0	0	0	0	27	101	25	45	0	31	0	0	15	39	0	0
S. robusta	0	0	25	17	0	51	32	0	0	0	93	3	0	83	56	0	0	0	81	0
Synedra acus	10	0	56	10	0	35	31	67	0	3	0	22	0	86	111	91	0	0	83	104
S. rumpens	21	25	25	18	16	22	20	24	0	12	0	36	15	36	6	39	12	17	0	7
S. ulna	0	42	8	45	0	48	5	8	0	15	0	18	56	45	0	11	42	21	83	37
Tabellaria fenestrata	0	17	32	2	27	0	31	32	75	5	10	8	43	0	38	0	45	43	26	29
Thalassionema bacillare	0	5	10	15	0	0	0	3	10	38	28	44	32	66	41	0	0	0	32	39
T. nitzschoides	0	17	32	0	28	10	0	32	0	78	8	32	0	0	0	48	4	46	60	11
Thalassiosira sp.	45	0	31	0	0	15	39	0	0	0	41	0	0	15	0	45	0	45	43	0
Thalassiothrix nitzschoides	22	0	86	111	91	0	0	83	104	67	25	0	0	64	0	46	9	45	71	8
Triceratium sp	10	49	38	0	0	0	38	35	10	54	41	15	28	125	90	45	0	28	37	79
Sub-Total	**1481**	**1187**	**1676**	**1416**	**1320**	**1012**	**1292**	**1333**	**1278**	**1553**	**1413**	**1016**	**1042**	**1277**	**1035**	**867**	**893**	**1367**	**1837**	**1376**
Chlorophyceae																				
Staurastrun seligerum	14	43	0	0	10	40	0	12	28	46	28	45	43	0	0	0	0	0	0	0
Closterium lineatum	56	0	49	0	48	0	50	54	8	20	10	29	64	15	0	0	31	0	0	15
Eudorina sp	28	23	27	12	20	20	25	25	25	45	0	45	63	8	19	0	0	25	17	0
Halosphaera viridis	10	36	15	36	6	39	12	17	0	7	25	28	37	79	59	10	0	56	10	0
H. spheroides	27	18	56	45	0	11	42	21	83	37	89	0	10	40	0	12	28	46	28	45
Pandorina	17	8	43	0	38	0	45	43	26	29	0	0	48	0	50	54	8	20	10	29
Phacolus	20	44	32	66	41	0	0	0	32	69	81	0	0	0	0	0	0	41	0	49
Phaeocystis globosa	4	32	0	0	0	48	4	46	60	11	26	0	0	0	0	0	0	65	39	59
Pleudorina sp	7	0	0	15	0	45	0	45	43	0	0	0	0	0	0	0	0	15	5	25
Scenedesmus excelcia	21	0	12	53	17	0	20	29	56	15	0	0	31	0	0	15	40	42	31	0
Scenedesmus quadricauda	7	0	0	64	0	46	9	45	71	8	19	0	0	25	17	0	51	32	0	0
Scenedesmus acuminatus	63	15	28	125	90	45	0	28	37	79	59	10	0	56	10	0	35	31	67	0
Micrasterias truncata	0	48	0	6	0	60	0	51	56	30	11	0	0	32	69	81	0	0	0	0
Sub-Total	**274**	**267**	**262**	**422**	**270**	**354**	**207**	**416**	**525**	**396**	**348**	**157**	**296**	**255**	**224**	**172**	**193**	**373**	**207**	**222**
Cyanophyceae																				
Anabaena flos-aquae	69	44	75	28	69	0	2	17	47	19	81	59	0	0	0	45	2	45	10	0
A. spiroides	81	0	86	0	75	0	81	33	67	25	42	25	34	20	0	19	15	29	19	0
Aphanozemenun flos-aquae	60	45	78	67	0	0	0	35	0	25	0	0	31	29	0	12	7	0	13	39
Gleocapsa rupestris	7	19	0	93	25	21	20	4	28	89	0	0	0	93	31	9	21	11	0	28
G. turgida	15	0	6	109	0	0	28	52	0	93	0	0	3	0	0	0	38	2	43	43
Isocystis planktonica	0	0	0	17	28	0	27	91	35	39	10	0	12	0	48	0	0	0	0	94
Isocystis sp.	33	15	31	65	0	0	46	0	26	8	0	0	15	0	15	46	75	16	59	69
Lyngbya lutea	0	5	21	76	10	24	83	11	0	0	0	75	5	10	0	0	0	0	0	0
L. aeruginneocoerulea	42	0	38	17	45	0	0	0	0	0	0	10	38	28	39	0	6	0	60	0
L. kutzingiana	0	20	37	0	68	0	56	26	18	0	91	0	78	8	21	69	32	10	17	0

Merismopedia elegans	43	0	38	29	12	31	15	0	0	0	32	0	0	41	81	33	67	45	0	38
Microcystis aeuroginosa	32	0	27	79	10	0	35	35	18	0	15	0	0	72	15	45	19	24	0	0
Oscillatoria formosa	61	46	10	43	4	37	5	65	21	39	0	76	67	25	12	53	17	28	20	29
O. limosa	3	56	28	0	12	10	36	4	27	0	45	7	25	24	19	21	12	6	38	87
O. pseudomina	25	0	20	9	0	0	0	0	75	0	57	65	43	17	89	27	0	56	10	49
O. terebriformis	54	11	62	27	22	27	8	35	22	0	0	0	0	12	19	20	25	24	19	0
O. bonnemaisonii	10	38	16	37	0	3	0	48	43	48	10	0	0	0	85	2	81	79	31	14
Phormedium sp	0	54	0	18	0	0	21	8	15	79	28	69	0	60	0	0	0	0	27	101
P. brevis	39	0	79	0	0	28	18	35	0	7	25	0	25	17	0	51	32	0	0	0
P. forseolarum	57	43	12	69	0	8	79	72	0	31	0	0	56	10	0	35	31	67	0	3
P. molle	45	0	48	56	0	0	28	27	7	16	83	25	25	18	16	22	20	24	0	12
P. uncinatum	17	17	18	10	20	0	28	27	0	20	10	42	8	45	0	48	5	8	0	15
P. tenue	45	0	56	0	10	0	35	22	0	32	16	17	32	2	27	0	31	32	75	5
Pseudoanabaena	38	2	38	44	0	0	0	0	0	59	0	5	10	15	0	0	0	3	10	38
Synchococcus aquatilis	10	49	38	0	44	0	38	0	10	0	0	0	18	0	0	21	8	15	0	12
Sub-Total	**786**	**464**	**862**	**893**	**454**	**189**	**689**	**647**	**459**	**629**	**545**	**475**	**525**	**546**	**517**	**578**	**544**	**524**	**451**	**676**
Dinophyceae																				
Ceratium sp	28	52	0	10	9	56	38	75	69	0	49	60	0	51	56	30	11	35	42	29
Ceratium tripos	21	69	32	10	17	0	0	48	0	46	0	17	0	0	48	0	46	48	21	39
Dinophysis caudata	59	33	67	45	0	38	0	0	48	35	28	0	38	0	0	48	35	28	54	11
Gonyaulax sp	15	45	19	24	0	0	26	0	0	38	68	0	0	26	0	0	38	68	15	0
Gonyaulax hurida	12	53	17	28	20	29	56	41	15	17	0	20	29	56	41	15	17	0	12	15
Sub-Total	**135**	**252**	**135**	**117**	**46**	**123**	**120**	**164**	**132**	**136**	**145**	**97**	**67**	**133**	**145**	**93**	**147**	**179**	**144**	**94**
Euglenophyceae																				
Euglena acus	36	0	15	5	12	0	34	51	0	27	0	67	0	29	19	0	12	0	4	11
Euglena caudata	0	35	35	14	43	0	0	54	12	25	21	0	0	0	13	39	18	0	12	2
Euglena obtusa	35	10	65	56	45	0	56	23	32	6	34	31	15	0	0	0	32	32	0	0
Phacus caudatus	28	24	53	81	21	0	71	0	0	0	0	0	0	15	40	42	31	28	0	12
Sub-Total	**99**	**69**	**168**	**156**	**121**	**0**	**161**	**128**	**44**	**58**	**55**	**98**	**15**	**44**	**72**	**81**	**93**	**60**	**16**	**25**
Total No. of cells 1000/l	**2775**	**2239**	**3103**	**3004**	**2211**	**1678**	**2469**	**2688**	**2438**	**2772**	**2506**	**1843**	**1945**	**2255**	**1993**	**1791**	**1870**	**2503**	**2655**	**2393**
No. of Species of Phytoplankton	86	67	89	78	68	55	73	74	68	76	69	59	59	67	59	56	67	80	75	69
Zooplankton	**SWc1**	**SWc2**	**SW8**	**SW9**	**SW10**	**SW11**	**SW13**	**SW15**	**SW16**	**SW17**	**SW18**	**SW19**	**SW20**	**SW21**	**SW22**	**SW23**	**SW24**	**SW25**	**SW26**	**SW27**
Rotifera																				
Brachionus caliciflorus	0	0	57	4	19	5	14	4	12	5	45	32	0	18	0	8	10	14	21	17
Brachionus ureolaris	4	3	0	0	45	11	11	7	11	20	36	15	0	17	0	14	3	0	5	0
Collotheca pelagica	0	0	0	10	0	0	21	11	32	20	2	10	20	0	30	3	10	27	15	31
Condonella ucinata	6	4	0	1	18	2	0	11	20	0	0	0	10	7	5	3	29	0	34	0
Lecane bulla	16	29	1	4	3	56	5	15	0	5	0	0	2	18	28	17	0	18	0	25
Lecane petica	0	0	0	6	3	0	0	0	17	0	0	1	6	3	7	15	21	15	17	0
Asplanchia prodonta	0	15	55	15	17	0	0	15	0	26	0	22	17	17	10	0	0	4	19	5
Asplanchia brightweli	52	54	0	0	1	7	36	3	15	35	15	0	6	0	6	22	0	0	0	0
Filinia longiseta	35	9	2	51	10	0	27	43	5	0	0	0	0	15	0	0	14	1	18	2
Sub-total	**113**	**114**	**115**	**91**	**116**	**81**	**114**	**109**	**112**	**111**	**98**	**80**	**61**	**95**	**86**	**82**	**87**	**79**	**129**	**80**
Cladocera																				

Alona affinis	6	32	0	18	0	8	10	14	21	17	1	15	0	17	0	20	3	0	5	0
Alona intermidia	0	15	0	17	0	14	3	0	5	0	0	10	22	0	30	3	10	27	15	31
Bosmina sp.	5	10	20	0	30	3	10	27	15	31	1	0	8	7	5	3	29	0	28	0
Daphnia carinata	2	0	10	7	5	3	29	0	34	0	20	0	2	18	28	17	0	18	0	25
Chydorus sp	4	0	2	18	28	17	0	18	0	25	45	22	39	22	0	21	13	10	0	0
Polyphemus pediculus	46	22	39	22	0	21	13	10	0	0	0	0	0	0	0	15	0	0	14	1
Sub-total	**63**	**79**	**71**	**82**	**63**	**66**	**65**	**69**	**75**	**73**	**67**	**47**	**71**	**64**	**63**	**79**	**55**	**55**	**62**	**57**
Crustaceans (Copepoda)																				
Acartia longiremis	6	7	50	28	26	5	9	21	0	2	5	8	1	6	4	7	1	3	3	6
Anomalocera patersoni	2	0	5	8	0	14	27	11	0	7	4	2	11	13	4	14	6	8	7	6
Calanus finmarchicus	26	5	27	11	14	0	9	0	1	6	3	2	1	28	14	6	4	2	2	2
Candacia speciosus	15	11	15	17	0	0	15	18	22	17	17	15	0	17	0	14	35	4	10	16
Candacia armatia	4	57	4	19	5	14	4	0	0	6	0	21	6	0	0	0	35	7	11	15
Centopages typicus	45	28	0	0	0	25	30	28	0	0	15	10	31	0	21	11	21	10	57	4
Coryceaus venustus	4	0	1	18	2	0	11	7	2	9	21	20	0	15	31	16	21	6	28	0
Cyclops americanus	11	0	21	6	0	0	0	35	7	15	21	17	16	28	4	17	10	0	0	1
Diaphanosoma sp	0	14	10	31	0	21	11	21	10	0	0	15	31	1	11	0	2	7	0	21
Diaptomus oregonensis	7	0	20	0	15	31	16	21	6	22	0	0	4	15	0	12	25	11	14	10
Enterpina acutifrons	0	2	17	16	28	4	17	10	0	0	14	0	45	11	11	7	2	0	0	20
Eurytemora affinis	8	8	15	31	1	11	0	2	7	0	10	8	1	6	4	7	1	3	2	17
Faranula gracilis	9	13	0	4	15	0	12	25	11	28	28	2	11	13	4	14	6	8	8	15
Gaetanus armiger	3	0	0	45	11	11	7	2	0	17	5	2	1	28	14	6	4	2	13	0
Oncaea venusta	21	0	8	1	6	4	7	1	3	3	6	15	0	17	0	14	35	4	0	0
Paracalanus parvus	1	1	2	11	13	4	14	6	8	7	6	21	34	41	6	12	25	15	0	1
Paracalanus pygmae	19	1	2	1	28	14	6	4	2	2	2	2	17	16	28	4	17	10	0	0
Pseudocalmus elongatus	0	0	15	0	17	0	14	35	4	10	16	8	15	31	1	11	0	2	7	0
Rhincalanus	0	0	21	34	41	6	12	25	15	11	0	0	45	11	11	7	2	0	0	20
Sub-total	**181**	**147**	**233**	**281**	**222**	**164**	**221**	**272**	**98**	**162**	**173**	**168**	**270**	**297**	**168**	**179**	**252**	**102**	**162**	**154**
Crustacea (Decapods)																				
Crab larvae	37	0	1	0	0	10	0	2	0	1	0	46	32	0	10	37	0	15	15	0
Paelemonates larvae	0	1	2	3	0	8	13	32	0	12	6	14	8	0	25	5	34	10	58	37
Lucifer faxoni	0	32	10	10	37	8	79	32	0	11	17	48	5	0	7	0	4	15	15	10
Upogebia nauplii	0	46	32	0	10	37	0	15	15	9	9	0	15	7	1	0	2	2	4	25
Alpheus nauplii	0	14	8	0	25	5	34	10	58	10	22	1	4	6	0	0	2	6	10	25
Obelia Larvae	15	48	5	0	7	0	4	15	15	22	16	0	5	0	8	15	12	2	4	25
Veliger larvae	14	0	15	7	1	0	2	2	4	3	12	7	1	0	2	2	4	4	4	4
Ballanus Larvae	0	1	4	6	0	0	2	6	10	0	8	19	1	2	1	28	14	6	4	2
Sub-total	**66**	**142**	**77**	**26**	**80**	**68**	**134**	**114**	**102**	**68**	**90**	**135**	**71**	**15**	**54**	**87**	**72**	**60**	**114**	**128**
Total No. of zooplankton (100/l)	423	482	496	480	481	379	534	564	387	414	428	430	473	471	371	427	466	296	467	419
No. of Species of Zooplankton	28	27	32	32	30	29	34	37	29	31	30	30	34	31	31	35	35	33	31	29
Benthos	**SWc1**	**SWc2**	**SW8**	**SW9**	**SW10**	**SW11**	**SW13**	**SW15**	**SW16**	**SW17**	**SW18**	**SW19**	**SW20**	**SW21**	**SW22**	**SW23**	**SW24**	**SW25**	**SW26**	**SW27**
Polychaete																				

Capitella capitata	3	1	1	0	0	0	0	3	3	3	1	3	0	0	1	1	1	1	2	2
Cirratulus sp	0	6	1	0	0	2	4	10	2	0	2	5	0	0	0	1	0	0	3	1
Cossura	0	4	4	10	0	3	0	1	3	0	2	0	0	1	0	1	2	2	1	0
Gycera	0	0	0	2	2	2	0	3	3	0	0	2	2	0	1	1	0	0	5	0
Heteromastus	1	6	1	1	0	4	0	1	5	2	0	0	0	0	1	4	1	4	2	2
Hyposoimus sp	0	0	0	0	3	5	0	0	3	2	0	0	0	4	0	1	3	0	2	0
Lumbrinereis sp.	3	0	1	0	0	1	0	1	0	0	2	1	1	3	1	1	0	1	1	4
Nephtys incisa	2	0	5	0	3	0	0	0	0	5	0	3	0	0	1	1	1	1	2	2
Nereis sp	0	0	13	10	1	0	2	3	6	0	0	5	0	0	0	1	0	0	3	1
Notomastus latericus	0	3	3	0	0	3	5	1	1	1	4	0	0	1	0	1	2	2	1	0
Scolopsis uniramus	6	2	0	0	0	0	2	5	2	0	0	2	2	0	1	1	0	0	5	0
Sternapsis scutata	0	0	1	1	1	1	1	0	4	3	4	0	0	0	1	4	1	4	2	2
Marphysa sanguinea	6	9	0	4	4	5	4	0	0	1	0	0	0	4	0	1	3	0	2	0
Sub-Total	**21**	**31**	**30**	**28**	**14**	**26**	**18**	**28**	**32**	**17**	**15**	**21**	**5**	**13**	**7**	**19**	**14**	**15**	**31**	**14**
Gastropods Molluscs																				
Tympanotonus fuscatus	3	2	3	7	6	4	2	7	3	2	5	2	0	0	0	0	1	4	1	4
Littorina sp	1	3	1	0	2	0	5	2	0	2	3	2	0	0	0	4	0	1	3	0
Neritina oweniana	0	10	2	3	0	1	0	0	0	0	0	0	2	1	1	3	1	1	0	1
Tellina nymphalis	2	0	4	0	6	0	6	1	0	1	0	5	0	3	0	0	1	1	1	1
Sub-Total	**6**	**15**	**10**	**10**	**14**	**5**	**13**	**10**	**3**	**5**	**8**	**9**	**2**	**4**	**1**	**7**	**3**	**7**	**5**	**6**
Bivalve Molluscs																				
Nucula	0	2	1	4	1	2	2	1	3	1	7	0	3	0	0	1	1	1	1	2
Stylaria	3	1	0	10	0	0	0	0	0	2	0	0	0	5	0	0	0	1	0	0
Sub-Total	**3**	**3**	**1**	**14**	**1**	**2**	**2**	**1**	**3**	**3**	**7**	**0**	**3**	**5**	**0**	**1**	**1**	**2**	**1**	**2**
Crustacea																				
Tianid sp.	0	2	0	0	1	2	2	1	0	3	0	1	4	0	3	0	0	1	0	0
Isodus sp	2	4	1	0	0	0	0	6	2	0	6	2	0	5	2	0	2	3	2	0
Leplalpheus sp.	5	0	0	0	1	0	0	3	1	0	0	0	0	5	0	2	2	0	3	0
Callianasa	0	0	1	0	1	2	2	1	0	0	5	0	2	4	0	0	0	3	2	0
Gammarus	2	2	0	1	1	0	0	5	0	2	4	0	10	2	0	2	5	0	0	0
Metagraspus	0	0	0	1	4	1	4	2	2	7	0	2	1	3	0	2	0	0	1	0
Ballanus	0	0	4	0	1	3	0	2	0	2	2	0	3	3	0	0	2	2	0	1
Sub-Total	**9**	**8**	**6**	**2**	**9**	**8**	**8**	**20**	**5**	**14**	**17**	**5**	**20**	**22**	**5**	**6**	**11**	**9**	**8**	**1**
Total (No. of orgnism/sq.m)	**39**	**57**	**47**	**54**	**38**	**41**	**41**	**59**	**43**	**39**	**47**	**35**	**30**	**44**	**13**	**33**	**29**	**33**	**45**	**23**
No. of Species of Benthos	13	15	17	12	16	16	13	20	15	16	13	12	10	14	9	19	16	17	21	12

Hydrobiology Results Swamp continue

Phytoplankton	SW28	SW29	SW30	SW31	SW32	SW33	SW34	SW35	SW36	SW37	SW38	SW50	SW51	SW52	SW56	SW60
Baccillariophyceae																
Amphora sp	8	28	6	39	11	42	3	45	10	12	18	18	94	44	9	11
Amphora ovalis	18	27	1	42	9	45	0	0	7	10	0	11	47	28	15	15
Bacillaria paradoxa	0	0	0	0	27	101	25	17	89	27	0	56	10	49	19	20
Bacillaria paxillifera	0	51	32	0	0	0	93	12	19	20	25	24	19	0	0	9
Bacteriastrum delicatulum	0	35	31	67	0	3	0	0	85	2	81	79	31	14	43	0

Biddulphia laevis	0	48	5	8	0	15	0	17	0	51	32	0	0	0	93	0
Biddulphia longicruris	27	0	31	32	75	5	10	10	0	35	31	67	0	3	0	10
Chaetoceros mulleri	0	0	0	3	10	38	28	18	16	22	20	24	0	12	0	7
Cheatoceros decipens	28	10	0	32	0	78	8	45	0	48	5	8	0	15	0	0
Cheatoceros didyma	0	15	39	0	0	0	41	2	27	0	31	32	75	5	10	0
Cheatoceros emeroli	0	0	0	81	0	0	72	15	0	0	0	3	10	38	28	0
Corethrone sp	91	0	0	83	104	67	25	0	28	10	0	32	0	78	8	5
Coscinodiscus centalis	44	9	0	0	0	40	22	0	0	15	39	0	0	0	5	21
Coscinodiscus concinniformis	28	15	0	0	48	43	12	7	0	13	39	18	0	72	0	0
Coscinodiscus concinnus	0	45	43	32	0	28	9	21	11	0	28	0	12	27	0	0
Coscinodiscus radiate	17	11	15	45	10	43	0	38	2	43	43	67	36	0	36	0
Coscinodiscus rothii	37	15	20	43	0	34	0	0	0	0	94	28	0	0	18	0
Cyclotella meneghianina	45	11	0	0	44	4	47	0	51	0	6	0	36	39	0	3
Cyclotella striata	37	20	0	0	65	43	17	89	27	0	56	10	49	19	55	22
Cymbella ovalis	45	9	12	26	0	0	12	19	20	25	24	19	0	0	0	28
Diatoma hiemale	0	0	40	54	0	0	0	85	2	81	79	31	14	43	44	0
Ditylum brightwelli	20	0	24	0	69	0	60	0	0	0	0	27	101	25	0	17
Eunotia gracilis	0	0	45	0	0	25	17	0	51	32	0	0	0	93	9	37
Fragillariopsis atlantica	45	10	12	10	0	56	10	0	35	31	67	0	3	0	2	0
Fragillriopsis oceanica	0	7	10	21	25	25	18	16	22	20	24	0	12	0	12	45
Gyrosigma	10	0	32	0	42	8	45	0	48	5	8	0	15	0	2	37
Hantzschia amphioxys	10	0	10	0	17	32	2	27	0	31	32	75	5	10	0	45
Lauderia borealis	0	0	2	0	5	10	15	0	0	0	3	10	38	28	25	0
Leptocylindricus sp.	95	5	29	0	17	32	0	28	10	0	32	0	78	8	42	20
Melosia moniliformis	0	0	52	45	0	31	0	0	15	39	0	0	0	41	17	0
Navicula bacillum	24	28	0	3	0	83	56	0	0	0	81	0	0	72	5	45
Navicula cuspidata	0	56	0	15	43	0	45	0	0	89	0	54	0	18	17	0
Navicula gracilis	6	38	87	0	49	0	0	0	10	0	39	0	79	0	0	10
Nitzschia closterium	6	28	45	5	25	34	20	0	8	0	0	28	18	35		0
N. linearis	0	5	19	31	0	62	29	0	0	31	15	79	28	0	0	31
N. longissima	11	32	14	0	29	10	34	0	94	63	0	7	25	10	0	0
Odontella sinensis	6	20	0	15	20	23	28	23	34	62	41	20	0	15	0	3
Pinnularia appendiculata	0	45	0	22	13	0	10	6	26	0		29	55	0	0	12
P. interrupta	0	0	0	73	53	0	46	0	4	0	0	32	15	0	0	15
Planktonella sol	34	20	0	19	15	29	19	0	12	0	0	65	39	42	10	38
Pleurosigma angulatum	31	29	0	12	7	0	13	39	18	0	0	15	5	43	0	78
P. elongatum	0	93	31	9	21	11	0	28	0	12	51	0	0	0	0	0
Rhizosolenia erensis	3	0	0	0	38	2	43	43	67	36	54	12	35	4	0	0
Rhizosolenia habetata	12	0	48	0	0	0	0	94	28	0	23	32	65	48	66	67
Rhizosolenia longiseta	15	0	15	46	75	16	59	69	46	28	0	0	4	15	7	25
R. simlpex	5	10	0	0	0	0	0	0	28	0	0	0	0	8	37	89
R. styliformis	38	28	39	0	6	0	60	0	51	56	30	11	35	42	29	0
Skeletonmema sp	78	8	21	69	32	10	17	0	0	48	0	46	48	21	39	45
Surirella caproni	0	41	81	33	67	45	0	38	0	0	48	35	28	54	11	26
S. robusta	0	72	15	45	19	24	0	0	26	0	0	38	68	15	0	0
Synedra acus	67	25	12	53	17	28	20	29	56	41	15	17	0	12	15	0
S. rumpens	25	24	19	21	12	6	38	87	43	24	34	18	0	19	8	19

S. ulna	89	0	20	37	0	68	0	56	26	18	0	91	43	20	79	59
Tabellaria fenestrata	0	43	0	38	29	12	31	15	0	0	0	32	32	0	0	15
Thalassionema bacillare	45	32	0	27	79	10	0	35	35	18	0	15	61	0	35	5
T. nitzschoides	26	61	46	10	43	4	37	5	65	21	39	0	3	46	10	38
Thalassiosira sp.	0	3	56	28	0	12	10	36	4	27	0	45	25	36	0	78
Thalassiothrix nitzschoides	19	54	11	62	27	22	27	8	35	22	0	0	43	11	0	8
Triceratium sp	59	10	38	16	37	0	3	0	48	43	48	10	4	33	66	67
Sub-Total	**1204**	**1176**	**1108**	**1352**	**1334**	**1359**	**1236**	**1122**	**1339**	**1211**	**1335**	**1370**	**1443**	**1310**	**926**	**1125**
Chlorophyceae																
Staurastrun seligerum	0	15	5	25	34	20	0	19	15	29	19	0	32	0	0	0
Closterium lineatum	40	42	31	0	31	29	0	12	7	0	13	39	61	0	0	0
Eudorina sp	51	32	0	0	0	93	31	9	21	11	0	28	3	46	0	73
Halosphaera viridis	35	31	67	0	3	0	0	0	38	2	43	43	25	36	0	45
H. spheroides	43	0	0	0	0	0	0	0	0	15	5	25	54	0	0	19
Pandorina	64	15	0	0	31	0	0	15	40	42	31	0	43	11	0	12
Phacolus	0	0	0	73	53	0	46	0	4	0	12	31	4	33	31	9
Phaeocystis globosa	0	0	0	45	2	45	10	0	9	24	10	0	35	35	18	0
Pleudorina sp	34	20	0	19	15	29	19	0	12	0	4	37	5	65	21	39
Scenedesmus excelcia	31	29	0	12	7	0	13	39	18	0	12	10	36	4	27	0
Scenedesmus quadricauda	0	93	31	9	21	11	0	28	0	12	0	0	0	0	75	0
Scenedesmus acuminatus	3	0	0	0	38	2	43	43	67	36	22	27	8	35	22	0
Micrasterias truncata	0	0	41	0	49	0	0	0	73	53	0	46	0	4	0	0
Sub-Total	**301**	**277**	**175**	**183**	**284**	**229**	**162**	**165**	**304**	**224**	**171**	**286**	**306**	**269**	**194**	**197**
Cyanophyceae																
Anabaena flos-aquae	9	24	0	41	0	125	0	0	0	0	0	0	65	0	0	78
A. spiroides	12	0	0	65	39	72	0	0	0	0	0	0	15	31	0	0
Aphanozemenun flos-aquae	18	0	0	15	5	27	0	31	0	0	15	40	42	53	0	0
Gleocapsa rupestris	0	12	51	0	0	0	0	0	25	17	0	51	32	2	76	67
G. turgida	67	36	54	12	35	0	10	0	56	10	0	35	31	15	7	25
Isocystis planktonica	28	0	23	32	65	63	21	25	25	18	16	22	20	7	65	43
Isocystis sp.	46	28	0	0	4	39	0	42	8	45	0	48	5	21	0	0
Lyngbya lutea	28	0	0	0	0	19	0	17	32	2	27	0	31	15	0	0
L. aeruginneocoerulea	51	56	30	11	35	0	0	5	10	15	0	0	0	0	69	0
L. kutzingiana	0	48	0	46	48	43	0	17	32	0	28	10	0	45	0	25
Merismopedia elegans	0	0	48	35	28	0	12	0	48	0	0	0	0	57	0	56
Microcystis aeuroginosa	26	0	0	38	68	0	15	0	15	46	75	16	59	0	25	25
Oscillatoria formosa	56	41	15	17	0	75	5	10	0	0	0	0	0	10	42	8
O. limosa	43	24	34	18	0	10	38	28	39	0	6	0	60		17	32
O. pseudomina	19	0	17	32	2	27	0	31	32	75	5	10	0	0	5	10
O. terebriformis	0	0	5	10	15	0	0	0	3	10	38	28	39	0	6	0
O. bonnemaisonii	43	0	17	32	0	28	10	0	32	0	78	8	21	69	32	10
Phormedium sp	25	45	0	31	0	0	15	39	0	0	0	41	81	33	67	45
P. brevis	93	3	0	83	56	0	0	0	81	0	0	72	15	45	19	24
P. forseolarum	0	22	0	86	111	91	0	0	83	104	67	25	12	53	17	28

P. molle	0	36	15	36	6	39	12	17	0	7	25	24	19	21	12	6
P. uncinatum	0	18	56	45	0	11	42	21	83	37	89	0	20	37	0	68
P. tenue	10	8	43	0	38	0	45	43	26	29	0	43	0	38	29	12
Pseudoanabaena	28	44	32	66	41	0	0	0	32	39	45	32	0	27	79	10
Synchococcus aquatilis	19	20	25	24	19	0	0	0	5	10	15	0	0	0	3	10
Sub-Total	**621**	**465**	**465**	**775**	**615**	**669**	**225**	**326**	**667**	**464**	**529**	**505**	**567**	**579**	**570**	**582**
Dinophyceae																
Ceratium sp	0	0	31	29	0	12	7	0	13	39	18	0	0	15	5	27
Ceratium tripos	45	0	0	93	31	9	21	11	0	28	0	12	51	0	0	0
Dinophysis caudata	26	0	3	0	0	0	38	2	43	43	67	36	54	12	35	0
Gonyaulax sp	0	0	12	0	48	0	0	0	0	94	28	0	23	32	65	63
Gonyaulax hurida	0	0	15	0	15	46	75	16	59	69	46	28	0	0	4	39
Sub-Total	**71**	**0**	**61**	**122**	**94**	**67**	**141**	**29**	**115**	**273**	**159**	**76**	**128**	**59**	**109**	**129**
Euglenophyceae																
Euglena acus	0	0	0	48	0	50	54	8	20	10	29	64	15	0	0	31
Euglena caudata	43	81	0	0	0	0	0	0	41	0	49	0	0	0	73	53
Euglena obtusa	15	26	0	0	0	0	0	0	65	39	59	0	0	0	45	2
Phacus caudatus	0	0	0	31	0	0	15	40	42	31	0	31	29	0	12	7
Sub-Total	**58**	**107**	**0**	**79**	**0**	**50**	**69**	**48**	**168**	**80**	**137**	**95**	**44**	**0**	**130**	**93**
Total No. of cells 1000/l	**2255**	**2025**	**1809**	**2511**	**2327**	**2374**	**1833**	**1690**	**2593**	**2252**	**2331**	**2332**	**2488**	**2217**	**1929**	**2126**
No. of Species of Phytoplankton	66	66	62	70	69	68	65	58	78	69	67	71	73	73	65	69
Zooplankton	**SW28**	**SW29**	**SW30**	**SW31**	**SW32**	**SW33**	**SW34**	**SW35**	**SW36**	**SW37**	**SW38**	**SW50**	**SW51**	**SW52**	**SW56**	**SW60**
Rotifera																
Brachionus caliciflorus	0	1	18	2	0	11	20	0	26	5	27	11	14	0	9	0
Brachionus ureolaris	1	4	3	56	5	15	0	5	15	11	15	17	0	0	15	18
Collotheca pelagica	0	6	3	0	0	0	17	0	4	57	4	19	5	14	4	0
Condonella ucinata	55	15	17	0	0	15	0	26	45	28	0	0	0	25	30	28
Lecane bulla	0	0	1	7	36	3	15	35	4	0	1	18	2	0	11	7
Lecane petica	2	51	10	0	27	43	5	0	11	0	21	6	0	0	0	35
Asplanchia prodonta	0	36	12	45	4	25	8	0	0	14	10	31	0	21	11	21
Asplanchia brightweli	10	31	0	7	5	3	29	0	7	0	20	0	15	31	16	21
Filinia longiseta	20	0	15	18	28	17	0	18	0	2	17	16	28	4	17	10
Sub-total	**88**	**144**	**79**	**135**	**105**	**132**	**94**	**84**	**112**	**117**	**115**	**118**	**64**	**95**	**113**	**140**
Cladocera																
Alona affinis	10	15	0	17	0	14	3	0	5	0	3	18	0	17	0	14
Alona intermidia	0	10	20	0	30	3	10	27	15	31	10	10	20	0	23	3
Bosmina sp.	0	0	10	7	5	3	29	0	34	0	29	0	10	7	5	3
Daphnia carinata	7	0	2	18	28	17	0	18	0	25	0	0	2	18	28	17
Chydorus sp	0	22	39	22	0	21	13	10	0	0	13	22	39	22	0	21
Polyphemus pediculus	18	2	20	0	15	18	28	17	0	18	0	2	17	7	0	2
Sub-total	**35**	**49**	**91**	**64**	**78**	**76**	**83**	**72**	**54**	**74**	**55**	**52**	**88**	**71**	**56**	**60**
Crustaceans (Copepoda)																
Acartia longiremis	0	15	31	16	21	6	22	0	0	4	15	0	12	25	11	14
Anomalocera patersoni	16	28	4	17	10	0	0	14	0	45	11	11	7	2	0	0

Calanus finmarchicus	31	1	11	0	2	7	0	10	8	1	6	4	7	1	3	2
Candacia speciosus	17	17	1	1	2	11	13	4	14	6	8	7	6	18	2	20
Candacia armatia	17	0	0	15	18	22	17	0	0	25	30	28	0	0	15	10
Centopages typicus	19	5	14	4	0	0	6	18	2	0	11	7	2	9	21	20
Coryceaus venustus	0	0	25	30	28	0	0	6	0	0	0	35	7	15	21	17
Cyclops americanus	18	2	0	11	7	2	9	31	0	21	11	21	10	0	0	15
Diaphanosoma sp	6	0	0	0	35	7	15	0	15	31	16	21	6	22	0	0
Diaptomus oregonensis	31	0	21	11	21	10	0	16	28	4	17	10	0	0	14	0
Enterpina acutifrons	0	15	31	16	21	6	22	31	1	11	0	2	7	0	10	8
Eurytemora affinis	16	28	4	17	10	0	0	4	15	0	12	25	11	28	28	2
Faranula gracilis	31	1	11	0	2	7	0	45	11	11	7	2	0	17	5	2
Gaetanus armiger	4	15	0	12	25	11	28	1	6	4	7	1	3	3	6	15
Oncaea venusta	45	11	11	7	2	0	17		31	0	21	11	45	11	11	7
Paracalanus parvus	18	2	0	11	7	2	9	21	0	15	31	16	1	6	4	7
Paracalanus pygmae	14	0	0	0	35	7	15	21	16	28	4	17	11	13	4	14
Pseudocalmus elongatus	10	0	21	11	21	10	0	0	31	1	11	0	1	28	14	6
Rhincalanus	0	15	31	16	21	6	22	0	4	15	0	12	0	17	0	14
Sub-total	**293**	**155**	**216**	**195**	**288**	**114**	**195**	**222**	**182**	**222**	**218**	**230**	**136**	**215**	**169**	**173**
Crustacea (Decapods)																
Crab larvae	8	13	32	0	21	6	0	0	0	35	7	11	15	17	0	0
Paelemonates larvae	8	79	32	0	10	31	0	21	11	21	10	57	4	19	5	14
Lucifer faxoni	37	0	15	15	20	0	15	31	16	21	6	28	0	0	0	25
Upogebia nauplii	5	34	10	46	15	18	22	17	0	0	25	30	28	0	0	15
Alpheus nauplii	5	34	10	8	4	0	0	6	18	2	0	11	7	2	9	21
Obelia Larvae	0	4	20		30	28	0	0	6	0	0	0	35	7	15	21
Veliger larvae	15	10	17	10	7	1	0	2	2	4	25	2	7	0	10	6
Ballanus Larvae	2	2	2	17	16	28	4	17	10	0	0	14	2	8	25	25
Sub-total	**80**	**176**	**138**	**96**	**123**	**112**	**41**	**94**	**63**	**83**	**73**	**153**	**98**	**53**	**64**	**127**
Total No. of zooplankton (100/l)	496	524	524	490	594	434	413	472	411	496	461	553	386	434	402	500
No. of Species of Zooplankton	30	31	34	31	36	34	26	28	29	29	33	35	32	30	31	36
Benthos	**SW28**	**SW29**	**SW30**	**SW31**	**SW32**	**SW33**	**SW34**	**SW35**	**SW36**	**SW37**	**SW38**	**SW50**	**SW51**	**SW52**	**SW56**	**SW60**
Polychaete																
Capitella capitata	0	3	3	3	0	0	3	5	1	1	1	4	0	3	3	3
Cirratulus sp	0	0	2	0	0	0	0	2	5	2	0	0	4	10	2	0
Cossura	0	5	0	1	1	1	1	1	0	4	3	4	0	1	3	0
Gycera	2	4	9	0	4	4	5	4	0	0	1	0	0	3	3	0
Heteromastus	7	0	0	6	1	0	0	2	4	10	2	0	0	1	5	2
Hyposoimus sp	2	2	0	4	4	10	0	3	0	1	3	0	0	0	3	2
Lumbrinereis sp.	5	7	0	0	0	2	2	2	0	3	3	0	0	1	0	0
Nephtys incisa	0	3	1	6	1	1	0	4	0	1	5	2	0	0	0	5
Nereis sp	0	0	0	0	0	0	3	5	0	0	3	2	2	3	6	0
Notomastus latericus	0	5	3	0	1	0	0	1	0	1	0	0	5	1	1	1
Scolopsis uniramus	2	4	2	0	5	0	3	0	0	0	0	5	2	5	2	0
Sternapsis scutata	7	0	0	0	13	10	1	0	2	3	6	0	1	0	4	3
Marphysa sanguinea	2	2	1	1	3	1	1	0	1	1	4	5	4	0	0	1

Sub-Total	**27**	**35**	**21**	**21**	**33**	**29**	**19**	**29**	**13**	**27**	**31**	**22**	**18**	**28**	**32**	**17**
Gastropods Molluscs																
Tympanotonus fuscatus	2	2	1	4	0	0	1	0	1	2	2	1	0	1	2	2
Littorina sp	2	0	0	5	0	0	0	1	0	0	3	1	0	0	0	0
Neritina oweniana	1	4	4	0	0	1	0	1	2	2	1	0	0	5	3	0
Tellina nymphalis	2	2	0	2	2	0	1	1	0	0	5	0	2	4	2	0
Sub-Total	**7**	**8**	**5**	**11**	**2**	**1**	**2**	**3**	**3**	**4**	**11**	**2**	**2**	**10**	**7**	**2**
Bivalve Molluscs																
Nucula	2	0	3	2	1	1	0	0	5	0	2	4	2	0	5	0
Stylaria	3	1	4	0	0	0	1	4	1	4	2	2	7	0	0	0
Sub-Total	**5**	**1**	**7**	**2**	**1**	**1**	**1**	**4**	**6**	**4**	**4**	**6**	**9**	**0**	**5**	**0**
Crustacea																
Tianid sp.	2	1	1	3	1	1	0	1	1	4	5	7	0	0	0	2
Isodus sp	0	0	4	0	1	3	0	0	0	1	0	1	2	2	1	0
Leplalpheus sp.	1	6	4	5	3	0	1	0	0	1	0	1	2	1	1	3
Callianasa	0	0	0	0	1	3	0	2	0	2	2	0	4	4	10	0
Gammarus	1	0	1	3	1	0	0	2	0	0	0	0	2	5	4	1
Metagraspus	1	2	1	1	0	0	5	0	1	1	1	1	1	0	1	3
Ballanus	1	0	0	5	0	2	4	9	0	4	4	5	4	0	1	0
Sub-Total	**6**	**9**	**11**	**17**	**7**	**9**	**10**	**14**	**2**	**13**	**12**	**15**	**15**	**12**	**18**	**9**
Total (No. of orgnism/sq.m)	**45**	**53**	**44**	**51**	**43**	**40**	**32**	**50**	**24**	**48**	**58**	**45**	**44**	**50**	**62**	**28**
No. of Species of Benthos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Hydrobiology Results for Shallow Atlantic

Phytoplankton	**SW c3**	**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW 7**	**SW 12**	**SW 14**	**SW 39**	**SW 40**	**SW 41**	**SW 42**	**SW 43**	**SW 44**	**SW 45**	**SW 46**	**SW 47**	**SW 48**	**SW 49**	**SW 53**	**SW 54**	**SW 55**	**SW57**	**SW 58**	**SW 59**	**SW 61**
Baccillariophyceae																												
Amphora sp	67	18	18	94	44	9	11	0	11	42	3	45	10	48	0	44	0	0	45	10	8	28	0	56	61	50	5	6
Amphora ovalis	34	55	44	47	28	56	15	56	67	45	0	43	97	0	59	0	61	0	0	94	18	27	67	53	41	34	69	9
Amphiprora costata	26	23	6	6	36	39	0	0	31	14	43	47	23	15	20	0	54	0	0	0	85	2	19	0	0	10	37	81
Bacillaria paradoxa	54	42	56	10	49	19	20	12	27	101	25	17	89	27	25	12	45	69	54	60	34	27	81	10	4	9	22	32
Bacillaria paxillifera	20	25	24	19	0	0	9	0	0	0	93	12	19	23	0	63	0	0	46	17	0	51	0	82	54	3	45	32
Bacteriastrum delicatulum	38	81	79	31	14	43	0	0	0	3	0	0	85	20	0	22	10	0	56	10	0	35	45	22	57	48	37	31
Biddulphia aurita	24	13	0	27	101	25	21	12	0	12	0	54	35	9	0	0	21	25	32	18	16	0	0	4	26	23	45	12
Biddulphia laevis	51	32	0	0	0	93	0	0	0	15	0	17	0	0	40	0	0	42	51	45	0	48	0	18	11	0	0	5
Biddulphia longicruris	35	31	67	0	3	0	10	43	75	5	10	10	0	0	24	0	0	17	32	2	27	0	24	60	0	18	20	31
Chaetoceros mulleri	22	20	24	0	12	0	7	15	10	38	28	18	16	0	45	36	0	5	20	15	0	0	22	76	28	0	0	0

Cheatoceros decipens	48	5	8	0	15	0	0	20	0	78	8	45	0	10	12	18	0	17	32	0	28	10	0	47	81	3	45	0
Cheatoceros didyma	0	31	32	75	5	10	0	25	0	0	41	2	27	7	10	0	45	0	31	0	0	15	12	0	0	0	0	39
Cheatoceros emeroli	0	0	3	10	38	28	14	0	0	0	72	15	0	0	32	0	3	0	83	56	0	0	63	0	0	29	10	0
Corethrone sp	10	0	32	0	78	8	5	0	104	67	25	0	28	0	10	65	22	0	86	111	91	0	22	0	86	32	10	0
Coscinodiscus centalis	15	39	0	0	0	5	21	12	0	40	22	0	0	0	2	0	28	20	0	0	44	9	5	0	41	39	0	0
Coscinodiscus concinniformis	13	39	18	0	72	0	0	40	48	43	12	7	0	51	0		0	21	45	0	28	45	0	9	26	47	0	0
Coscinodiscus concinnus	0	28	0	12	27	0	0	24	0	28	9	21	11	27	0	0	17	45	0	41	0	45	0	28	28	17	89	43
Coscinodiscus radiate	43	43	67	36	0	36	0	45	10	43	0	38	2	20	25	9	37	20	32	10	17	11	36	0	18	12	19	15
Coscinodiscus rothii	45	94	0	17	0	18	0	12	0	34	0	0	0	0	81	2	0	18	29	10	37	15	2	18	94	0	85	20
Cosinosira oestrupi	59	69	46	28	63	0	45	10	0	33	46	75	16	0	0	12	45	21	0	0	0	27	0	11	47	60	0	25
Cyclotella meneghianina	0	6	0	36	39	0	3	32	44	4	47	0	51	51	32	2	37	11	41	3	45	11	0	21	12	17	0	0
Cyclotella striata	0	56	10	49	19	55	22	10	65		17	89	27	35	31	0	45	42	7	48	37	20	65	0	0	10	0	0
Cymbella ovalis	25	24	19	0	0	0	28	2	0	0	12	19	20	22	20	0	0	11	43	0	45	9	0	12	18	18	16	12
Diatoma hiemale	81	79	31	14	43	44	0	29	0	0	0	85	2	48	5	0	20	27	0	0	0	0	45	19	29	45	0	40
Ditylum brightwelli	0	0	27	101	25	0	17	52	69	0	60	0	0	0	31	0	0	25	16	18	20	0	53	0	0	2	27	24
Eunotia gracilis	32	0	0	0	93	9	37	0	0	25	17	0	51	0	0	32	45	0	0	0	0	0	53	23	2	15	0	45
Fragillariopsis atlantica	31	67	0	3	0	2	0	0	0	56	10	0	35	10	0	0	0	11	42	3	45	10	27	35	9	0	28	12
Fragillriopsis oceanica	20	24	0	12	0	12	45	87	25	25	18	16	22	15	39	0	10	9	45	0	0	7	43	11	29	0	0	10
Gyrosigma	5	8	0	15	0	2	37	0	42	8	45	0	48	0	0	0	10	32	0	29	10	0	42	38	7	56	0	32
Hantzschia amphioxys	31	32	75	5	10	0	45	45	17	32	2	27	0	0	0	5	0	21	69	32	10	0	0	22	0	111	91	10
Lauderia borealis	0	3	10	38	28	25	0	19	5	10	15	0	0	0	38	0		29	36	39	0	0	0	0	24	0	0	2
Leptocylindricus sp.	0	32	0	78	8	42	20	14	17	32	0	28	10	0		0		21	67	25	95	5	10	28	0	4	0	29
Melosia moniliformis	39	0	0	0	41	17	0	0	0	31	0	0	15	0	0	0	93	85	47	54	0	0	0	48	0	51	32	52
Navicula bacillum	0	81	0	0	72	5	45	0	0	83	56	0	0	67	0	3	0	15	45	19	24	28	0	89	54	35	31	0
Navicula cuspidata	89	0	54	0	18	17	0	0	43	0	45	0	0	24	0	12	0	94	21	0	0	56	10	0	43	22	20	0
Navicula gracilis	0	39	0	79	0	0	10	0	49	0	0	0	10	8	0	15	0	19	21	12	6	38	0	0	12	48	5	87
Navicula minima	0	0	0	21	8	0	10	0	59	0	0	0	0	32	75	5	10	20	20	26	0	104	8	0	16	0	31	0
Nitzschia closterium	0	0	28	18	35		0	0	25	34	20	0	8	3	10	38	28	41	0	0	6	28	0	31	14	0	0	45

N. linearis	31	15	79	28	0	0	31	0	0	62	29	0	0	32	0	78	8	18	31	27	0	5	94	63	0	10	0	19
N. longissima	63	0	7	25	10	0	0	23	29	10	34	0	94	0	0	0	41	20	0	29	11	32	34	62	0	15	39	14
Odontella sinensis	62	41	20	0	15	0	3	6	20	23	28	23	34	0	15	0		29	73	41	6	20	26	0	0	5	8	0
Pinnularia appendiculata	0		29	55	0	0	12	0	13	0	10	6	26	0	0	0	0	32	15	43	0	45	4	0	5	0	0	0
P. interrupta	0	0	32	15	0	0	15	0	53	0	46	0	4	0	0	0	0	41	0	49	0	0	9	24	21	0	0	0
P.maior	24	0	41	0	16	75	5	0	2	45	10	0	9	0	0	0	0	65	39	59	0	0	12	0	125	0	0	0
Planktonella sol	0	0	65	39	42	10	38	39	15	29	19	0	12	0	0	0	0	15	5	25	34	20	18	0	72	0	0	0
Pleurosigma angulatum	0	0	15	5	43	0	78	28	7	0	13	39	18	0	0	15	40	42	31	0	31	29	0	12	27	0	31	0
P. elongatum	12	51	0	0	0	0	0	43	21	11	0	28	0	25	17	0	51	32	0	0	0	93	67	36	0	0	0	31
Rhizosolenia erensis	36	54	12	35	4	0	0	94	38	2	43	43	67	56	10	0	35	31	67	0	3	0	28	0	0	10	0	0
Rhizosolenia habetata	0	23	32	65	48	66	67	69	0	0	0	94	28	25	18	16	22	20	24	0	12	0	46	28	63	21	25	48
Rhizosolenia longiseta	28	0	0	4	15	7	25	6	75	16	59	69	46	8	45	0	48	5	8	0	15	0	0	36	39	0	42	15
R. simlpex	0	0	0	0	8	37	89	56	0	0	0	0	28	32	2	27	0	31	32	75	5	10	10	49	19	0	17	0
R. styliformis	56	30	11	35	42	29	0	24	6	0	60	0	51	10	15	0	0	0	3	10	38	28	19	0	0	0	5	39
Skeletonmema sp	48	0	46	48	21	39	45	79	32	10	17	0	0	32	0	28	10	0	32	0	78	8	31	14	43	0	17	21
Surirella caproni	0	48	35	28	54	11	26	0	67	45	0	38	0	31	0	0	15	39	0	0	0	41	27	101	25	45	0	81
S. robusta	0	0	38	68	15	0	0	0	19	24	0	0	26	83	56	0	0	0	81	0	0	72	0	0	93	3	0	15
Synedra acus	41	15	17	0	12	15	0	67	17	28	20	29	56	86	111	91	0	0	83	104	67	25	0	3	0	22	0	12
S. rumpens	24	34	18	0	19	8	19	24	12	6	38	87	43	36	6	39	12	17	0	7	25	24	0	12	0	36	15	19
S. ulna	18	0	91	43	20	79	59	8	0	68	0	56	26	45	0	11	42	21	83	37	89	0	0	15	0	18	56	20
Tabellaria fenestrata	0	0	32	32	0	0	15	32	29	12	31	15	0	0	38	0	45	43	26	29	0	43	75	5	10	8	43	0
Thalassionema bacillare	18	0	15	61	0	35	5	3	79	10	0	35	35	66	41	0	0	0	32	39	45	32	10	38	28	44	32	0
T. nitzschoides	21	39	0	3	46	10	38	32	43	4	37	5	65	0	0	48	4	46	60	11	26	61	0	78	8	32	0	46
Thalassiosira sp.	27	0	45	25	36	0	78	0	0	12	10	36	4	15	0	45	0	45	43	0	0	3	0	0	41	0	0	56
Thallasiothrix sp.	75	0	57	54	0	5	0	81	9	0	0	0	0	53	17	0	20	29	56	15	0	25	0	0	72	0	12	0
Thalassiothrix nitzschoides	22	0	0	43	11	0	8	83	27	22	27	8	35	64	0	46	9	45	71	8	19	54	104	67	25	0	0	11
Triceratium sp	43	48	10	4	33	66	67	35	37	0	3	0	48	125	90	45	0	28	37	79	59	10	10	54	41	15	28	38
Sub-Total	**1606**	**1537**	**1525**	**1596**	**1534**	**1111**	**1220**	**1448**	**1493**	**1420**	**1335**	**1341**	**1512**	**1396**	**1147**	**884**	**1088**	**1527**	**2126**	**1494**	**1339**	**1391**	**1378**	**1568**	**1729**	**1152**	**1189**	**1266**
Chlorophyceae																												

Staurastrun seligerum	29	19	0	32	0	0	0	12	34	20	0	19	15	0	0	0	0	0	0	0	0	15	28	46	28	45	43	5
Closterium lineatum	0	13	39	61	0	0	0	54	31	29	0	12	7	15	0	0	31	0	0	15	40	42	8	20	10	29	64	31
Eudorina sp	11	0	28	3	46	0	73	25	0	93	31	9	21	8	19	0	0	25	17	0	51	32	25	45	0	45	63	0
Halosphaera viridis	2	43	43	25	36	0	45	17	3	0	0	0	38	79	59	10	0	56	10	0	35	31	0	7	25	28	37	67
H. spheroides	15	5	25	54	0	0	19	21	0	0	0	0	0	40	0	12	28	46	28	45	43	0	83	37	89	0	10	0
Pandorina	42	31	0	43	11	0	12	43	31	0	0	15	40	0	50	54	8	20	10	29	64	15	26	29	0	0	48	0
Phacolus	0	12	31	4	33	31	9	0	53	0	46	0	4	0	0	0	0	41	0	49	0	0	32	69	81	0	0	0
Phaeocystis globosa	24	10	0	35	35	18	0	46	2	45	10	0	9	0	0	0	0	65	39	59	0	0	60	11	26	0	0	0
Pleudorina sp	0	4	37	5	65	21	39	45	15	29	19	0	12	0	0	0	0	15	5	25	34	20	43	0	0	0	0	0
Scenedesmus excelcia	0	12	10	36	4	27	0	29	7	0	13	39	18	0	0	15	40	42	31	0	31	29	56	15	0	0	31	0
Scenedesmus quadricauda	12	0	0	0	0	75	0	45	21	11	0	28	0	25	17	0	51	32	0	0	0	93	71	8	19	0	0	31
Scenedesmus acuminatus	36	22	27	8	35	22	0	28	38	2	43	43	67	56	10	0	35	31	67	0	3	0	37	79	59	10	0	0
Micrasterias sol	0	0	3	0	48	43	48	28	0	0	0	94	28	25	18	16	22	20	24	0	12	0	0	19	15	21	25	48
Micrasterias truncata	53	0	46	0	4	0	0	51	49	0	0	0	73	32	69	81	0	0	0	0	0	0	56	30	11	0	0	41
Sub-Total	**224**	**171**	**289**	**306**	**317**	**237**	**245**	**444**	**284**	**229**	**162**	**259**	**332**	**280**	**242**	**188**	**215**	**393**	**231**	**222**	**313**	**277**	**525**	**415**	**363**	**178**	**321**	**223**
Cyanophyceae																												
Anabaena flos-aquae	0	0	0	65	0	0	78	17	0	125	0	0	0	0	0	45	2	45	10	0	9	24	47	19	81	59	0	0
A. spiroides	0	0	0	15	31	0	0	33	39	72	0	0	0	20	0	19	15	29	19	0	12	0	67	25	42	25	34	0
Aphanozemenun flos-aquae	0	15	40	42	53	0	0	35	5	27	0	31	0	29	0	12	7	0	13	39	18	0	0	25	0	0	31	0
Gleocapsa rupestris	17	0	51	32	2	76	67	4	0	0	0	0	25	93	31	9	21	11	0	28	0	12	28	89	0	0	0	51
G. turgida	10	0	35	31	15	7	25	52	35	0	10	0	56	0	0	0	38	2	43	43	67	36	0	93	0	0	3	54
Isocystis planktonica	18	16	22	20	7	65	43	91	65	63	21	25	25	0	48	0	0	0	0	94	28	0	35	39	10	0	12	23
Isocystis sp.	45	0	48	5	21	0	0	0	4	39	0	42	8	0	15	46	75	16	59	69	46	28	26	8	0	0	15	0
Lyngbya lutea	2	27	0	31	15	0	0	11	0	19	0	17	32	10	0	0	0	0	0	0	28	0	0	0	0	75	5	0
L. aeruginneocoerulea	15	0	0	0	0	69	0	0	35	0	0	5	10	28	39	0	6	0	60	0	51	56	0	0	0	10	38	30
L. kutzingiana	0	28	10	0	45	0	25	26	48	43	0	17	32	8	21	69	32	10	17	0	0	48	18	0	91	0	78	0
Merismopedia elegans	0	0	0	0	57	0	56	0	28	0	12	0	48	41	81	33	67	45	0	38	0	0	0	0	32	0	0	48
Microcystis aeuroginosa	46	75	16	59	0	25	25	35	68	0	15	0	15	72	15	61	19	24	0	0	26	0	18	0	15	0	0	0
Oscillatoria formosa	0	0	0	0	10	42	8	65	0	75	5	10	0	25	12	53	17	28	20	29	56	41	21	39	0	76	67	15
O. limosa	0	6	0	60		17	32	4	0	10	38	28	39	24	19	21	12	6	38	87	43	24	27	0	45	7	2	3

																										5	4
O. pseudomina	75	5	10	0	0	5	10	0	2	27	0	31	32	17	89	27	0	56	47	49	19	0	75	0	57	65	43	17
O. terebriformis	10	38	28	39	0	6	0	35	15	0	0	0	3	12	19	20	25	24	38	0	0	0	22	0	0	0	0	5
O. bonnemaisonii	0	78	8	21	69	32	10	48	0	28	10	0	32	0	85	2	81	79	31	14	43	0	43	48	10	0	0	17
Phormedium sp	0	0	41	81	33	67	45	8	0	0	15	39	0	60	0	0	0	0	45	101	25	45	15	79	28	69	0	0
P. brevis	0	0	72	15	45	19	24	35	56	0	0	0	81	17	0	51	32	4	0	0	93	3	0	7	25	0	25	0
P. forseolarum	104	67	25	12	53	17	28	72	111	91	0	0	83	10	0	35	31	67	0	3	0	22	0	31	0	0	56	0
P. molle	7	25	24	19	21	12	6	27	6	39	12	17	0	18	16	23	20	24	0	12	0	36	7	16	83	25	25	15
P. uncinatum	37	89	0	20	37	0	68	27	0	11	42	21	83	45	0	48	5	32	0	15	0	18	0	20	10	42	8	56
P. tenue	29	0	43	0	38	29	12	22	38	0	45	43	26	2	27	0	31	32	75	5	10	8	0	32	16	17	32	43
Pseudoanabaena	39	45	32	0	27	79	10	0	41	0	0	0	32	15	0	0	0	3	56	38	28	44	0	59	0	5	10	32
Synchococcus aquatilis	10	15	0	0	0	3	10	0	19	0	0	0	5	0	0	21	8	15	0	12	19	20	10	0	0	0	18	25
Sub-Total	**464**	**529**	**505**	**567**	**579**	**570**	**582**	**647**	**615**	**669**	**225**	**326**	**667**	**546**	**517**	**595**	**544**	**552**	**571**	**676**	**621**	**465**	**459**	**629**	**545**	**475**	**525**	**465**
Dinophyceae																												
Ceratium hirundinella	0	12	0	0	65	39	72	17	0	19	15	29	19	28	0	0	0	4	8	37	89	25	17	0	0	0	0	34
Ceratium sp	39	18	0	0	15	5	27	75	0	12	7	0	13	51	56	30	11	35	42	29	0	0	69	0	49	60	0	31
Ceratium tripos	28	0	12	51	0	0	0	48	31	9	21	11	0	0	48	0	46	48	21	39	45	0	0	46	0	17	0	0
Dinophysis caudata	43	67	36	54	12	35	0	0	0	0	38	2	43	0	0	48	35	54	54	11	26	0	48	35	28	0	38	3
Gonyaulax sp	94	28	0	23	32	65	63	0	48	0	0	0	0	26	0	0	38	68	23	0	0	0	0	38	68	0	0	12
Gonyaulax hurida	69	46	28	0	0	4	39	41	15	46	75	16	59	56	41	25	17	0	12	15	0	0	15	17	0	20	29	15
Pyrocystis sp.	25	24	35	0	11	0	0	24	0	0	25	21	25	43	24	34	18	0	19	8	19	0	34	18	0	38	87	0
Sub-Total	**298**	**195**	**111**	**128**	**135**	**148**	**201**	**205**	**94**	**86**	**181**	**79**	**159**	**204**	**169**	**137**	**165**	**209**	**179**	**139**	**179**	**25**	**183**	**154**	**145**	**135**	**154**	**95**
Euglenophyceae																												
Euglena acus	10	29	64	15	0	0	31	51	0	50	54	8	20	29	19	0	12	0	14	11	0	0	0	27	0	67	0	0
Euglena caudata	0	49	0	0	0	73	53	54	0	0	0	0	41	0	13	39	18	7	12	2	43	81	12	25	21	0	0	0
Euglena obtusa	39	59	0	0	0	45	2	23	0	0	0	0	65	0	0	0	32	32	0	0	15	26	32	6	34	31	15	0
Euglena tripteris	5	25	34	20	0	19	15	0	0	0	0	0	15	35	18	0	15	61	0	35	5	0	0	67	0	0	35	0
Phacus caudatus	31	0	31	29	0	12	7	0	0	0	15	40	42	15	40	42	31	28	0	12	0	0	0	0	0	0	0	0
Sub-Total	**85**	**162**	**129**	**64**	**0**	**149**	**108**	**128**	**0**	**50**	**69**	**48**	**183**	**79**	**90**	**81**	**108**	**128**	**26**	**60**	**63**	**107**	**44**	**125**	**55**	**98**	**50**	**0**
Total No. of cells	**267**	**259**	**255**	**266**	**256**	**221**	**235**	**287**	**248**	**245**	**197**	**205**	**285**	**250**	**216**	**188**	**212**	**280**	**313**	**259**	**251**	**226**	**25**	**28**	**28**	**2**	**2**	**2**

1000/l	**7**	**4**	**9**	**1**	**5**	**5**	**6**	**2**	**6**	**4**	**2**	**3**	**3**	**5**	**5**	**5**	**0**	**9**	**3**	**1**	**5**	**5**	**89**	**91**	**37**	**038**	**239**	**049**
No. of Species of Phytoplankton	78	76	78	81	82	73	78	82	74	74	71	66	87	75	66	61	77	91	84	77	74	74	74	82	76	67	68	69
	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
	38	40	38	35	34	43	38	34	42	42	45	50	29	41	50	55	39	25	32	39	42	42	42	34	40	49	48	47
in SW 44	**SW c3**	**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW 7**	**SW 12**	**SW 14**	**SW 39**	**SW 40**	**SW 41**	**SW 42**	**SW 43**	**SW 44**	**SW 45**	**SW 46**	**SW 47**	**SW 48**	**SW 49**	**SW 53**	**SW 54**	**SW 55**	**SW57**	**SW 58**	**SW 59**	**SW 61**
Rotifera																												
Brachionus caliciflorus	5	27	11	14	0	9	0	4	0	11	20	0	26	18	0	8	10	14	21	17	0	1	12	5	45	32	0	18
Brachionus ureolaris	11	15	17	0	0	15	18	7	5	15	0	5	15	17	0	14	3	0	5	0	1	4	11	20	36	15	0	3
Collotheca pelagica	57	4	19	5	14	4	0	11	0	0	17	0	4	0	30	3	10	27	15	31	0	6	32	20	2	10	20	3
Condonella ucinata	28	0	0	0	25	30	28	11	0	15	0	26	45	7	5	3	29	0	34	0	55	15	20	0	0	0	10	17
Lecane bulla	0	1	18	2	0	11	7	15	36	3	15	35	4	18	28	17	0	18	0	25	0	0	0	5	0	0	2	1
Lecane petica	0	21	6	0	0	0	35	0	27	43	5	0	11	3	7	15	21	15	17	0	2	51	17	0	0	1	6	10
Asplanchia prodonta	14	10	31	0	21	11	21	15	4	25	8	0	0	17	10	0	0	4	19	5	0	36	0	26	0	22	17	12
Asplanchia brightweli	0	20	0	15	31	16	21	3	5	3	29	0	7	0	6	22	0	0	0	0	10	31	15	35	15	0	6	0
Filinia longiseta	2	17	16	28	4	17	10	43	28	17	0	18	0	15	0	0	14	1	18	2	20	0	5	0	0	0	0	15
	8	15	31	1	11	0	2	25	27	47	5	0	8	21	7	0	10	21	6	0	2	44	8	0	14	2	9	10
Sub-total	**125**	**130**	**149**	**65**	**106**	**113**	**142**	**134**	**132**	**179**	**99**	**84**	**120**	**116**	**93**	**82**	**97**	**100**	**135**	**80**	**90**	**188**	**120**	**111**	**112**	**82**	**70**	**89**
Cladocera																												
Alona affinis	0	3	18	0	17	0	14	14	0	14	3	0	5	17	0	20	3	0	5	0	10	15	21	17	1	15	0	0
Alona intermidia	31	10	10	20	0	23	3	0	30	3	10	27	15	0	30	3	10	27	15	31	0	10	5	0	0	10	22	20
Bosmina sp.	0	29	0	10	7	5	3	27	5	3	29	0	34	7	5	3	29	0	28	0	0	0	15	31	1	0	8	10
Daphnia carinata	25	0	0	2	18	28	17	0	28	17	0	18	0	18	28	17	0	18	0	25	7	0	34	0	20	0	2	2
Chydorus sp	0	13	22	39	22	0	21	18	0	21	13	10	0	22	0	21	13	10	0	0	0	22	0	25	45	22	39	39
Polyphemus pediculus	18	0	2	17	7	0	2	10	15	18	28	17	0	0	0	15	0	0	14	1	18	2	0	0	0	0	0	20
Sub-total	**74**	**55**	**52**	**88**	**71**	**56**	**60**	**69**	**78**	**76**	**83**	**72**	**54**	**64**	**63**	**79**	**55**	**55**	**62**	**57**	**35**	**49**	**75**	**73**	**67**	**47**	**71**	**91**
Molluscan larvae																												
Tympanotonus sp	25	11	28	28	0	0	10	3	0	4	15	0	12	14	28	26	5	9	21	0	2	5	17	18	30	6	7	9
Pachymelania sp	2	0	17	5	7	0	2	12	0	45	11	11	7	5	8	0	14	27	11	0	7	4	4	1	7	2	0	3
Oxygiris sp.	1	3	3	6	0	22	39	17	8	1	6	4	7	27	11	14	0	9	0	1	6	3	0	11	14	26	5	21

Sub-total	28	14	48	39	7	22	51	**32**	8	50	32	15	26	46	47	40	19	45	32	1	15	12	**21**	**30**	**51**	34	12	33
Crustaceans (Copepoda)																												
Acartia longiremis	4	15	0	12	25	11	14	21	21	6	22	0	0	6	4	7	1	3	3	6	0	15	0	2	5	8	1	31
Anomalocera patersoni	45	11	11	7	2	0	0	11	10	0	0	14	0	13	4	14	6	8	7	6	16	28	0	7	4	2	11	4
Calanus finmarchicus	1	6	4	7	1	3	2	0	2	7	0	10	8	28	14	6	4	2	2	2	31	1	1	6	3	2	1	11
Candacia speciosus	6	8	7	6	18	2	20	18	2	11	13	4	14	17	0	14	35	4	10	16	17	17	22	17	17	15	0	1
Candacia armatia	25	30	28	0	0	15	10	0	18	22	17	0	0	0	0	0	35	7	11	15	17	0	0	6	0	21	6	0
Centopages typicus	0	11	7	2	9	21	20	28	0	0	6	18	2	0	21	11	21	10	57	4	19	5	0	0	15	10	31	14
Coryceaus venustus	0	0	35	7	15	21	17	7	28	0	0	6	0	15	31	16	21	6	28	0	0	0	2	9	21	20	0	25
Cyclops americanus	21	11	21	10	0	0	15	35	7	2	9	31	0	28	4	17	10	0	0	1	18	2	7	15	21	17	16	0
Diaphanosoma sp	31	16	21	6	22	0	0	21	35	7	15	0	15	1	11	0	2	7	0	21	6	0	10	0	0	15	31	0
Diaptomus oregonensis	4	17	10	0	0	14	0	21	21	10	0	16	28	15	0	12	25	11	14	10	31	0	6	22	0	0	4	21
Enterpina acutifrons	11	0	2	7	0	10	8	10	21	6	22	31	1	11	11	7	2	0	0	20	0	15	0	0	14	0	45	31
Eurytemora affinis	0	12	25	11	28	28	2	2	10	0	0	4	15	6	4	7	1	3	2	17	16	28	7	0	10	8	1	4
Faranula gracilis	11	7	2	0	17	5	2	25	2	7	0	45	11	13	4	14	6	8	8	15	31	1	11	28	28	2	11	11
Gaetanus armiger	4	7	1	3	3	6	15	2	25	11	28	1	6	28	14	6	4	2	13	0	4	15	0	17	5	2	1	0
Oncaea venusta	0	21	11	45	11	11	7	1	2	0	17		31	17	0	14	35	4	0	0	45	11	3	3	6	15	0	11
Paracalanus parvus	15	31	16	1	6	4	7	6	7	2	9	21	0	41	6	12	25	15	0	1	18	2	8	7	6	21	34	0
Paracalanus pygmae	28	4	17	11	13	4	14	4	35	7	15	21	16	16	28	4	17	10	0	0	14	0	2	2	2	2	17	0
Pseudocalmus elongatus	1	11	0	1	28	14	6	35	21	10	0	0	31	31	1	11	0	2	7	0	10	0	4	10	16	8	15	21
Rhincalanus	15	0	12	0	17	0	14	25	21	6	22	0	4	11	11	7	2	0	0	20	0	15	15	11	0	0	45	31
Sub-total	**222**	**218**	**230**	**136**	**215**	**169**	**173**	**272**	**288**	**114**	**195**	**222**	**182**	**297**	**168**	**179**	**252**	**102**	**162**	**154**	**293**	**155**	**98**	**162**	**173**	**168**	**270**	**216**
Crustacea (Decapods)																												
Crab larvae	35	7	11	15	17	0	0	0	21	6	0	0	0	0	10	37	0	15	15	0	8	13	0	1	0	46	32	32
Paelemonates larvae	21	10	57	4	19	5	14	32	10	31	0	21	11	0	25	5	34	10	58	37	8	79	0	12	6	14	8	32
Lucifer faxoni	21	6	28	0	0	0	25	32	20	0	15	31	16	0	7	0	4	15	15	10	37	0	0	11	17	48	5	15
Upogebia nauplii	0	25	30	28	0	0	15	15	15	18	22	17	0	7	1	0	2	2	4	25	5	34	15	9	9	0	15	10
Alpheus nauplii	2	0	11	7	2	9	21	10	4	0	0	6	18	6	0	0	2	6	10	25	5	34	58	10	22	1	4	10
Obelia Larvae	0	0	0	35	7	15	21	15	30	28	0	0	6	0	8	15	12	2	4	25	0	4	15	22	16	0	5	2

																												0
Veliger larvae	4	25	2	7	0	10	6	2	7	1	0	2	2	0	2	2	4	4	4	4	15	10	4	3	12	7	1	17
Ballanus Larvae	0	0	14	2	8	25	25	6	16	28	4	17	10	2	1	28	14	6	4	2	2	2	10	0	8	19	1	2
Sub-total	**83**	**73**	**153**	**98**	**53**	**64**	**127**	**112**	**123**	**112**	**41**	**94**	**63**	**15**	**54**	**87**	**72**	**60**	**114**	**128**	**80**	**176**	**102**	**68**	**90**	**135**	**71**	**138**
Euphausiacea																												
Meganycliphanes norvegica	8	7	6	0	4	5	4	14	11	13	4	14	6	7	1	0	2	2	4	3	12	1	6	10	13	0	15	1
Meganycliphanes spp	2	2	2	0	2	5	10	10	1	28	14	6	4	6	0	0	2	6	10	0	8	19	37	15	0	1	4	1
Sub-total	**10**	**9**	**8**	**0**	**6**	**10**	**14**	**24**	**12**	**41**	**18**	**20**	**10**	**13**	**1**	**0**	**4**	**8**	**14**	**3**	**20**	**20**	**43**	**25**	**13**	**1**	**19**	**2**
Total No. of zooplankton (100/l)	542	499	640	426	458	434	567	643	641	572	468	507	455	551	426	467	499	370	519	423	533	600	459	469	506	467	513	569
No. of Species of Zooplankton	35	38	41	36	34	34	42	42	40	40	32	32	35	37	36	37	40	39	36	31	36	37	34	36	35	35	39	40
	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
	13	10	7	12	14	14	6	6	8	8	16	16	13	11	12	11	8	9	12	17	12	11	14	12	13	13	9	8
Benthos	**SW c3**	**SW 1**	**SW 2**	**SW 3**	**SW 4**	**SW 5**	**SW 6**	**SW 7**	**SW 12**	**SW 14**	**SW 39**	**SW 40**	**SW 41**	**SW 42**	**SW 43**	**SW 44**	**SW 45**	**SW 46**	**SW 47**	**SW 48**	**SW 49**	**SW 53**	**SW 54**	**SW 55**	**SW57**	**SW 58**	**SW 59**	**SW 61**
Polychaete																												
Capitella capitata	5	5	4	0	3	3	7	3	0	0	7	5	1	0	1	1	1	1	2	2	0	3	3	3	1	3	0	3
Cirratulus sp	2	0	0	4	10	2	0	10	0	0	0	2	5	0	0	1	0	0	3	1	0	0	2	0	2	5	0	2
Cossura	4	3	4	0	1	3	0	1	1	1	1	1	0	1	0	1	2	2	1	0	0	5	3	0	2	0	0	0
Gycera	0	1	0	0	3	3	0	3	4	4	5	4	0	0	1	1	0	0	5	0	2	4	3	0	0	2	2	9
Heteromastus	10	2	0	16	1	5	2	1	1	0	0	2	4	0	1	4	1	4	2	2	7	0	5	2	0	0	0	0
Hyposoimus sp	1	3	0	0	0	3	2	0	4	10	0	3	0	4	0	1	3	0	2	0	2	2	3	2	0	0	0	0
Lumbrinereis sp.	3	3	0	0	1	0	0	1	0	2	2	2	0	3	1	1	0	1	1	4	5	7	0	0	2	1	1	0
Nephtys incisa	1	5	2	0	0	0	5	0	1	1	0	4	0	0	1	1	1	1	2	2	0	3	0	5	0	3	0	1
Nereis sp	0	3	2	2	3	6	0	3	0	0	3	5	0	0	0	1	0	0	3	1	0	0	6	0	0	5	0	0
Notomastus latericus	1	0	0	5	1	1	1	1	1	0	0	1	0	2	0	1	2	2	1	0	0	5	1	1	4	0	0	3
Scolopsis uniramus	0	0	5	2	5	2	0	5	5	0	3	0	0	0	1	1	0	0	5	0	2	4	2	0	0	2	2	2
Sternapsis scutata	3	6	0	1	0	4	3	0	13	10	1	0	2	0	1	4	1	4	7	2	7	0	4	3	4	0	0	0
Marphysa sanguinea	1	4	5	4	0	0	1	0	3	1	1	0	1	4	0	1	3	0	2	0	2	2	0	1	0	0	0	1
Sub-Total	**31**	**35**	**22**	**34**	**28**	**32**	**21**	**28**	**33**	**29**	**23**	**29**	**13**	**14**	**7**	**19**	**14**	**15**	**36**	**14**	**27**	**35**	**32**	**17**	**15**	**21**	**5**	**21**
Gastropods Molluscs																												
Tympanotonus fuscatus	14	2	1	17	1	2	12	7	0	0	1	0	1	0	0	0	1	4	1	4	2	2	3	2	5	2	0	1
Littorina sp	0	3	1	0	0	0	0	2	0	0	0	1	0	0	0	4	0	1	3	0	2	0	0	2	3	2	0	0
Neritina oweniana	2	1	0	0	5	3	0	0	0	1	0	1	2	1	1	3	1	1	0	1	1	4	0	0	0	0	2	4
Tellina nymphalis	10	5	0	2	16	2	0	1	2	0	11	1	0	3	13	6	1	6	6	1	10	2	2	1	3	5	18	9
Sub-Total	**26**	**11**	**2**	**19**	**22**	**7**	**12**	**10**	**2**	**1**	**12**	**3**	**3**	**4**	**14**	**13**	**3**	**12**	**10**	**6**	**15**	**8**	**5**	**5**	**11**	**9**	**20**	**14**
Bivalve Molluscs																												
Nucula	4	2	4	2	0	5	0	1	1	1	0	0	5	12	0	1	1	1	1	2	2	0	3	1	7	0	3	3

Stylaria	4	2	2	7	0	0	0	0	0	0	1	4	1	5	0	0	0	1	0	0	3	1	0	2	0	0	0	4
Sub-Total	**8**	**4**	**6**	**9**	**0**	**5**	**0**	**1**	**1**	**1**	**1**	**4**	**6**	**17**	**0**	**1**	**1**	**2**	**1**	**2**	**5**	**1**	**3**	**3**	**7**	**0**	**3**	**7**
Crustacea																												
Tianid sp.	4	5	7	0	0	0	2	1	5	1	0	1	1	0	3	0	0	1	0	0	2	1	0	3	0	1	4	1
Isodus sp	9	5	1	2	2	1	0	6	2	3	0	0	0	10	2	0	2	3	2	0	0	0	2	0	6	2	0	4
s	0	1	9	0	0	5	0	2	5	0	1	2	2	0	0	0	0	0	0	2	1	1	2	0	3	2	1	3
Leplalpheus sp.	1	0	1	2	1	1	3	3	3	0	1	0	0	5	0	2	2	0	3	0	1	6	1	0	0	0	0	4
Callianasa	2	2	0	4	4	10	0	1	1	3	0	2	0	4	0	0	0	3	2	0	0	0	0	0	5	0	2	0
Gammarus	0	0	0	2	5	4	1	5	1	0	0	2	0	2	0	2	5	0	0	0	1	0	0	2	4	0	10	1
Metagraspus	1	1	1	1	0	1	3	2	0	0	5	0	1	3	0	2	0	0	1	0	1	2	2	7	0	2	1	1
Ballanus	4	4	5	4	0	1	0	2	0	2	4	9	0	3	0	0	2	2	0	1	1	0	0	2	2	0	3	0
ddccxxxxxxxxz	1	0	0	2	4	1	1	1	2	7	0	0	6	5	2	0	0	0	0	1	4	1	4	5	7	0	1	4
Sub-Total	**22**	**18**	**24**	**17**	**16**	**24**	**10**	**23**	**19**	**16**	**11**	**16**	**10**	**32**	**7**	**6**	**11**	**9**	**8**	**4**	**11**	**11**	**11**	**19**	**27**	**7**	**22**	**18**
Total (No. of orgnism/sq.m)	**87**	**68**	**54**	**79**	**66**	**68**	**43**	**62**	**55**	**47**	**47**	**52**	**32**	**67**	**28**	**39**	**29**	**38**	**55**	**26**	**58**	**55**	**51**	**44**	**60**	**37**	**50**	**60**
No. of Species of Benthos	26	26	20	22	20	26	16	26	22	18	19	23	17	20	15	24	20	21	25	18	24	22	22	21	20	18	17	23