The Shell Petroleum Development Company of Nigeria Limited
Operator for the NNPC/Shell/Total E&P/Agip

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF SAGHARA ASSOCIATED GAS SOLUTION (AGS) PROJECT IN WARRI SOUTH LGA, DELTA STATE

FINAL REPORT

SUBMITTED TO THE FEDERAL MINISTRY OF ENVIRONMENT, ABUJA

APRIL 2015

STATUS PAGE

Title: ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF SAGHARA ASSOCIATED GAS SOLUTION (AGS) PROJECT IN WARRI SOUTH LGA, DELTA STATE

Originator: The Shell Petroleum Development Company of Nigeria Limited.

Author: Approved by:

Document Number: **SPDC**

Date:

Version: **03**

Security:

Change History:

Version	Date	Pages	Reason
02		**Whole Document**	**Final Report**

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LIST OF ABBREVIATIONS AND ACRONYMS

AG	Associated Gas
AGG	Associated Gathering Gas
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
AQ	Air Quality
BCA	Benisede Catchment Area
Bcf	Billion cubic feet
BOD	Biochemical Oxygen Demand
Bscf	Billion standard cubic feet
Ca	Calcium
CAPEX	Capital Expenditure
CAS	Catch Assessment Survey
CBO	Community Based Organisation
CBR	Crude Birth Rate
CDR	Crude Death Rate
CEC	Cation Exchange Capacity
CITES	Conversion to regulate International Trade in Endangered Species
cm	Centimeter
COD	Chemical Oxygen Demand
CPF	Central Processing Facility
Cr	Chromium
CRI	Cutting Re-Injection
Cu	Copper
DEP	Design and Engineering Practice
DO	Dissolved Oxygen
DOMGAS	Domestic Gas
DPR	Department of Petroleum Resources
DSMEnv	Delta State Ministry of Environment
EC	Electrical Conductivity
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
ELPS	Escravos Lagos Pipeline System
EMP	Environmental Management Plan
EPF	Early Production Facility
FDP	Field Development Plan

FEED	Front-End Engineering Design
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FID	Final Investment Decision
FLB	Field Logistics Base
FMEnv	Federal Ministry of Environment
Ft	Feet
FYIP	Forcados Yokri Integrated Project
GEM	Gender Empowerment Measure
GHF	Gas Handling Facility
GIIP	Gas Initially in Place
GW	Groundwater
HAZID	Hazard Identification
HAZOP	Hazard Operability
HDI	Human Development Index
HIA	Health Impact Assessment
HNO_3	Nitric Acid
HPI	Human Poverty Index
HSE	Health, Safety, Environment
HSE	Health, Safety and Environment
HSE-MS	Health, Safety and Environment Management System
IA	Impact Assessment
IFC	International Finance Corporation
ISO	International Organisation for Standardisation
IUCN	International Union for Conservation of Nature and Natural Resources
Km	Kilometres
LGA	Local Government Area
m/s	meter per second
m^3	meter cube
m^3/d	meter cube per day
MAC	Mid Arm Circumference
MEDEVAC	Medical Emergency Evacuation Response
mg/l	milligram per liter
Mm	Millimeter
MMbbl	Million Barrel

MMboe	Million Barrel of oil Equivalent
MMscf/d	Million Standard cubic feet of gas per day
MMstb	Million stock tank barrel
MoU	Memorandum of Understanding
Na	Sodium
NAG	Non Associated Gas
NDPC	Niger Delta Peace Coalition
NDT	Non Destructive Test
NERC	National Electricity Regulatory Commission
NFA	No Further Activity
NGC	Nigerian Gas Company
NGO	Non-Governmental Organisation
NH_4^+	Ammonium ion
NIWA	National Inland Waterways Authority
NPF	Nigeria Police Force
^{o}	Degree
^oC	Degree Celsius
OML	Oil Mining License
P	Phosphorus
Pb	Lead
pH	Hydrogen ion concentration
PMoU	Project Memorandum of Understanding
PO_4^-	Tetraoxophosphate (VI) ion
Ppm	Parts Per Million
PRA	Participatory Rural Appraisal
Q1	Quarter one
Q4	Quarter four
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
RF	Recovery Factor
RoW	Right of Way
SCD	Sustainable Community Development
SD	Sustainable Development
SED	Sediment
SIA	Social Impact Assessment
SMART	Specific, Measurable, Achievable, Realistic and Time-based
SPDC	Shell Petroleum Development Company of Nigeria Limited

SPDC	The Shell Petroleum Development Company of Nigeria Ltd
SS	Soil Sample
SS	Suspended Solids
SSAGS+	Southern Swamp Associated Gas Solution Plus Project
SSIOGP	Southern Swamp Integrated Oil & Gas Project
SW	Surface Water
SWL	Static Water Level
Tcf	Trillion cubic feet
TDS	Total Dissolved Solid
TDS	Total Dissolved Solids
THC	Total Hydrocarbon
THC	Total Hydrocarbon Content
ToR	Terms of Reference
Tscf	Trillion standard cubic feet
TSP	Total Suspended Particulates
TSS	Total Suspended Solid
TSS	Total Suspended Solids
UR	Ultimate Recovery
VAR	Value Assurance Review
VEG	Vegetation
VOC	Volatile Organic Carbon
WHO	World Health Organisation
%	Percentage
$\%_o$	Parts per thousand
µg/l	Microgram per liter
µS	Micro Siemen

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EXECUTIVE SUMMARY

ES 1.1: Background

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on the Otumara Node (Otumara and Saghara flow stations) Associated Gas Solution (AGS) Project to meet the business objectives of Domestic Gas supply and gas flares down by 2014. At present, produced AG is currently used as fuel gas for the pumps and generators, for lift gas, and the excess flared. The Saghara AG Solution Project is part of the wider Otumara Node AGS Project. The project aims at effectively stopping routine gas flaring in SPDC operations. At present, most of the associated gas produced at Saghara Flowstation is flared. All Otumara oil wells currently producing into Saghara flowstation will be re-routed back to Otumara Flowstation. The remaining Saghara oil wells will be comingled at low pressure and allowed to flow freely (with the associated gas) to Otumara Flow station. The proposed Saghara project will involve decommissioning mothballing of the existing flowstation through the installation of new inlet manifold, 6” bulk line and 4” testline in order to harvest AG from the Saghara field in Delta State of Nigeria.

ES1.2: EIA Objectives

The objectives of the EIA study are to:

- Determine the current status of the Environment and impacts of the existing SPDC facilities and operations in the project area.
- Determine baseline conditions of the environment as well as the socio-economic and health conditions of the host communities;
- Evaluate the residual impacts of the existing facilities on the receiving environment;
- Determine and evaluate the potential impacts of the proposed project activities on the environment, using the current environmental conditions as the baseline;
- Identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural properties, social infrastructures, natural resources and impact on lifestyles/values as well as analysis of the opportunity cost to chemical spills during project activities;
- Identify health hazards that may result from the different phases of the project during execution (including operation & decommissioning) and evaluate local population exposure to these hazards;
- Develop cost effective mitigation measures and appropriate Environmental Management Plan (EMP) for all identified impacts.

ES1.3: The Project

The new activities will include the following: Installation of a new bulking manifold; Laying of new testline (4” x 5km) from Saghara to Otumara Flowstations; Laying of new bulkline (6” x 5km) from Saghara to Otumara Flowstations; Decommissioning, mothballing and preservation of existing equipment in the Saghara flow station; and Electrification of the communities.

ES1.4: Legal and Administrative Framework

The EIA was carried out in accordance with the Mineral Oil (Safety) Regulations, 1963, Oil Pipelines Ordinances (CAP) 145, 1956 and Oil Pipelines Act, 1965, Petroleum (Drilling and Production) Regulations (1969), Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988, FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995), S.I. 15 - National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv), Environmental Impact Assessment Act No. 86, 1992 (FMEnv), FEPA (Now FMEnv) National Guidelines for Spilled Oil Fingerprinting (Act 14 of 1999), FEPA (Now FMEnv) National Guidelines on Waste Disposal through Underground Injection (1999), FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999), FEPA (Now FMEnv) National Policy on the Environment (1989), National Oil Spill Detection and Response Agency (NOSDRA), 2006 and National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007. Other regulations include Forestry Law CAP 51, 1994, Land Use Act of 1978, The Bendel State Town and Country Planning Laws Cap 165 (as applicable to Delta State) of 1975, Delta State Environmental Protection Agency Edict No 5 of 1997, Delta State Ecology Law,2006, Bendel State Forestry Law Cap 59, 1976 (now applicable to Delta State), Delta State Revenue Edict, 1997, Delta State Waste Management Law, 2004 and Delta State Internal Revenue Consolidation Law, 2009. Other regulations are the National Inland Waterways Authority Act No 13 of 1997, International Laws and Regulations (World Bank Guidelines on Environmental Assessment {EA} (1991), International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, Convention on the Migratory Species of Wild Animals (Bonn Convention), Convention of Biological Diversity, Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention), Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and United Nations Framework Convention on Climate Change (1992)), Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26), Nigerian Ports Authority Act No 38 of 1999, Endangered Species (Control of International Trade and Traffic) Act 11 of 1985, and the Environmental Impact Assessment (EIA) Process – A Manual for EIA Execution in SPDC, SPDC 99-201, 2000. This document sets down the guidelines for an enhanced, cost effective and improved EIA process in SPDC, which fully incorporates Social Impact Assessment (SIA), Health Impact Assessment (HIA) and effective consultation with all the Stakeholders in the EIA.

ES2.1: Project Justification

Need for the Project

This project is needed for several reasons among which are:

- To align with Nigeria's aspiration to reduce environmental pollution caused by gas flaring.
- To utilize gas that was hitherto flared for economic benefit via sales.

To increase domestic gas supply for local consumption thereby contributing to Nigeria's ability to sustain her growing energy needs.

ES2.2: Project Alternatives

The Saghara Field Associated Gas (AG) Solution Project has addressed various project alternatives based on the availability of process facilities, utilization of existing facilities, technology, cost effectiveness and environmental issues. The project development alternatives considered were;

- No Project Option
- Multiphase Pumping from Saghara Flowstation
- Free flow from Saghara Flowstation

Option 3 Free Flow from Saghara was selected based on the criteria as shown in Table 2.1. The concept allows Saghara wells to flow freely to Otumara flowstation. This is premised on re-routing these Otumara wells: 17T, 36L, 40T and 43S (currently producing into Saghara flowstation), back to Otumara Flowstation. Future oil development in Saghara will not be constrained by this option as reservoir forecasts have shown.

ES2.3: Envisaged Sustainability

The envisaged sustainability is categorized as follows:

Economic sustainability

Saghara field has substantial reserves of associated gas. There are proven reserves that can economically and commercially support the project. The Saghara AGS project will, in the long run, contribute substantially to Nigeria's revenue from petroleum.

Technical sustainability

The Saghara AGS Project (which is part of Otumara field) is technically sustainable because SPDC has proven oil and gas technology and adheres strictly to Nigerian national and international engineering design and construction standards. Technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized during project execution.

Environmental sustainability

Facilities and pipeline construction techniques vary according to the environment, and are guided by Regulatory and Engineering Design standards. Pipelines in marshy/swampy areas and water crossings would have a yard-applied concrete coating over the external, anti-corrosion coating. 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.

ES3.1: Project Description

The Saghara AG Solutions Project involves mothballing of Saghara flow station and re-routing of Saghara wells back to Otumara Flowstation while the remaining Saghara oil wells will be comingled at low pressure and allowed to flow freely (with the associated gas) to Otumara Flowstation. Some of the existing facilities, (generators & export pumps) within the flow station will be decommissioned and preserved. The project does not involve drilling of new oil wells. The work comprises of engineering review and verification, procurement of materials, construction and commissioning of a new bulkline (6" x 5km) and testline (4" x 5km) for Saghara flowstation to Otumara flowstation including all associated tie-ins and manifold works. The above scope will enable re-routing of Otumara wells currently producing to Saghara flowstation to Otumara flowstation. The works will be carried out in the Saghara flowstation and only existing flowline Right of Way (RoW) will be used for the construction works. Therefore there will be no requirement for land acquisition. The scope also includes installation of 21km long fibre optic cable from Saghara wells to Otumara CPF for data transmission from the wells (downhole data gathering) and communication with the wells (ability to control instruments on the wellheads)**.**

ES3.2: Facilities Bulkline and Testlines (Flowlines) Construction

This section describes the construction activities for the proposed Saghara facility, bulklines and testlines. These shall include:

- Pipeline route surveys and soil investigations as necessary.
- Site preparation activities
- Construction of 2" x 5km corrosion inhibition lines from Otumara CPF to Saghara flowstation manifold
- Installation of 4" x 5km oil testline lines from Saghara flowstation inlet manifold to Otumara flowstation inlet manifold
- Installation of 6" x 5km oil bulkline lines from Saghara flowstation inlet manifold to Otumara flowstation inlet manifold
- Re-routing of 4" x 5km oil flowline lines from Saghara wells to Otumara flowstation inlet manifold
- Installation of 4" and 6" pig launching and receiving facilities and tie-in at Saghara flowstation

- Installation of 21km fibre optic cable from Otumara CPF to Escravos through Saghara flowstations. Fibre optic cable shall be installed along the same pipeline trench.
- Tie-ins to existing inlet manifolds/hook-ups.
- Installation of cathodic protection system
- Hydrotesting
- Pre-commissioning and commissioning activities
- Decommissioning, Mothballing and Site restoration

Details of Mothballing procedure include:

- Plant Shutdown
- Inspection and Technical Audit of facilities
- Decision on extent of preservation
- Engineering work for preservation
- Planning and Management of Mothballed facility

ES3.3: Project Location

The Saghara field is located in OML 43 (Warri South LGA, Delta State) in the greater Forcados area in the coastal swamp depo-belt of the western Niger Delta. The field was discovered in 1970 and to date a total of 8 wells have been drilled in the field, of which two (wells 4 and 6) have been abandoned. Production in the field started in 1972. Oil is produced to Saghara flowstation with nominal capacity of 30,000 barrels of oil per day (gross).

ES3.4: Project Schedule

The current activity schedule for the Saghara AGS Project is shown in Figure 3.3 below. First gas is expected from the node by 2014.

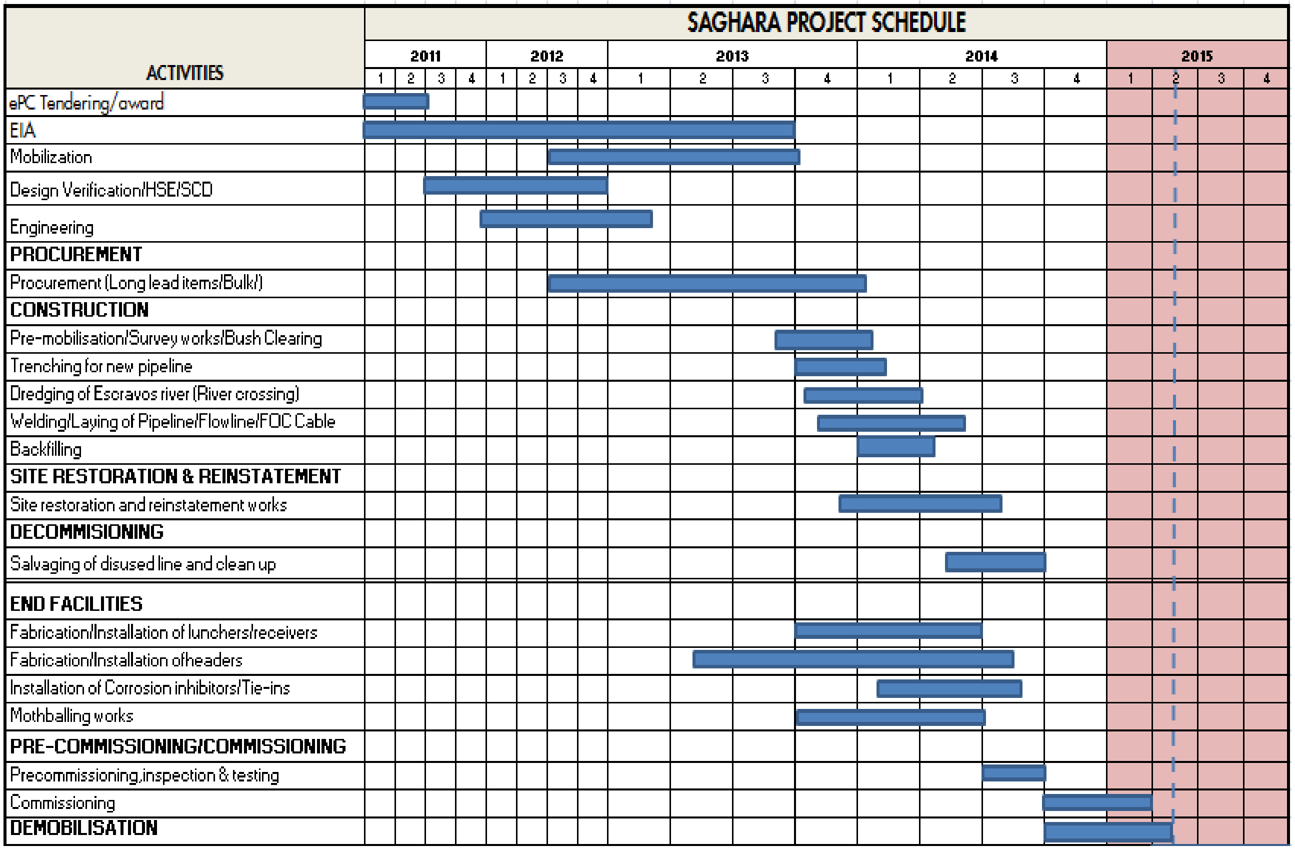

Fig. ES.1: Saghara AGS Project Schedule

ES4.0: Environmental Description

Baseline environmental studies have shown the existing state of the project environment is still relatively pristine.

Climate and Air Quality

The measured mean wind speed within the field ranged from 0.8 to1.4 m/sec in the Wet Season, and from 0.8 to 2.0 m/sec in the Dry Season., with the highest in the coastal areas. The prevailing wind directions were predominantly Southwesterly in the Wet Season and Northeasterly in the Dry Season. Measured mean temperatures within the field ranged from 27.8°C to 31.5°C in the Wet season, and from 30.5°C to 34.8°C in the Dry Season, while relative humidity ranged from 55% to 76.1% in the Wet Season and from 70% to 87% in the Dry Season. Historically, Relative Humidity is higher in the Wet season, than in the Dry Season. The apparent deviation from the norm obtained in this study, was due to heavy rainfall experienced during the field work. This probably is part of the impacts of the global weather changes currently being witnessed worldwide. Historical data show that the region experiences rainfall throughout the year. On the average, the region receives annual rainfall of over 2,472mm; however it is not uncommon to record total annual rainfall of over 3,200mm, for a very wet year. The monthly variation was a minim um of 20 mm in January and a maximum of 355 mm in July.

Air quality studies indicated that concentrations of NO_x as NO_2 and SO_x as SO_2 exceeded Regulatory limits at many sampling locations. The exceedances were more in the Dry Season than in the Wet Season. However, caution must be exercised in interpreting these results because of the relatively short averaging sampling times (5 – 10 mins) used in this study, compared to the averaging times of 8-24 hours used for regulatory limits. On the other hand, it is equally probable that these concentrations may remain at these levels over longer periods. Fortunately, there will be no air quality problem in Saghara field, since the Flowstation is to be mothballed.

Soil Physicochemistry

Both physicochemical and microbiological characteristics of the soil of Saghara field were carried out over two seasons (wet and dry) and at two strata (0-15 cm and 15-30cm). Ten surface and subsurface samples were collected including control. During the dry season, pH ranged from 2.89 – 6.52 with a mean of 4.94 at the surface, which was not different from the subsurface values ranging from 2.86 – 6.53 with a mean of 4.69. The results show that the soil of the study area is generally acidic, the subsoil being slightly more acidic than the top soil. The pH exhibited little seasonal variation, being slightly more acidic during the wet season.

Exchangeable cations analyzed in the soil include sodium, potassium, magnesium and calcium. During the dry season, Na ranged from 9.40 – 15.58 meq/100g with a mean of 11.92 meq/100g at the soil surface and 7.73 – 13.03 meq/100g with a mean of 10.84 meq/100g at the subsurface. Among the cations, calcium was dominant followed by sodium and magnesium, while the potassium was the least. Sodium, calcium, magnesium and potassium in the dry season were about 5-10 times higher than that of the wet season. Also, the surface soil samples were slightly higher than the subsurface samples. These spatial and seasonal variations are expected due to the combined effects of rainfall and evaporation.

Electrical conductivity (EC) in the study area during the dry season ranged from 570 – 19,240 µS/cm with a mean of 5052 µS/cm at the soil surface, whereas at the subsurface it ranged from 220 –18,350 with a mean of 4730 µS/cm. The control sample had an EC of 12,510 µS/cm at the surface and 2710 µS/cm at the subsurface. In the wet season, EC ranged from 270 – 3010 µS/cm with a mean of 1245 µS/cm. The control sample had an EC of 2050 µS/cm at the surface and 2100 µS/cm at the subsurface. Sulphate and chloride appears to be the major anionic species in the study area. During the dry season, chloride ranged from 102 – 705 mg/kg with a mean of 192 mg/kg at the soil surface, whereas it was 74 – 570 mg/kg with a mean of 156 mg/kg at the subsurface. During the dry season, sulphate was 98 -1118 mg/kg with a mean of 400 mg/kg at the surface and 84 – 1112 mg/kg at the subsurface with a mean of 368 mg/kg. Like chloride, sulphate was higher in the wet season and at the surface strata. Increased tidal water inundation of the soils may have caused this pattern of variation in the soil.

In the wet season, phosphate was 19.2 -48 mg/kg with a mean of 33.58 mg/kg at the surface and 16.4 – 31.2 mg/kg with a mean of 25.67 mg/kg at the subsurface. The control sample had a phosphate concentration of 32.2 mg/kg at the surface and 29 mg/kg at the subsurface. Phosphate did not exhibit significant differences across the two seasons and between the two soil strata.

Nitrogen related parameters analyzed include total nitrogen (TN), ammonium, nitrite and nitrate. During the dry season, TN ranged from 0.06 – 0.64 % with a mean of 0.37% at the soil surface. At the subsurface, it was 0.05 – 0.63% with a mean of 0.33 %. The control had a TN of 0.39 % at the surface and 0.42 % at the subsurface. During the wet season, TN was significantly higher ranging from 0.29 – 1.18% (mean = 0.56 %) at the surface and 0.04 – 1.11 % (mean = 0.54%) at the subsurface. The control had a TN concentration of 0.60% and 0.51% at the surface and subsurface respectively. The higher total nitrogen in the wet season and in the top soil layer could be linked to faster biodegradation activities in the wet season and at the top layer.

Hydrocarbon related parameter analyzed over the two seasons and along the two strata include THC, TPH, PAH, BTEX, TOC and phenol. During the dry season, THC ranged from 23.2 – 85 mg/kg with a mean of 55.58 mg/kg at the surface soil level and 11.6 – 77.9 mg/kg with a mean of 46.57 mg/kg at the subsoil. The THC level at the control was significantly lower than that of the main samples; it was 16.3 mg/kg at the surface and 14.7 mg/kg at the subsurface. The wet season THC was higher than that of the dry season ranging from 51.3 -150.1 mg/kg (75.36 mg/kg) at the surface soil and significantly lower at the subsoil ranging from 35.9 – 60.5 mg/kg mean 49.88 mg/kg). The wet season control had a THC concentration of 75.5 mg/kg and 65.2 mg/kg at the surface and subsoil respectively. Notwithstanding, TPH was several orders lower than the THC and was generally <1 mg/kg at all the sampling points in both seasons. This value was several orders lower than the 5000 mg/kg DPR intervention level. Other hydrocarbon related parameters including PAH, BTEX and phenol was similarly <1 mg/kg at all the sampling points in both seasons.

Eleven heavy metal parameters were analyzed. During the dry season, iron was the dominant heavy metal occurring at a concentration of 98.8- 133.6 mg/kg with a mean of 123.52 mg/kg at the surface and mean of 123.43 mg/kg at the subsurface. High levels of iron are not unusual in mangrove ecosystems of the world including the Niger Delta. The next abundant heavy metal in the area is manganese ranging from 11.8 – 57.9 mg/kg (mean = 21.5 mg/kg) at the surface and 8 – 56.8 mg/kg (mean = 17.83 mg/kg) at the subsurface. The control was 15.4 mg/kg at the surface and 11.1 mg/kg at the subsurface. The other heavy metal concentrations ranged from <0.001 - <1.0 mg/kg (Hg, Cd, Ba), 1.0 – 10.0 mg/kg (Cr), and 11 – 20 (Cu, Zn, Pb, Ni, V). The concentrations of all the metals were higher at the surface except Cu and Pb that were higher at the subsurface. Apart from iron that was slightly higher during the wet season, all the other parameters were significantly lower perhaps due to dilution effects of the rains and tides. Mechanical analysis of the soil revealed that sand ranged from 89.9 -93% (mean = 91.28 %) at the surface and 91.7 – 93.1 % (mean = 91.1%) at the subsurface. Clay was 5.0 – 9.3 % (mean = 6.33%) at the surface and 4.3 – 7.7 % (mean = 5.74%) at the subsurface, while silt accounted for the remainder. With these properties, the texture of the soils of the study area could be described as sand.

Soil Microbiology

Microbiological parameters considered include total heterotrophic bacteria (THB) and hydrocarbon utilizing bacteria (HUB), total fungi (TF) and hydrocarbon utilizing fungi (HUF). During the dry season, the population of THB ranged from 3.8 – 8.6 x 10^5 cfu/g at the soil surface and 3.6 – 8.2 x 10^5 cfu/g in the subsurface. During the wet season, THB was slightly higher ranging from 6.5 - 9.9 x 10^5 cfu/g in the surface and 5.1 – 9.6 x 10^5 cfu/g in the subsurface. The control station had a THB population density of 9.1 x 10^5 cfu/g at the surface and 4.2 x 10^5 cfu/g at the subsurface. The population of HUB during the dry season, ranged from 1.7 – 3.2 x 10^3 cfu/g in the surface and 1.2 – 3.1 x 10^3 cfu/g in the subsurface. During the wet season, it was 2.8 - 5.5 x 10^5 cfu/g in the surface soil and 1.5 – 4.7 x 10^3 cfu/g in the subsurface. HUB makes up about 1 % of the THB, which suggest non-pollution from petroleum sources. Generally, the population of microbes was slightly higher in the top soil due to more availability of oxygen, organic matter and other nutrients. The predominant genera of bacteria isolated from the soil of the study were *Bacillus*, *Pseudomonas*, *Enterobacter*, Micrococcus and *Staphylococcus*. During the dry season, TF was an order lower than THB with population ranging from 0.9 - 2.9 x 10^4 cfu/g in the soil surface and 0.6 - 3.0 x 10^4 cfu/g in the subsurface. During the wet season, TF ranged from 1.0 – 2.5 x 10^4 cfu/g in the surface and 0.8 – 2.0 x 10^4 cfu/g in the subsurface. HUF population ranged from 0.2 (non-significant) - 2.0 x 10^2 cfu/g in the soil surface and 0.1 (non-significant) – 1.6 x 10^2 cfu/g in the subsurface. The control soil sample had TF population of 2.5 x 10^4 cfu/g at the surface and 2.0 x 10^4 cfu/g at the subsurface; HUF population was 1.8 x 10^2 cfu/g at the soil surface and 0.9 x 10^2 cfu/g at the subsoil. Hence, HUF is <1% of the TF. Predominant fungal genera in the study area are *Mucor*, *Penicillium* and *Aspergillus*.

Surface Water Physico-Chemistry

All the water samples in this study were slightly alkaline in nature. The mean pH values of the surface water samples ranged from 7.2 in the wet season to 7.5 in the dry season. These alkaline pH values are typical of brackish water environment, and they fall within the regulatory limits of FMEnv and DPR. The mean conductivity values were correspondingly high, ranging from 10534 µS/cm in the wet season to 22945 µS/cm in the dry season. The salinity values are of the brackish water range, with higher dry season values. The Total Dissolved Solids were also high, and typical of the brackish water environment. The mean DO values recorded in this study ranged from 7.14 mg/l in the wet season to 5.08 mg/l in the dry season. The mean BOD values ranged from 3.08 mg/l to 2.8 mg/l in the wet and dry seasons respectively. The mean COD values ranged from 8.8 mg/l to 43.5 mg/l in the wet and dry seasons respectively. Bicarbonate values ranged between 85.4 and 125 mg/l in the wet and dry seasons respectively. The control values for the wet and dry seasons were 134.5 mg/l and 287 mg/l respectively.

Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg), the earth metals in solution constitute the exchangeable cations. In this study, the mean concentration of sodium ranged between 146.4 mg/l in the dry season and 156.3 mg/l in the wet season; potassium (107.9 – 135.7 mg/l), calcium (29.0 – 49.9 mg/l) and magnesium (39.3 – 55.3 mg/l). These values are characteristic of brackish water environment and not different from values obtained for the control station for both the wet and dry seasons. The order of dominance is as follows: Na > K > Mg > Ca. Chloride had mean values ranging between 7473 mg/l in the dry season and 12078 mg/l during the wet season. The mean nitrate and nitrite values recorded in this study ranged from 3.20 – 3.34 mg/l and 1.76 – 2.47 mg/l respectively. Higher values were recorded during the dry season. The ammonium nitrogen values were low, ranging from 0.03 – 0.12 mg/l in dry and wet seasons respectively.

The levels of Total Hydrocarbon (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and Phenol recorded in this study were low, indicating an environment not polluted by petroleum hydrocarbons. The mean THC values ranged between 0.33 and 0.37 mg/l, TPH values ranged between 0.059 and 0.066 mg/l, while PAH values ranged from 0.001 to 0.018 µg/l. The BTEX and Phenol values ranged from 0.00 to 0.003 µg/l and 0.002 to 0.003 µg/l respectively. These values are below the regulatory limits. The concentrations of heavy metals in the water samples were generally low and in some cases not detected. All heavy metals had mean values less than the regulatory limits, except for Fe (0.04 – 1.23 mg/l) and Pb (0.159 - 0.193 mg/l) which had values slightly greater than the regulatory limits of DPR (WHO) and FMEnv. High lead levels recorded in this study may be attributed to combustion of lead-containing fuel used in our water crafts (speed boats and barges).

Surface Water Microbiology

Total coliform counts in the surface water ranged from 11 – 35 MPN/100ml in the dry season and 12 – 40 MPN/100ml in the wet season. The control samples had total coliform in the range of 15 – 17 MPN/100ml in the dry and wet seasons. Faecal coliform is virtually absent in the wet season and scanty in the dry season (0 – 2.5 MPN/100ml). Total heterotrophic bacteria (THB) in the surface water ranged from no growth to 2.8 x 10^4 cfu/ml in the dry season and were slightly higher in the wet season ranging from 6.8 – 8.0 x 10^4 cfu/ml. The control samples had THB in the range of 6.8 – 7.1 x 10^4 cfu/ml in the dry season and 5.8 – 6.2 x 10^4 cfu/ml in the wet season. Hydrocarbon utilizing bacteria (HUB) ranged from 0 – 2.8 x 10^2 cfu/ml in the dry season and 1.1 – 3.7 x 10^2 cfu/ml in the wet season. HUB in the control station in both dry and wet seasons was within the range reported for the main samples. HUB consists of <1% of the THB. The predominant genera of bacteria isolated from the surface water of the study were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Proteus*, *Alcaligenes* and *Staphylococcus*. Fungal population density was at least an order lower than bacteria population. Total fungi are within the range of 0.6 – 6.5 10^3 cfu/ml in the dry season and 0.8 – 1.7 10^3 cfu/ml in the wet season. Hydrocarbon utilizing fungi was virtually non-existent in both seasons.

Sediment Physico-chemistry

The physicochemical and microbiological characteristics of the bottom sediment were studied over two seasons (dry and wet). The pH ranged from 4.26 – 5.66 with a mean of 4.90 in the dry season and 5.20 – 6.40 with a mean of 5.70 during the wet season. The control stations had pH of 4.8 – 4.9 in the dry season and higher in the wet season, ranging from 6.1 – 6.4. Electrical conductivity (EC) ranged from 10,370 – 16,200 µS/cm (mean = 14,065 µS/cm) in the dry season and was significantly lower in the wet season ranging from 3960 – 11,920 µS/cm (mean =7327 µS/cm). The major exchangeable cations in the sediment include sodium, potassium, calcium and magnesium.

The major anionic species in the sediment are chloride and sulphate. Chloride was lower in the dry season (107 – 113 mg/kg; mean = 109 mg/kg) than the wet season 1233 – 3767 (mean =2338 mg/kg). Chloride in the control ranged from 110 – 121 mg/kg in the dry season and 1609 – 1731 mg/kg in the wet season. Similarly, sulphate was lower in the dry season (200 – 520, mean = 283 mg/kg) than the wet season (350 – 6,120 , mean 958 mg/kg). The control sample had sulphate 250 – 320 mg/kg in the dry season and 350 – 428 mg/kg in the wet season. Total Nitrogen (TN) was 0.58 – 0.81% (mean = 0.70%) in the dry season and 0.27 – 0.92% (mean = 0.71%). The control samples had a TN of 0.59 – 0.65% in the dry season and 0.27 – 0.95 %in the wet season. There was no seasonal difference in TN. During the dry season, other nitrogen related parameters include ammonium (1.00 – 22.4 mg/kg), nitrate (4.7 – 11.5 mg/kg) and nitrate (6.5 -23.2 mg/kg). In the wet season, they were 12.2 – 19.2 mg/kg, 2.0 – 15.4 mg/kg and 4.0 – 19.8 mg/kg respectively. Phosphate ranged from 3.9 – 8.9 mg/kg in the dry season and 0.4 – 5.6 mg/kg in the wet season.

Hydrocarbon/organic related parameters studied include TOC, THC, TPH, BTEX, PAH and phenols was studied in the sediments over the two seasons. TOC ranged from 4.90 – 6.20% (mean = 5.63%) in the dry season and 1.32 – 4.77% (mean 3.60%) in the wet season. THC ranged from 26.40 – 69.50 mg/kg (mean = 49.37 mg/kg) in the dry season and 36.5 – 69.6 mg/kg (55.9 mg/kg) in the wet season. The THC concentration at the control sample was 41.2 – 41.5 mg/kg and 52.1 – 53.5 mg/kg in the dry and wet season respectively. During this study, was <2.0 mg/kg in both seasons, which is very low compared to the DPR intervention level of 5,000 mg/kg. All the other hydrocarbon related parameters including BTEX, PAH and phenols occurred in traces and were generally <0.01 in both seasons.

Iron is the dominant heavy metal in the sediment. Iron ranged from 133.0 – 135.8 mg/kg with a mean of 140.71 mg/kg in the dry season and was higher in the wet season ranging from 194.2 – 212.1 mg/kg with a mean of 207.0 mg/kg. In both seasons, some heavy metals ranged not detected (ND) to 0.1 mg/kg (Cr and Cd), 1 – 10 mg/kg (Ni and V), 11 – 20 (Zn) and 21 – 40 mg/kg (Mn, Cu and Pb).The concentrations of all the heavy metals were lower during the wet season except iron. Mechanical analysis of the soil revealed that sand ranged from 88.10 – 92.5% (mean = 90.29 %). Clay was 6.8 – 11.4 % (mean = 8.54) while silt accounted for the remainder. With these properties, the texture of the soils of the study area could be described as sandy according to USDA soil classification. Because of the high porosity and permeability of sandy formation, contaminants can easily migrate though these formations.

Sediment Microbiology

Microbial analysis was carried out in the bottom sediment of the study area. Total heterotrophic bacteria (THB) in the sediments ranged from 2.4 – 3.3 x 10^4 cfu/g in the wet season and 2.4 – 3.7 x 10^4 cfu/g in the wet season. Hydrocarbon utilizing bacteria (HUB) ranged from 0.3 – 1.8 x 10^2 cfu/g in the dry season and 0.3 – 1.0 x 10^2 cfu/g in the wet season. In both seasons, HUB consists of <1% of the THB. The population of THB and HDB of the control samples is within the same range reported for the main samples. The predominant genera of bacteria isolated from the sediment of the study were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Proteus*, *Alcaligenes*, *Micrococcus* and *Staphylococcus*. The population of total fungi is an order lower than that of bacteria, ranging from 0.1 – 3.7 x 10^3 cfu/g in the dry season and was slightly lower in the wet season ranging from 0.1 – 2.0 x 10^3 cfu/g in the wet season. The total fungi in the control sample ranged from 1.3 – 1.5 x 10^3 cfu/g in the dry season and 2.9 -3.2 x 10^2 cfu/g in the wet season. Hydrocarbon utilizing fungi (HUF) was scanty in both seasons, ranging from 0 – 62 cfu/g in the dry season and 0 – 30 cfu/g in the dry season. Predominant fungal genera in the study area are *Penicillium* and *Aspergillus*.

Hydrobiology

The ecological aspect of this study includes phytoplankton, zooplankton, benthic macroinvertebrates and fisheries study. Phytoplankton flora are microscopic chlorophyll containing plants that are found in aquatic ecosystems where they function as primary producers. The wet season phytoplankton flora were represented by thirty three (33) taxa belonging to five divisions the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids). The dry season phytoplankton community were represented by forty (40) species distributed into similar divisions, the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids) as in the wet season. The major phytoplanktonic organisms identified during both seasons are characteristic of brackish and oligohaline environment.

The zooplankton are microscopic animals found mainly in the pelagic zone of water bodies where they depend on water currents and waves for motion. In this study, 27 zooplankton taxa were recorded for both wet and dry seasons, with more species occurring in the dry (27) than in the wet (24) season. The wet season community comprised 13 species of Cladocera, 4 Copepod taxa, and 7 species of Rotifera. The dry season zooplankton fauna were made up of 15 species of Cladocera, 5 species of Copepoda and 7 species of Rotifera.

Benthic macroinvertebrates are those organisms which are over 1.0 mm in size, living on or in the substrate. In this study, 28 benthic macroinvertebrate taxa belonging to the Crustacea (13), Mollusca (6), Annelida (4) and Insecta (5)) were recorded for the both wet and dry seasons. They were mainly brackish water species. Common fin fishes in the area include but not limited to *Tilapia zilli*, *Ethmalosa fimbriata*, *Chrysicththys* sp; while the shell fish in this area are mainly shrimps of the genera *Panaeus* and *Macrobrachium.*

Vegetation

The Saghara Field transverses two barrier islands: the Saghara/Otumara, and the Escravos barrier islands respectively. The vegetation cover of Saghara Field falls within the sensitive tropical wetland vegetation ecosystem including four basic categories: the Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest.

This environment is transitional, in depositional land formation, as well as in vegetation. It is at the early stage of succession from mud flats (downstream) to terrestrial / fresh water swamp habitat (upstream); and from aquatic (or semi aquatic) to terrestrial plants. This process could take centuries and low tides may expose bare mud or salt flats which can still be seen interspersing the vegetation landscape in many places. Generally the low marsh vegetation cover is in near pristine condition.

The sampled areas were dominated by semi aquatic herbaceous halophytic shrubs and a few more or less clustered trees. The vegetation community consists mainly of *Acrostichum aureum* (Golden leather / Mangrove fern) interspersed with groves of *Avicennia germinans;* while *Dalbergia ecastaphyllum* and *Rhizophora racemosa* occur as fringe vegetation around VG3. Generally, *Alchornea laxiflora* dominates the slot margins colonizing the dredge dump lining. There is no sign of any inundation from the tidal slots, creeks or rivers due to artificial vegetation and landforms lining them. Structurally, the vegetation can be stratified into the grass layer (*Paspalum vaginatum*), shrub layer (*Acrostichum aureum*) up 1.3 meters, and the tree layer (*Avicennia germinans*). The predominance of the mangrove grass *Paspalum vaginatum* (up to 70% of total veg. cover) and the presence of *Avicennia germinans* (20% or more) as well as clusters of *Acrostichum aureum* indicate the high salinity prevailing in the soil as is characteristic of salt flats. In this vegetation cover type, few other mangrove associates where sighted including, *Rhynchospora corymbosa*, and small thickets of *Dalbergia ecastaphyllum*, *Machaerium lunatum* and, *Phyllanthus muellerianus.* Oppurtunistic species include, *Alchornea laxiflora, Ludwigia abyssinica,* and *Cassia alata.*

The vegetation is homogenous and in near pristine condition with typically tall *Rhizophora racemosa.* Mature trees here are timber sized with girth of 2-2.5 meters gbh and height of up to 20 meters. The short mangrove rarely competes with the *R. racemosa* for the tidal river fringes and is mostly seen immediately behind the tall mangrove belt and before the dwarf mangrove which is further inland in basin forest. The drier type is dominated by *Elaeis guineensis* (247 trees pa ha). Other species include *Pycnanthus angolensis*, *Anthocleista djalonensis*. Species emerging above the canopy here include *Uapaca guineensis*, *Lophira alata* (10 trees per ha), *Spondianthus preusii*, *Staudtia* stipitata, and *Cyclodiscus gabonensis*. The vegetation cover is affected by dredging and dumping of spoils along the numerous slots at Otumara. There is no widespread disease condition; only pockets of infections as are expected in plant communities. Phytochemistry reveals that the level of heavy metal in the leaves of plants sampled across the study area. Heavy metal pollutants of concern include Cadmium, Nickel, Copper, and Zinc.

Wildlife

Otumara field is in a protected area. The wildlife diversity and distribution pattern observed in the Saghara field reflects the uniqueness of this area in terms of terrain and vegetation cover. The wildlife composition and species diversity in the Saghara area is low. This is traceable to the predominance of the high and low salt marsh in the Saghara axis which does not support land animals; hence the predominance of amphibians generally. Amongst the reptiles, the slender snouted crocodile, the African dwarf Crocodile and python species were common across the entire area. Due to the prominence of high vegetation at the Saghara end of the Otumara/Saghara Island, Primates sighted was mostly around the flare site area and the mangrove between Sahara and Otumara; the Mona monkey occurs in the Saghara Field.

Geology and Geomorphology

The study area (Saghara) and the adjoining fields (Saghara and Escravos) are part of the geologic sequence of the Quartenary and Tertiary formations of the Niger Delta, consisting of three main geological formations – the Benin formation (the topmost unit), the Agbada and the Basal Unit, the Akata formations. Lithological units of the study area are generally composed of sands, silty sands and clays (Short and Stauble 1967). The land surface of the study area is characterized by low lying plains typical of the modern Niger Delta. These plains have swamps that are commonly flooded during the peak of the rainy season. The area slopes imperceptibly in the South direction towards the Atlantic Ocean and is drained by a network of Escravos River and the adjoining creeks, mangrove swamps, marshes and dredge slots.

Groundwater Physicochemical Quality

The results of this study have revealed that the groundwater in most part of the area is high in dissolved constituents and not suitable for drinking and other domestic purposes. The groundwater is slightly acidic to slightly basic with mean pH values ranging from 6.5 to 7.23 in the wet and dry seasons respectively. These values fall within the regulatory requirement of 6.5 to 8.5 for groundwater. The pH is influenced by the brackish nature of the environment, with salinities varying from 5.09 to 5.77 ‰ and conductivity from 11260 in the wet season to 12185 µS/cm in the dry season. The groundwater colour (13.1 – 16.1 Pt.co.), total suspended solids (TSS) and dissolved solids (TDS)) are high for both wet and dry seasons, exceeding the regulatory limits of 1.0 NTU, <10 mg/l and 500 mg/l for turbidity, TSS and TDS respectively for potable water. These high values are typical of areas experiencing salt water intrusion. The mean concentration of Chloride was high, ranging from 4650 – 7775 mg/l in the dry and wet seasons respectively. The entire study area has values of Cl that exceed permissible limits. There are no health-related standards for chloride. FMEnv and WHO have set a regulatory limit of 250 mg/L for domestic water. Chloride content of 40mg/l and above is indicative of salt water intrusion. The cations were dominated by sodium (Na), followed by K, Ca and Mg. This order of dominance is characteristic of groundwater in the brackish environment with high chloride content.

The mean nitrate-nitrogen level (1.34 – 3.43 mg/l) was low and fell within the regulatory limit of 10 mg/l for potable water. Higher concentrations can lead to Methaemoglobinemia (Blue Baby Syndrome) in infants, where the oxygen-carrying ability of the child's blood is severely reduced. The concentration of sulphate ranged from 56.2 – 64.93 mg/l. There are no health-related standards for sulphate. The WHO have set a limit 40mg/L for sulphate because water containing more than this amount has an unpleasant taste that makes it unsuitable for domestic use.

The organic contaminants in the groundwater samples (i.e. Benzene, Ethylbenzene, Toluene, and Xylenes) were all below detectable limits of 0.001 mg/l. The concentration of petroleum hydrocarbons did not show any evidence of oil contamination. All the heavy metals were very low in concentration and in some cases were not detectable; they all fell within the national regulatory limits. This further affirms the non-hydrocarbon contamination status of the groundwaters of the Saghara Field.

Groundwater Microbiology

Microbiological properties measured in the groundwater of the study include heterotrophic and hydrocarbon degrading bacteria, total and hydrocarbon degrading fungi, total and faecal coliform. The total coliform ranged from 12 – 20 MPN/100ml in the dry season and 14 – 20 MPN/100ml in the wet season. However, faecal coliform were not detected in any of the groundwater sample. Heterotrophic bacteria population in the groundwater ranged from 3.2 – 6.8 x 10^4 cfu/ml in the dry season and 4.5 – 6.8 x 10^4 cfu/ml in the wet season, whereas hydrocarbon degrading bacteria ranged from 0.5 – 1.1 x 10^2 cfu/ml in the dry season and 0.4 – 1.1 x 10^2

cfu/ml in the wet season. Hence, hydrocarbon degrading bacteria accounted for about 1% of the heterotrophic population in both seasons. The predominant genera of bacteria in the study area were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Alcaligenes* and *Staphylococcus*. The total fungi in the groundwater ranged 3.2 – 6.8 x 10^4 cfu/ml in the dry season and 4.5 – 6.8 x 10^4 cfu/ml in the wet season. Hydrocarbon degrading fungi in both seasons are not viable. The results suggest that the groundwater is not contaminated with hydrocarbons. *Aspergillus* and *Penicillium* are the most frequently isolated fungi in the study area.

Socioeconomics

The project area has three major host communities namely Ugborodo, Ugbeogungun and Deghele located in Warri South-west Local Government Area of Delta State. In these communities are also range camps around, which are largely involved in fishing activities and these satellites camps could be considered also a receptive communities with respect to the potential impacts that are associated with the proposed project. With the exception of a few migrants of Yoruba, Ilaje, Urhobo, Isoko and Ijaw origin living along dotted settlements in the area, the Itsekiris are the landowners and major ethnic group in the project environment. Apart from Christianity, which is a predominant religious affiliation of majority of the residents, there are established cultural properties and values in the forms of sacred groves, deities, festivals and taboos that the landowners have close affinity. Governance system is typical of well developed hierarchical structure that is gender and age sensitive, which have in-built mechanism to provide social cohesion, security and conflict prevention and resolution.The population of the communities shows a skewed distribution in favour of lower age-cohorts of persons below 20 years old, with child dependency ratio of 31.23% and old age dependency of 5.06%. The sex-ratio is approximately 2:1 with average of 8 persons per household having a modal educational level of primary school attainment. Marriage is highly valued with polygamy being the major form of marriage.

The micro-economy and livelihood structure in the area is common to the general structure in typical rural Niger Delta communities. Occupational structure is consistently dominated by fishing, farming and petty trading that generated daily income levels just enough to cover household daily expenditure requirements; typical. The settlement pattern of the habitations in the area is rural nucleated cluster type, many also characteristically nodal, established along water courses (rivers, creeks and creeklets). The general quality of life measured in terms of housing types, productive and household asset ownership, and presence of functional social infrastructure in the communities was noted to be very low, suggesting high level of poverty among the residents of the communities. Perception rating concerning the proposed project showed fairly low fears with respect to impact on health and environment; and high level of expectations of improved local economies and provision of quality and functional social infrastructures in the communities.

Health Impact Assessment

The determinants of health among the population in Saghara AGG Project communities include demographic, environmental and behavioural factors.

Permanent residents in the communities were mostly the elderly, fisher-folks and traders while several younger members, particularly males in the 20 – 39 year age range reside in Warri. A sizable number of young girls and traders that derive their livelihood from their proximity to the oil facility was observed. The implications of this for commercial sex work and its consequences for sexually transmitted diseases (STI) and HIV as well as other social vices such smoking, drug and alcohol abuse, and violence is obvious.

Most members of the project communities were able to meet their total daily per capita water requirement albeit mainly from a variety of potentially contaminated surface sources. Tanker supply by SPDC and sachet water were the main sources of drinking water. Significant health threat is associated with the use contaminated surface water source. In addition, surface water bodies provide favourable breeding grounds for vectors of important diseases including Malaria, Filariasis and Schistosomiasis. Regrettably, underground water sources in some of the communities were salty and showed evidence of faecal contamination. Extensive faecal contamination of water bodies in the project communities is not surprising considering that the jetty or over-hung toilets that discharge faeces directly to surface water is the predominant method of faecal disposal. Access to adequate quantities of potable water is therefore a challenge in the project communities. Increase in population that may arise as a consequence of the project may further compromise access to potable water. The concentrations of suspended particulate matter (SPM) in the ambient air of the study communities were significantly lower than the Federal Ministry of Environment’s stipulated limit. The Saghara AGS project should contribute significantly to better air quality when the flare out is achieved.

Behaviours with significant implications for health were prevalent in the project communities. Alcohol and cigarette are reported to be commonly used although cases of alcoholism was said to be rare. Sexual practices of members of the project communities also posed significant risk for the transmission of sexually transmitted infections including HIV/AIDS: polygamy was common among the married adult males while single girls reported that they had multiple sexual partners. Furthermore, fidelity in marriage is prescribed for women while men could engage in extra-marital affairs. Some of the communities were also reported to accommodate commercial sex workers. However, good knowledge about HIV prevention demonstrated by members of these communities is encouraging.

Prevalence of malnutrition among children was lower than the national average but higher than the average for the South-south geopolitical zone. The common causes of ill health in the communities were malaria, diarrhoeal diseases, typhoid fever, upper respiratory tract infections and skin diseases. Incidence of non-communicable diseases like hypertension, diabetes mellitus were also believed to be increasing in the communities. Members of the project communities had adequate access to health facilities as most live within 5 km or 30 min travel time to a health facility. Maternal and child mortality were said to be declining in the communities due to early recognition and referral of cases to Warri, Sapele, Oghara and Benin.

Consultation Programme

The identified stakeholders for this study were government (Federal, State and Local), regulators (FMEnv, DPR, Delta State Ministry of Environment), communities, CBOs, NGOs, Government agencies, Media, consultants, etc. The various stages of consultation were HSE Workshop and fieldwork. Special sessions were held, namely: interface meetings with the communities, and a scoping workshop with the identified stakeholders, to obtain their issues and concerns on the proposed project. The Communities issued Freedom to Operate (FTOs) to signify their consultation.

ES5.1: Associated and Potential Impacts

The Saghara AGS Project were divided into Premobilization/Mobilization, Construction, Commissioning, Operation, Maintenance and decommissioning/ abandonment. The Pre-mobilization and Mobilization Phases included the following activities: land acquisition and survey, Right of Way clearance, tree felling/destumping, pipeline/bulkline construction, civil works, facility construction, laying of optic fiber cables, trenching and backfilling, welding and NDT testing, Coating/Wrapping, Hydrostatic testing, River crossing, waste/Spoil disposal, Community electrification, transportation of personnel and equipment, tie- in and precommissioning of facilities, Mothballing of Saghara Flowstation. Operation phase included the following activities: maintenance (Corrosion Control) and Pigging. Activities during the decommissioning and abandonment included cutting/Lifting, waste disposal and Restoration.

Potential Impacts during Premobilization/Mobilization phase

Significant negative impacts arising from the Premobilization/Mobilization phase include the increase of water related diseases due to poor sanitation practices when more pressure is put on already poor state of housing. Other negative impacts in this phase will include Increase in cases of sexually transmitted diseases and other disease strains resulting from migrant workers and accidents to workers especially for local labour not sufficiently skilled for the type of work.

Significant positive impacts were: income to local workers that may be employed for the bush clearing activities, improved quality of life resulting from increased project spending which will stimulate economic activity in the area and increased infrastructures in the communities as part of the projects' CD initiatives.

Potential Impacts during Construction phase

Significant negative impacts during the construction phase will include trenching and backfilling, coating and wrapping of pipes, welding and non-destructive testing and river crossing. Trenching and backfilling will increase surface water sediment loading and suspended solids. River crossing will promote shoreline erosion. Other negative impacts will include irreversible soil compaction of the RoW which may alter the topography of and the drainage pattern of the RoW. Salt water intrusion into ground water, may occur through ELPS river crossing (hydraulic seepage around the circumference of the pipe). Exposure to radioactivity from NDT of pipe welds, and release of toxic fumes and impairment of vision from arc welding, are potential occupational health hazards. Improper disposal of lay barge deck drainage will contaminate surface water and sediment. Discharge of untreated hydrotest water into the receiving environment, disaggregation of benthic habitats resulting in loss of benthic organisms, shoreline erosion and improper disposal of backfill residue will alter the morphology of the area and impede drainage pattern. Water related diseases might increase due to poorer sanitation practices when more pressure is put on already poor state of housing. Increase in cases of sexually transmitted disease (HIV AIDS) and other disease strains may result through migrant workers. Water crafts conveying personnel and materials may generate waves which may endanger small canoes/boats and curtail fishing activities and commercial transport. Contamination of water may result from the use of paints, corrosion inhibitor, leaks and spills of diesel fuel and lubricants into water.

Significant positive impacts in this phase will include increased income to local workers, increased project spending which will stimulate economic activity in the area, construction of more infrastructures in the communities as part of the projects' CD initiatives, giving rise to improved socio-economic activities. Electric power supply to the communities will boost socioeconomic activities.

Potential Impacts during Operation and Maintenance phase

Contamination of surface water by corrosion inhibitors and disposal of pigging sludges are the key potential impacts.

Potential Impacts during decommissioning/abandonment phase

Significant impacts from the decommissioning/abandonment phase include accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works, poor aesthetic features from abandoned structures on site and alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment.

ES6.1: Mitigation Measures

Mitigation measures are often implemented on a continuous basis through the project’s life-cycle. Specific mitigation measures are aimed at reducing negative impacts to As Low As Reasonable Practicable (ALARP) and where possible enhance positive ones. In concert with SPDC HSE Policy, all impacts identified as being of Medium or High significance, require appropriate mitigation measures.

Mitigation Measures for Premobilization/mobilization Phase

Mitigation measures proposed for the identified significant negative impacts during Premobilization/Mobilization phase can be summarized as follows; minimization of bush clearing to what is required for construction activities, avoidance of de-stumping as much as possible within the RoW, minimization of land-take as much as practicable, payment of adequate compensation for loss economic trees/plants, avoidance of cutting down timber-size trees greater than 60 cm girth, as they are protected by law. Others include the use of low-noise equipment, stepping-up health education and sensitization activities prior commencing construction activities and the support of condom donation initiatives by augmenting the supply and issue of condoms to workers on the project and extending it to commercial sex workers in the vicinity if identified.

Other actions include organizing awareness session on communicable diseases related to water and sexual behaviour such as HIV/AIDS, ensure the provision and enforcement of the use of appropriate PPEs on site, provision of adequate First Aid and functional Medevac system on site, ensure that approved detailed Job Hazard Analysis (JHA) and Security Plans, are provided by the contractor and that all the controls and barriers are adhered to, and ensuring that daily tool box meetings are held. Others include the use of silt curtains to curtail the spread of solid waste to water bodies outside the project area, treatment of all waste water to DPR standards prior to disposal, provision of mobile toilets for its work-force, regularly monitoring of the quality of effluent to ensure that it meets regulatory standards, the adherence to its waste management procedure, carry-out shoreline protection in areas susceptible to erosion,
adherence to journey management guidelines and sensitization of boat captains to exercise due diligence in order to avoid negative impact on fishing and commercial water transport. Other activities include ensuring no hydraulic connection between the sea and the coastal forest by using cofferdams at pipeline river crossing. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, institute good marine journey management plan in-line with SPDC policy.

Mitigation Measures for Construction Phase

Mitigative actions for the activities during construction phase include some of the actions mentioned during the premobilization/mobilization phase. Others for this phase include the use low pressure track equipment to minimize soil compaction on the RoW; provision of radiation counter for workers carrying out NDT on pipe welds, to monitor individual radiation levels; ensure that the activities are carried out in accordance with standard procedures. SPDC shall ensure that waste management specifications and guidelines (especially with regards to the discharges into the environment), are complied with. SPDC shall ensure minimal disturbance to the river bed during pipeline crossing. SPDC shall ensure that automatic leak detection facilities shall be installed for pipelines. SPDC shall ensure adequate security for the Mothballed Saghara Flowstation.

Mitigation Measures for Operation Phase

SPDC shall apply due diligence to ensure that paints and corrosion inhibitors do not contaminate surface water, and that adequate pipeline surveillance measures are adopted to minimize sabotage of oil/gas pipelines.

Mitigation Measures for Decommissioning/ Abandonment Phase

Mitigation actions for this phase may include some of the actions discussed during the premobilization/mobilization, construction phases and operation phases. Other actions include the provision of adequate and relevant training of all staff especially local hands adopt safe operating procedures consistent with good statutory and SPDC HSE requirements and ensure that native species are employed in restoration activities.

ES7.1: Environmental Management Plan

Environmental management plan provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from feasibility study to abandonment. It address significant negative impacts, enhances project benefits, delivers on commitments made publicly in the EIA and introduces standards of good practice to be adopted for all project works. The EMP lists actions to ensure effective mitigation of potential environmental, social and health impacts (identified in the EIA).

In Chapter 5 of the EIA, potential impacts resulting from all the activities of the various phases were enumerated. In Chapter 6, mitigation actions have been proffered. This Chapter 7, ties the mitigation measures to the corresponding impacts, while rating the level of the impact residue after mitigation, identifying the monitoring parameters and responsibility for necessary action.
Parameters/methods for monitoring include, site inspection reports, monthly and quarterly compliance monitoring reports, security plans/reports, community engagement records/ reports, compensation records/reports, employment records, contractor records, Project Memorandum of Understanding (PMoU) records, Sessions on health awareness, with records, records of daily tool box meetings, Job Hazard Analyses Records, evidence of functional MEDEVAC procedures, Safety plans/records and Impact Mitigation Exercises, both conducted internally(by SPDC) and externally by the regulators. Monitoring frequency may range from daily such as tool box meetings/pep talks to yearly IMM. The responsible parties are SPDC personnel (Project Manager, Project Engineer, Environmental Adviser and HSE adviser) and the regulators.

ACKNOWLEDGEMENT

The Shell Petroleum Development Company of Nigeria Limited wishes to express sincere appreciation to the Federal Ministry of Environment (FMEnv) and Department of Petroleum Resources (DPR), for their support, advice and invaluable assistance throughout the period of this study. The efforts of our environmental consultant, relevant Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) are also highly commendable. Finally, we give special thanks to the Paramount Rulers, Clan Heads, Village Heads, Women and Youth Groups, Local Government Councils, etc for their co-operation and willingness to express their views, concerns as well as expectations.

CHAPTER ONE
INTRODUCTION

1.1: Background

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, and Total), plans to embark on the Otumara Node (Otumara & Saghara flow stations) Associated Gas Solution (AGS) Project to meet the business objectives of Domestic Gas supply and gas flares down by 2014. At present, produced AG is currently used as fuel gas for the pumps and generators, for lift gas, and the excess flared. The Saghara AG Solution Project is part of the wider Otumara Node AGS Project. The project aims at effectively stopping routine gas flaring in SPDC operations. At present, most of the associated gas produced at Saghara Flowstation is flared. All Otumara oil wells currently producing into Saghara Flowstation will be re-routed back to Otumara Flowstation. The remaining Saghara oil wells will be comingled at low pressure and allowed to flow freely (with the associated gas) to Otumara Flowstation. The proposed Saghara project will involve decommissioning mothballing of the existing flowstation through the installation of new inlet manifold, 6” bulk line and 4” testline in order to harvest AG from the Saghara field in Delta State of Nigeria (Figs. 1.1 and 1.2).

The SPDC Business Plan 2005 (BP05) forecast for Otumara/Saghara showed that substantial Further Oil Development (FOD) activities may commence in the field and will need disposal of AG and probably more lift gas. In view of this, it is considered that a pre-investment in AG pipeline from Otumara through Saghara to Escravos beach will be required by installing a 12’’x 12 km pipeline to the NGC manifiold to accommodate 30 mmscf/day. The new activities will include the following:

- Installation of a new bulking manifold;
- Laying of new testline (4” x 5km) from Saghara to Otumara Flowstations;
- Laying of new bulkline (6” x 5km) from Saghara to Otumara Flowstations; Decommissioning, mothballing and preservation of existing equipment in the Saghara flow station; and
- Electrification of the communities.

As part of the flowstation upgrade, gas pipelines with pigging facilities will be constructed using existing SPDC pipeline Right of Way (RoW). This Environmental Impact Assessment (EIA) report has been prepared by SPDC in line with National and International environmental guidelines to evaluate this development proposed for the Saghara field. This EIA has identified the key potential impacts of the project activities on environmental, socio-economic and health resources within the project area and proffered mitigation measures for Environmental Management.

1.2: Objectives of the EIA

The objectives of the EIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Use the baseline data to describe and characterize the study area;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and the interactions between the sensitivities;
- Recommend appropriate mitigation measures; and
- Develop an Environmental Management Plan (EMP).

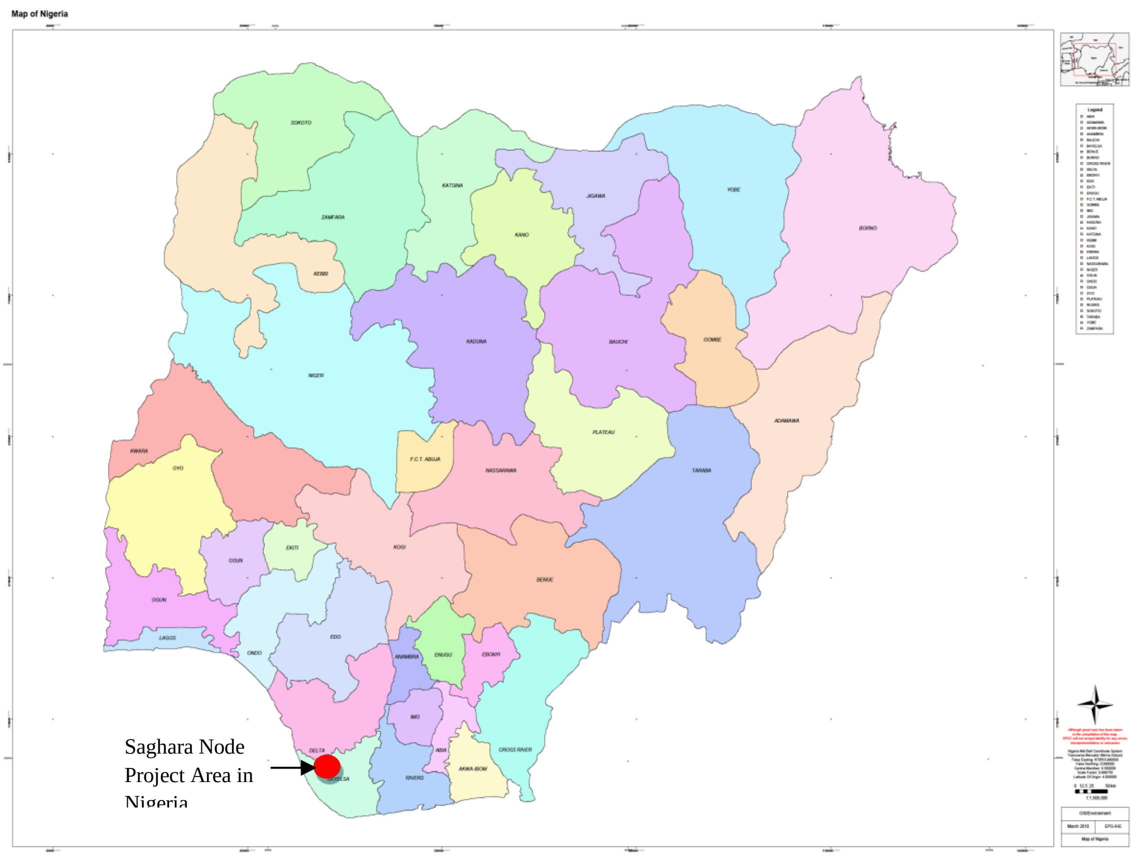

Fig. 1.1: Map of Nigeria Showing Saghara Project Area

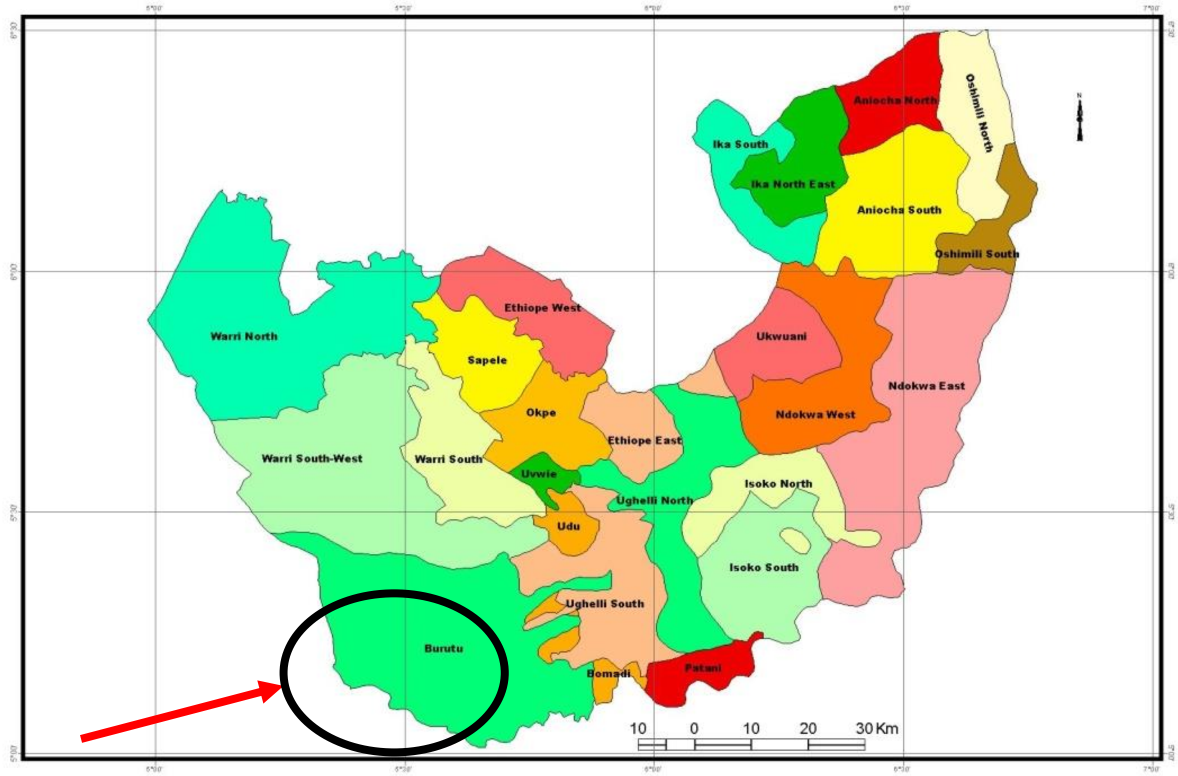

Fig. 1.2: Map of Delta State showing Saghara AG Solution Project Area

1.3: The Project

The new activities will include the following: Installation of a new bulking manifold; Laying of new testline (4" x 5km) from Saghara to Otumara Flowstations; Laying of new bulkline (6" x 5km) from Saghara to Otumara Flowstations; Decommissioning, mothballing and preservation of existing equipment in the Saghara flow station; and Electrification of the communities.

Project Premises

The project is within the Saghara field on OML 43, which has been in operation since 1972 (34 years). The area is thus a brown field with existing facilities such as the Saghara flowstation, flare site, flowlines, pipelines, and oil well heads.

1.4: Legal and Administrative Framework

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

1.4.1: Legislations guiding Environmental management in Nigeria

The Mineral Oil (Safety) Regulations, 1963

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

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

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

Petroleum (Drilling and Production) Regulations (1969)

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

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

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

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

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

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

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

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

Environmental Impact Assessment Act No. 86, 1992 (FMEnv)

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

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

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

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

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

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

Nigeria's National Agenda 21 was developed to:

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

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

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

Forestry Law CAP 51, 1994

The Forestry Act 1958 which was amended as the Forestry Law CAP 51, (1994) prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property in Nigeria. The law prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria, which is applicable to the mangrove, and other forests of the Niger Delta.

Land Use Act of 1978

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

National Inland Waterways Authority Act No 13 of 1997

This Act established the National Inland Waterways Authority with a view to improving and developing inland waterways for navigation, providing an alternative mode of transportation for the evacuation of economic goods and persons, executing the objectives of the national transport policy as they concern inland waterways. The Act also prescribes regulations and sanctions on the use and exploitation of resources of inland waterways such as dredging, sand or gravel, mining and erection of permanent structures within the right-of-way or diversion of water from a declared waterway.

Nigerian Ports Authority Act No 38 of 1999

Nigerian ports Authority (NPA) was established in 1954 by ports Act (Cap 155 of the law of the Federation of Nigeria –amended 1999) as an operating port with the responsibility of providing all port services.

- Ownership and administration of land and water within port limits.
- Planning and development of port operational infrastructure.
- Leasing and concession of port infrastructure and setting bench mark for tariff structure Responsible for nautical/Harbour operations and hydrographic survey.
- Marine incidents and pollution
- Maintenance of safety and security at the common user areas.
- Enacting port regulations and bye-laws as well as monitor and enforce them
- Day to day monitoring of operations and enforcement of relevant sections of respective agreements.

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

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

National Environmental Standards Regulatory and Enforcement Agency (NESREA), 2007

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established as a parastataI of the Federal Ministry of Environment. NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria.

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

An Act to compel every company producing oil and gas in 1979 No . 99. Nigeria to submit preliminary programmes for gas reinjection and detailed plans for implementation of gas re-injection.

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

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

1.4.2: Legislations guiding Environmental management in Delta State

The Bendel State Town and Country Planning Laws Cap 165 (as applicable to Delta State) of 1975

This law grants the Government and its operating agencies the authority to require lands and undertake layouts and boundary adjustments of plots, if necessary, authority to grant leases and sell plots as necessary as well as preservation of trees, landmarks for amenities, authority to approve building designs and external appearance of structures; prohibition of unsuitable buildings.

Delta State Environmental Protection Agency Edict No 5 of 1997

The DSEPA is an agency under the Delta State Ministry of Environment. Although the EIA decree No 86 of 1992 is the substantive law that regulates the sitting of industrial projects that impinge on environmental elements in Nigeria, with part of the project in Delta State, this edict has a role to play in the overall EIA process as a matter of law. The Edict setting up the Delta State Environmental Protection Agency (DELSEPA). captioned as Edict No 5 of 1997 outlines the primary responsibilities of the agency, which is to protect and develop the general environment of Delta State.

Delta State Ecology Law, 2006

The law empowers the Delta State Ministry of Environment with the responsibility of protecting the environment in order to achieve sustainable environmental development in the State .It empowers the Ministry with the statutory responsibility of handling environmental pollution cases. It liaises with oil companies on pollution matters. It enables, the Ministry to participate in the management of oil spills in the State .It empowers the Ministry to be an integral part of the Joint Investigation team (JIV) that investigates the causes of oil spills; carrying out assessment of damage to the environment, property, health and assessment of the ecological damage to the marine and terrestrial habitat as well as vegetation and ecosystem. The law also empowers the Ministry to handle flood and erosion cases.

Bendel State Forestry Law Cap 59, 1976 (now applicable to Delta State)

This law is all about the sustainable use of Delta State forests and its bio-diversity which is a renewable source of wealth in the area especially for tourism, food supply, fuel and timber as well as the protection of the environment.

Delta State Revenue Edict, 1997

This edict appropriates sources of revenue in Delta State to include Internally Generated Revenue, Statutory Allocation from the Federal Government, Value Added Tax and Other Capital Receipts. It also appropriates expenditure sources to include Recurrent Expenditure and Capital Expenditure

Delta State Waste Management Law, 2004

This law establishes the Delta State Waste Management Board charged with evacuation and management of wastes. The issue of waste evacuation is the statutory responsibility of the Local Government Councils. However, due to financial constraints they have not been able to exercise this function effectively. As a result, the State Government has intervened in waste evacuation and management in the State through the Waste Management Board.

Delta State Internal Revenue Consolidation Law, 2009

The law is aimed at improving tax administration, tax revenues and enhancing the ability of government to fruitfully pursue the diversification of the State’s economy and to create more wealth and generate employment for the teeming youth population of the State.

1.4.3: International Laws and Regulations

Nigeria is signatory to several laws, treaties and regulations that govern the environment.
Among these are:

(i) World Bank Guidelines on Environmental Assessment {EA} (1991)
(ii) International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines

(iii) Convention on the Migratory Species of Wild Animals (Bonn Convention)
(iv) Convention of Biological Diversity
(v) Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)
(vi) Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and.
(vii) United Nations Framework Convention on Climate Change (1992)

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

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

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

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

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

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

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

Convention on Biological Diversity

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

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

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

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

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

United Nations Framework Convention on Climate Change (1992)

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

1.4.4: SPDC Policies and Principles

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

(a) Business Principles

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

(b) Governing Policies

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

(c) HSE Policy

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

- Preserves the health, safety and security of all Company and contractor personnel and members of the public;
- Preserves the integrity and security of Company assets;
- Minimises the impact of operations on the environment; and

- Is sensitive to the needs and concerns of the Host Communities.

Implications of implementing this policy are that,

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

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

(d) Environmental Assessment Policy (1998)

It is SPDC's policy that all activities shall be planned and executed in such a manner so as to minimize the impact of its operations on the environment i.e.:

- Carry out Environmental Impact Assessments and Evaluation in relation to all aspects of the natural and social environment that may affect or be affected by its activities;
- Identify any such interface for the complete life cycle of both new and existing facilities and operations;
- Enhance positive effects, 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.

The implications of implementing the policy are:

- The environmental impact of all new activities or developments shall be thoroughly evaluated and the necessary preventive measures implemented,

- An Environmental Impact Assessment (EIA) shall be carried out for each new project or activity,
- Seismic Acquisition Field Development and Operations Reference Plans, shall include the recommendations of the EIA,
- The environmental impact of each operation shall be routinely monitored and corrective actions taken as necessary.
- All practical and reasonable measures shall be taken to minimize the generation of waste and to manage and dispose of unavoidable wastes in an environmentally acceptable manner,
- Waste Management plans shall catalogue waste identifications, quantification and appropriate disposal methods,
- Waste streams shall be monitored and recorded and efforts taken to progressively reduce emission or discharge of waste known to have negative impact on the environment with the eventual aim of eliminating them,
- Waste records shall cover the full life-cycle of each stream and shall provide an auditable trail as to its management and disposal,
- Past polluted sites shall be investigated and practical and efficient measures put in place to rehabilitate them,
- Chemicals shall only be used where operationally necessary only after justification with a balanced management decision. In selecting chemicals for use, the HSE aspects shall be considered together with commercial and process performance attributes with the aim of choosing the least harmful,
- All chemicals shall be transported, stored, used and disposed of in accordance with statutory requirements and in a safe and environmentally acceptable manner.
- No new chemical shall be accepted from a supplier without the appropriate Material Safety Data Sheet (MSDS),
- All chemicals shall be covered with Safe Handling of Chemicals (SHOC) cards, and shall be acquired, transported, used and disposed of in compliance with the Department of Petroleum Resources (DPR), Federal Ministry of Environment (FMEnv) and SPDC regulations,
- All chemical handlers shall be specifically trained in the safe handling of chemicals.
- All hydrocarbon and chemical spills in the vicinity of the Company’s operations shall be cleaned up in a timely and efficient manner,
- Resources shall be provided and contingency plans drawn up to respond to spills in a timely manner,
- Where the cause of the spill is unknown then the Company shall still effect the clean up and recoup costs at a later date.

(e) SCiN Biodiversity Policy

‘’In Shell, we recognise the importance of biodiversity.

Therefore, we are committed to:

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

(f) Waste Management Policy

It is the policy of SPDC to:

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

Other considerations, including:

- Societal Expectations;
- Government Relations;
- Joint Venture Partner Relations;
- Sustainable Community Development;
- Land Acquisition and Compensation;
- Media Relations; etc.

are based on SPDC Corporate Policies – 2000.

The development of an effective HSE Management Strategy is intended to ensure that throughout the life of the project, from conceptualization through construction, operation and abandonment, SPDC’s HSE policy is constantly kept in focus. Responsibility for the implementation of the policy rests on both SPDC staff and Contractor(s).

1.5: Declaration

SPDC in its capacity as the operator of the NNPC/Shell/Total/NAOC Joint Venture, and on behalf of her partners, hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the mothballing of the Saghara flowstation and construction of new 6” x 5 km bulkline and 4” x 5 km testline from Saghara to Otumara. SPDC management is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report. SPDC hereby declares that it has prepared this EIA report using the best available expertise in personnel, equipment, and internationally acceptable methods.

1.6: Structure of this EIA Report

- ***Chapter One*** - Introduction presents the background information, administrative and legal framework, terms of reference;
- ***Chapter Two*** - Project Justification, discusses the project background, project objectives, rationale for the project, envisaged sustainability, and development options considered;
- ***Chapter Three*** - Project Description, describes the type of project, scope, location, material input/output and by-products, waste generation, technical layout and process, operation and maintenance, schedule;
- ***Chapter Four*** **-** Description of Existing Environment - provides information on the baseline environmental conditions of the project area describing the physical, chemical, biological social, and health environment
- ***Chapter Five*** - Associated and Potential Environmental Impacts - highlights the Potential Environmental Impacts of the proposed project;
- ***Chapter Six*** – Mitigation Measures/Alternatives – describes the mitigation options of impacts;
- ***Chapter Seven*** **-** Environmental Management Plan - provides the proposed plans for environmental management; and
- ***Chapter Eight*** **-** Conclusion and Recommendations – provides remediation plans after decommissioning/abandonment.

1.7: Terms of Reference

Shell Petroleum Development Company (SPDC) commissioned this EIA of the proposed Saghara (AG) Solution project in order to comply with statutory requirements. The EIA will establish the environmental issues associated with the project, predict their impacts and magnitudes; suggest and evaluate project alternatives with regard to cost effectiveness and environmental friendliness, and recommend mitigation measures. The Terms of Reference (ToR) for this EIA were prepared after a scoping workshop held on 25th October, 2005 with identified stakeholders (Community representatives, NGOs, CBOs, Governments representatives {FMEnv, DPR, DSMEnv, Ministry of Health, and Representatives of the affected Local Government Area}. The summary of the scope of the EIA as contained in the ToR is as follows:

EIA scope

- Literature review
- Detailed description of the project
- Baseline data collection
- Field work and laboratory analysis
- Impact identification, prediction and assessment
- Determination of appropriate Mitigation and Monitoring Measures
- Development of an Environmental Management Plan (EMP)

- Decommissioning/Abandonment Plan
- Report Production

For the purpose of this study, the environmental resources have been classified into the following:

- Natural/Biophysical Environment
- Social Environment
- Health Environment

The detailed scope of the baseline data acquisition was:

Biophysical

Because of the close proximity of the Saghara and Otumara Fields, sampling nomenclature and coordinates began with Saghara and ended with Otumara. The following parameters were studied under Biophysical.

- Topography and land use pattern
- Climate and meteorology
- Air quality, noise and vibration
- Soil
- Land use/cover
- Surface water and sediment quality
- Biodiversity
- Vegetation
- Wildlife
- Hydrobiology and fisheries
- Geology and hydrogeology
- Groundwater quality

Social needs

- Population distribution and communities
- Demographic composition
- Social characteristics
- Economy
- Land use and resource harvesting
- Education and social services
- Physical infrastructure and utilities
- Cultural and historical resources
- Political and institutional arrangement

Health needs

The fieldwork will involve *in situ* determination and study of health determinants and conditions/outcomes in the communities. The fieldwork data gathering approach will be:

- Oral Interviews
- Physical observation
- Focus group discussion (FGD)
- Administration of questionnaires
- Environmental sample collection (potable water, air quality-indoor/outdoor, soil with emphasis on bio-chemical contaminants like parasites, heavy metals etc)
- In situ testing and assessment of clinical status of the population (e.g. nutritional status assessment in children, etc)
- Environmental health with emphasis on quality and/or quantity of housing, hygiene, sanitation, water and waste management practices in the communities
- Plant use with reference to traditional curative care, as food.

Table 1.1: Data Requirements and Environmental Indicators (Biophysical Aspect)

Environmental Component	**Environmental Aspect**	**Data Acquisition**	**Potential Environmental Impact Indicator**
Climate/ Meteorology	Microclimate/Regional Climatic features	*In situ* measurement, secondary data	Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover and their local effects.
Air Quality	Local and Regional	*In situ* / laboratory analysis	Particulate, NO_x, SO_x, CO_2, CO, VOCs, H_2S Heavy metals (Fe, Cd, Cr, Pb, Ni, V, Zn)
Noise	Local	*In situ* measurement	Ambient noise level dB(A), communication interference.
Surface Water /Sediment Characteristics	Hydrology/ Hydrodynamics	*In situ* /secondary data	River depth, width, flow direction, flow rate, current/tidal information, drainage characteristic, sediment transport, river bank erosion
	Physicochemical Features	*In situ* measurements, Composite samples for laboratory analysis	Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, Redox potential, BOD_5, COD, Oil & Grease, Anions/Cations, NH_4^+, NO_3^- , NO_2^-, PO_4^{3-}, SO_4^{2-} , SiO_2, Na^+, K^+, Ca^{2+}, Mn^{2+}, Mg^{2+} . Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg).
	Hydrobiology	Composite samples for laboratory analysis	Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic macrophytes, Macrophyte-associated macrofauna

Environmental Component	**Environmental Aspect**	**Data Acquisition**	**Potential Environmental Impact Indicator**
Surface Water /Sediment Characteristics	Fisheries	Direct observations/interviews, *In situ* measurements, composite samples for laboratory analysis	Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology, Population of Fisher- Folks Proportion of male/female, Adult/Children etc
	Microbiology (surface water)	Composite samples for laboratory analysis	Total heterotrophic bacteria, fungi, Total hydrocarbon utilizing bacteria and fungi, total and faecal coliforms.
	Sediments	Composite grab samples for laboratory analysis	Colour, Texture, Temperature, pH, Redox potential, THC, Oil & Grease , Sediment geochemistry (Fe, Ni, V, Cd, Cr, Hg etc.), Sediment microbiology
	Water Use	Direct observation/ interviews	Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic etc)
Ground Water Characteristics	Physicochemical Features	*In situ* / laboratory analysis	Colour, odour, alkalinity, TDS, TSS, Turbidity, EC, THC, DO, pH, Redox potential, BOD_5, COD, Oil & Grease, Anions/Cations, NH_4+, NO_3, NO_2, PO_4, SO_4, SiO_2, Na, K, Ca, Mn, Mg, Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg).
	Microbiology	Composite samples for laboratory analysis	Total heterotrophic bacteria, fungi, Total hydrocarbon utilising bacteria and fungi, total and faecal coliforms.

Environmental Component	**Environmental Aspect**	**Data Acquisition**	**Potential Environmental Impact Indicator**
	Groundwater dynamics	*In situ*	Static Water Level (SWL), Flow direction/ Flow Rate.
Soil	Physical characteristics	In situ/ composite auger samples for lab analysis, Soil profile pits	Permeability, porosity, bulk density, texture (grain size), colour,
	Chemical characteristics	Composite samples for laboratory analysis	pH, anion, cation and cation exchange capacity (CEC), THC, heavy metals, Soil capability
	Soil microbiology	Composite samples for laboratory analysis	Total heterotrophic bacteria, fungi, Total hydrocarbon bacteria and fungi, total and faecal coliforms
Biodiversity Status & issues relevant to biodiversity	Wildlife	Transect, direct observation, interviews, secondary data sources	Species composition/distribution, Information of level of hunting, seasonality, exploitation methods/level (kill rates/month/year, estimates of wildlife population etc). IUCN categorisation
	Vegetation	Transect, herbarium studies, tissue analysis	Vegetation map of locality, Land use, Quantification of different vegetation types, area cover, Habitat status, floral composition, density and distribution, vegetation structure, plant pathology
	Conservation	*In situ* observation, interviews, secondary data	Conservation status (rare, threatened and endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices.

Table 1.2: Sampling Specifications and Parameters for Laboratory Analysis for Biophysical Samples

Environmental Component	Evironmental Aspect	Data Acquisition	Potential Environmental Impact Indicator
Climate/ Meteorology	Microclimate/Regional Climatic features	*In situ* measurement, secondary data	Temperature, Rainfall, Relative humidity, Wind direction and speed, visibility, cloud cover, sun shine duration and their local effects.
Air Quality	Local and Regional	*In situ* / laboratory analysis	Particulate, NO_x, SO_x, CO_2, CO, VOC, H_2S, BTEX Heavy metals (As, Fe, Cd, Cr, Pb, Ni, V, Zn)
Noise	Local	*In situ* measurement	Ambient noise level dB(A), communication interférence.
Surface Water Characteristics	Hydrology/ Hydrodynamics	*In situ* /secondary data	River depth, width, flow direction, flow rate, current/tidal information, Drainage characteristic, sediment transport, river bank erosion
	Physicochemical Features	*In situ* measurements, Composite samples for laboratory analysis	Colour, Total alkalinity, carbonate alkalinity, Total hardness, TDS, TSS, Turbidity, EC, pH, salinity, DO, , BOD_5, COD, Oil & Grease, TOC, THC, TPH, Phenol, H_2S, NH_3 , SiO_2, Anions/Cations, (NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}, CN^- Ca^{2+}, Mg^{2+}, Mn^{2+}), Heavy metals (Fe, Ba, Cd, Cr, Cu, Ni, V, Pb, Zn, Hg).
	Hydrobiology	Composite samples for laboratory analysis	Species composition, distribution, diversity and abundance of Phytoplankton, Zooplankton, Aquatic macrophytes, Macrophyte-associated macrofauna
Surface Water Characteristics	Fisheries	Direct observations/interviews, *In situ* measurements, composite samples for laboratory analysis	Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology.
	Microbiology (surface water)	Composite samples for laboratory analysis	Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi, total bacterial count, total and faecal coliforms.

Environmental Component	**Evironmental Aspect**	**Data Acquisition**	**Potential Environmental Impact Indicator**
	Sediments	Composite grab samples for laboratory analysis	Colour, Texture, pH, Redox potential, TOC, Available PO_4-P, Total-N, Oil & grease, THC, TPH, heavy metals (Fe, Ni, V, Ba, Cd, Cr, Mn, Cu, Pb, Zn, Hg, etc.),
	Sediment Biology/Microbiology	Composite grab samples for laboratory analysis	Species composition, distribution, diversity and abundance of Benthos, Total heterotrophic bacteria & fungi, Total hydrocarbon utilizing bacteria & fungi.
	Water Use	Direct observation/ interviews	Traditional use of rivers and water bodies (navigation, sand mining, food processing, aquaculture, domestic, potable etc)
Groundwater Characteristics	Physicochemical Features	*In situ* / laboratory analysis	Temperature, colour, total alkalinity, carbonate, Hardness , TDS, TSS, Turbidity, EC, DO, pH, , BOD_5, COD, H_2S, Oil & Grease, THC, TPH, PAHs, TOC, Phenol, NH_3 , Anions/Cations, (Cl^-, NO_3^- NO_2^-, PO_4^{3-}, SO_4^{2-}, CN^-, Ca^{2+}, Mg^{2+},), Heavy metals (As, Fe, Ba, Cd, Cr, Cu, Ni, Mn, V, Pb, Zn, Hg).
	Microbiology	Composite samples for laboratory analysis	Total heterotrophic bacteria, fungi, Total hydrocarbon utilising bacteria and fungi, total bacterial count, total and faecal coliforms.
	Groundwater dynamics	*In situ*	Static Water Level (SWL), Flow direction/ Flow Rate.
	Hydrogeology	Laboratory analysis, secondary data sources	Stratigraphy, Aquifer characteristics
Geology	Local and Regional	Secondary data, laboratory analysis	Regional geology, Stratigraphic / Lithologic properties, etc.

Environmental Component	Evironmental Aspect	Data Acquisition	Potential Environmental Impact Indicator
Soil	Physical characteristics	In situ/ composite auger samples for lab analysis, Soil profile pits	Permeability, porosity, bulk density, texture (grain size), colour, temperature
	Chemical characteristics	Composite samples for laboratory analysis	pH, TOC, exchangeable Cations, exchangeable acidity and cation exchange capacity (CEC), available PO_4-P, Total-N,, Oil and grease, heavy metals (As, Fe, Ba, Cd, Cr, CU, Ni, Mn, V, Co, Pb, Zn, Hg), THC, TPH
	Soil microbiology	Composite samples for laboratory analysis	Total heterotrophic bacteria and fungi, Total hydrocarbon utilizing bacteria and fungi
Land Use/Cover	Land cover	Secondary data sources	Land Use types: Recreational, agricultural, forestry, industrial, residential, institutional, commercial. Trends and time lapse mapping.
Biodiversity Status & issues relevant to biodiversity	Wildlife	Transect, direct observation, interviews, secondary data sources	Species composition/distribution (vegetational map of locality), seasonality, exploitation methods/level (kill rates/month/year, estimates of wildlife population etc). IUCN categorisation
	Vegetation	Transect, herbarium studies, tissue analysis	Type, diversity, Habitat status, floral composition, density and distribution, vegetation structure, plant pathology, plant tissue chemical analysis.
	Conservation	*In situ* observation, interviews, secondary data	Conservation status (rare, threatened or endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices.

Table 1.4: List of Study Communities and Local Governments

S/N	Community	Fishing Camps	Local Government Area
1	Ugborodu/Aruton	Udeaja, Ogiehgben, Madagho, Ajudayibo, Ijaghala, Costain, Aruton, Otumara, Okitimekpo, Saghara, Ubaoke	Warri South West
2	Ugbeogungun	Ugbeogungun	Warri South West
3	Deghele	Deghele	Warri South West

Necessary data and information on the communities as detailed in Table 1.5 will be collected.

Table 1.5: Socio-economic Data Needs

S/N	Social Features	Variables
1	Demography	Population size and distribution (age, gender, ethnic groupings, population density, dependency and sex ratio), marital status, educational attainment, primary and secondary school drop out rates, history and trend of migration, net enrolment ratios for primary and secondary schools, etc.
2	Livelihood	Income distribution and consumption patterns, employment status, occupation, occupational mobility and adjustment, poverty profile, land use and tenure system, and other economic activities.
3	Social Infrastructure	Major means of transportation; educational institutions, water supply, electricity, communication, recreational facilities, waste management facilities, housing (type, pattern and quality) etc,
4	Cultural Properties	Value system, social norms, location and spatial distribution of historical sites, archaeological artefacts, shrines, sacred forests/scenic areas; religion, plants/animal species of cultural value, festivals, marriage practices, cultural calendar etc.
5	Natural Resources and Land Use	Values and use of natural resources including rights over private, rental, common ownership and access to resources – especially with respect to women; local conservation practices (closed seasons/closed locations) etc.
6	Perception of the project	Perception of associated project risks and impacts on quality of life, rating of relationship with SPDC, pleasure/displeasure with proposed project, expectations etc.
7	The role of women and children	Rights and privileges, contribution to socio-economic development; activity systems and political organisation, women trafficking, child labour etc.
8	Physically Challenged	Rights and privileges, contribution to socio-economic development; activity systems, social exclusion etc.

S/N	Social Features	Variables
9	Social Structure and Organisation	Settlement history, ethnic groups, social organisation and traditional governance – power and authority structure; history of conflicts and their resolution including the role of women
10	Vehicular Traffic Analysis	Vehicular volume count, origin and destination survey
11	Sex Trade	Population, Frequency, Nature, types, origin, and socio-economic aspects etc.

Table 1.6: Health Data Needs

S/N	Health Parameters	Data Requirements
1	Demographic profile of the Communities	Population, age-sex distribution, migration pattern, occupation, religion, marital status, educational attainment, fertility rate, crude birth rate (CBR), life expectancy.
2	Morbidity/Mortality Patterns	Pattern of morbidity and mortality in the area; computation of crude death rate (CDR); age-specific death rate (infant mortality rate, under 5 years mortality rate, maternal mortality ratio), etc
3	Healthcare facilities	Inventory of existing healthcare facilities and the types/ quality of services rendered; health programs available and their providers etc. Qualifications, experience and competence of local health professionals; availability of Medical Emergency Response Facilities (MEDEVAC)
4	Nutritional Status of <5 years and the general population.	Feeding habits, weight, height, mid arm circumference (MAC), clinical examinations for signs of malnutrition.
5	Maternal and Child Health	Maternal mortality ratio; <5 mortality rate; Immunization Status; number, distribution and patronage of traditional birth attendants
6	Knowledge, Attitude Practice and Behaviour (KAPB)	Knowledge of causes of common diseases and methods of preventing them. Behaviour/Lifestyle that could influence Health (e.g. Substance abuse, reproductive health behaviour; health care seeking behaviour (traditional medicine utilisation, spiritual healing, etc) Key household practices e g personal hygiene, intake of proteinous food like fish, egg, meat, etc by children.
7	Environmental health factors	Domestic and Portable water supply, sanitation, housing, waste management practices (disposal of human and

S/N	Health Parameters	Data Requirements
		domestic wastes), noise levels, air quality (indoor and outdoor) and levels of radioactivity, pest/vector control

1.8: Statistical Analysis

The biophysical, health and socio-economic information collected during the fieldwork and laboratory analysis will be analyzed statistically where necessary to bring out the inherent trends and patterns. Specifically the health and socio-economic studies will focus on the different parameters listed in Table-1.

1.9: Quality Assurance and Quality Control

Quality Assurance and Quality Control (QA/QC) shall be an integral part of the entire process of field data gathering, laboratory analysis and reporting exercise.

Field Procedures

All field procedures shall be in accordance with general QA/QC requirements.

- Contamination of samples shall be avoided by using clean and sterile sampling containers
- Separate samples shall be used in analysing for parameters requiring different treatment or preservation before analysis
- Composite sampling technique shall be adopted for soil.
- Control samples shall be collected at appropriate points remote from focus areas
- Samples shall be appropriately preserved and labeled
- Proper chain of custody shall be applied

Laboratory Procedures

- Analyses shall be carried out within the holding time of respective parameters
- Only functional and calibrated equipment shall be used for sample analysis.
- Only competent and experienced staff shall be involved in analytical work

Reporting Exercise

The data obtained from the study shall be analyzed using appropriate statistical tools to ensure appropriate level of confidence in conclusions made on trends on the facility. Relevant relationships between the present and past studies on the environment shall be established.

1.10: Quantification and evaluation of impacts

Actual impacts on soil, sediments, vegetation, surface water, ground water, socio-economics and health of the communities will be quantified and evaluated scientifically using data acquired from control points and the baseline data gathered in the same environment during previous environmental studies in the area. Furthermore, the evaluation will determine the likely receptors in the environment and establish the source-receptor pathways. In addition, it should determine the current and likely future risks posed by the logistics operations on the environment.

1.11: Determination of appropriate remedial measures

After quantification and evaluation of impacts, appropriate remedial measures will be recommended. These measures will help to restore the impacted site to its original form, as much as possible, in accordance with the Nigerian regulatory requirements.

1.12: Monitoring Plan

The monitoring plan shall provide detailed environmental, social and health variables to be monitored so as to ensure that the recommended remedial measures are implemented correctly and ascertain its effectiveness over a defined period. The plan should also provide guidelines on the review of measures when adjudged necessary. Additionally, the plan shall indicate the responsible parties and timelines for the implementation of the remedial measures.

1.13: Report Writing

It is expected that all findings relating to this EIA will be documented in a report, after management challenge and review.

CHAPTER TWO
PROJECT JUSTIFICATION

2.1: Project Background

The Saghara AGS project is a part of the wider Otumara Node AGS Project. The project aims at effectively stopping routine gas flaring in SPDC operations. At present, most of the associated gas produced at Saghara flowstation (1750000scf/d) is flared. All Otumara oil wells currently producing into Saghara flowstation will be re-routed back to Otumara flowstation, and the remaining Saghara oil wells will be commingled at low pressure and allowed to flow freely (with the associated gas) to Otumara flowstation.

The Saghara flowstation will be mothballed by constructing a new gathering manifold, a 6" bulkline and a 4" testline that will re-route and free flow all the oil wells within the field. The new gathering manifold shall be installed in Saghara and all the flowlines (6" bulkline and 4" testline) within the field shall be tied into the new manifold. Part of the mothballing and preservation works for the flowstation includes the 8" delivery line from Saghara to the Trans-Forcados Pipeline (TFP). Saghara flowstation will be made into a remote manifold. Existing facilities within the flowstation will be decommissioned and preserved for future use.

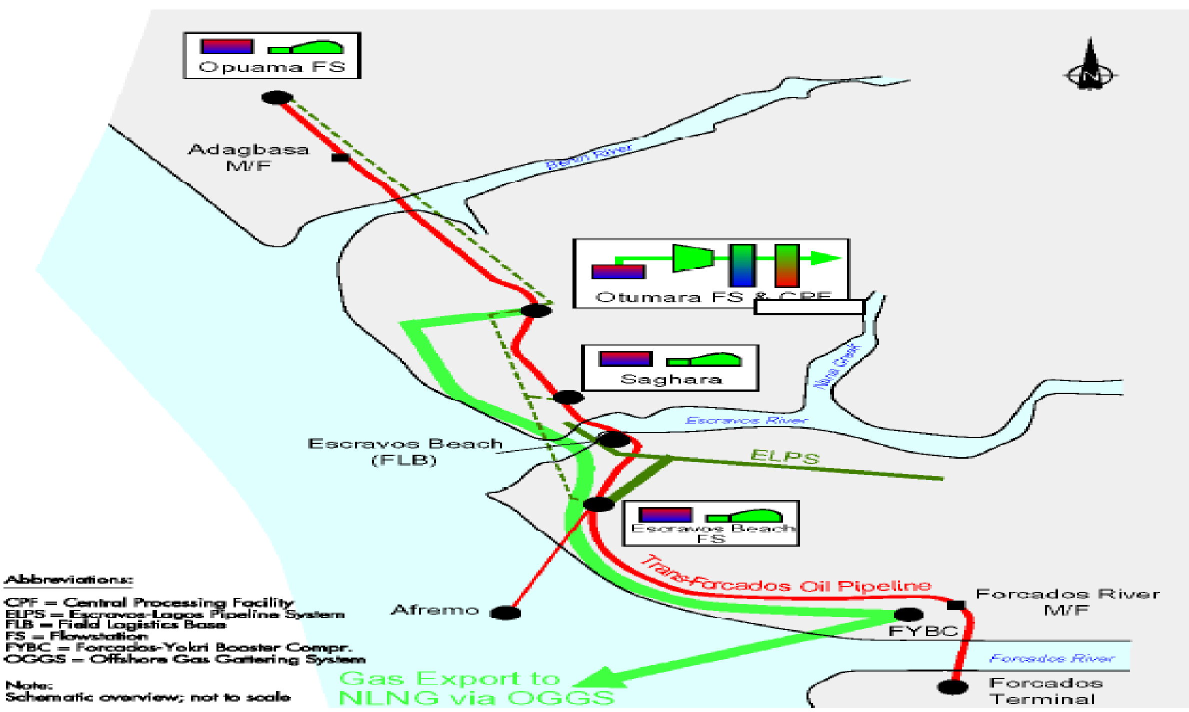

Fig. 2.1: Pipeline route Trans Forcados Oil Pipeline

2.2: Need for the Project

This project is needed for several reasons among which are:

- To align with Nigeria's aspiration to reduce environmental pollution caused by gas flaring.
- To utilize gas that was hitherto flared for economic benefit via sales.
- To increase domestic gas supply for local consumption thereby contributing to Nigeria's ability to sustain her growing energy needs.

2.3: Value of the project

The revenue that will accrue from the sale of the hitherto flared gas will add to the foreign exchange earnings of the Federal Government of Nigeria in addition to the revenue from oil and condensate. The elimination of routine gas flaring will significantly reduce environmental pollution, thus improving the social and health standards of the area covered by the project. In addition, the project will contribute towards producing gas that will be used in electrification of the 3 host communities.

2.4: Project Schematics

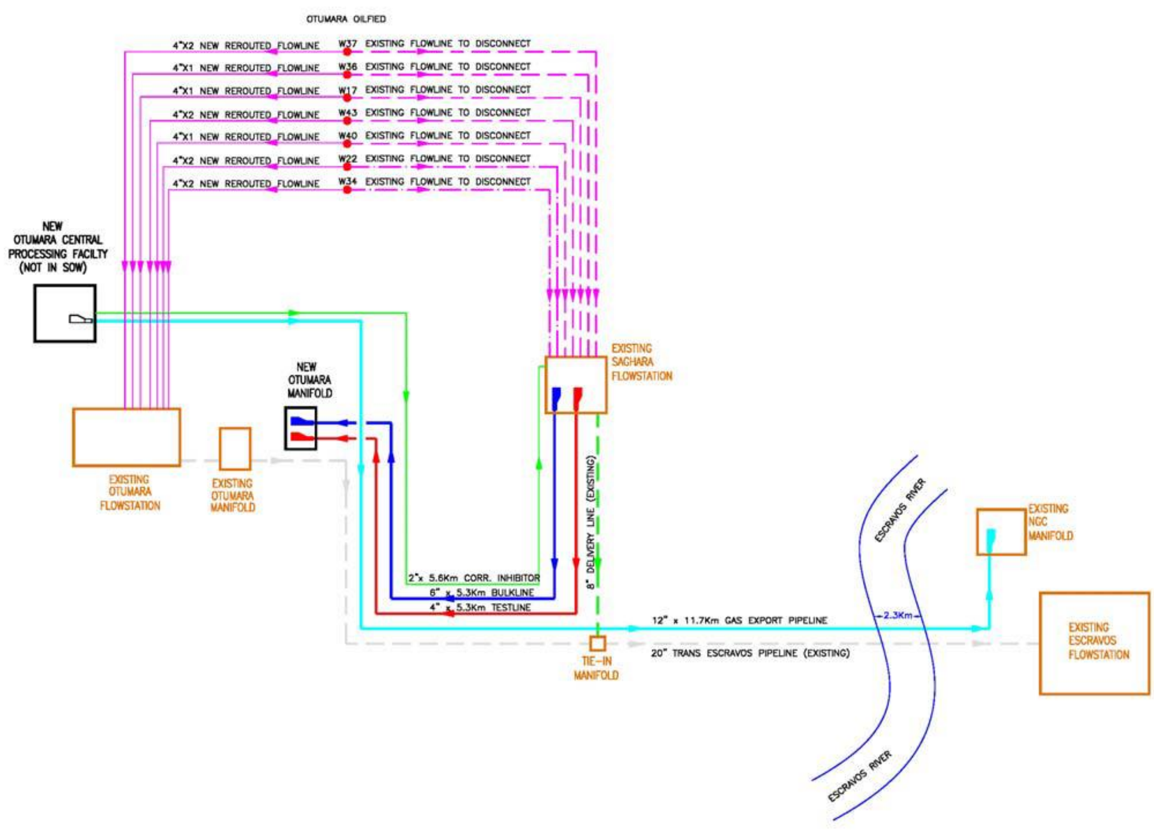

Fig 2.2: Saghara Pipeline Scope Schematics

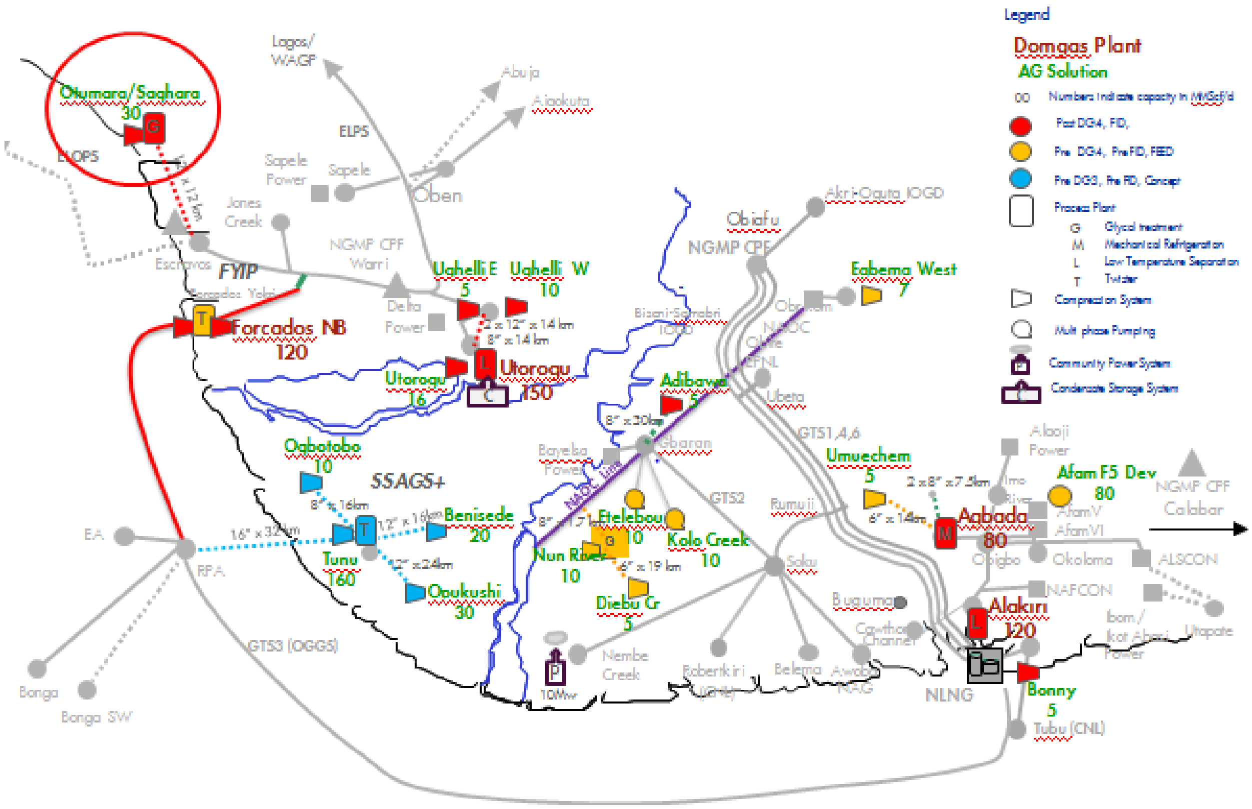

Fig. 2.3: Saghara AGS Project and other Gas Portfolio Projects

2.5: Project Alternatives

Project Options

The project development alternatives considered were;

- Do Nothing,
- Multiphase Pumping from Saghara Flowstation
- Free flow from Saghara Flowstation

The advantages and disadvantages of each alternative/ options are summarized in Table below:

Table 2.1: Project Alternatives/ Options Considered

S/N	Options	Advantages	Disadvantages
1.	Do nothing	• No Capital Expenditure • No negative impact of project on the environment	• No Gas to sustain supply to the Gas Plants • Government aspirations to improve power supply by year 2014 will not be met. • Environmental degradation from gas flare will persist. • Gas supply to domestic market will not be met. • Loss of revenue.
2.	Multiphase pumping from Saghara	• .No land take • Employment opportunities • Contract opportunities	• Increased & high capital expenditure • Increased energy utilization. • .Negative environmental impact
3.	Free flow from Saghara	• No land take • Contract opportunities • Employment opportunities • No negative impact on project schedule • Minimal vegetation clearing • Improved environmental performance. • More gas availability • Allows for future oil development. • Free flow, no pumps required. • Low Capital investment	• Increased surveillance. • Increase frequency of pigging operations.

Option 3 Free Flow from Saghara was selected based on the criteria as shown in Table 2.1. The concept allows Saghara wells to flow freely to Otumara flowstation. This is premised on re-routing these Otumara wells: 17T, 36L, 40T and 43S (currently producing into Saghara flowstation), back to Otumara Flowstation.

Future oil development in Saghara will not be constrained by this option as reservoir forecasts have shown.

Table 2.2: Surface elements for NFA+STA development

Otumara-Saghara-Opuama AG Solution Project								
		Hydrocarbon Development Building Blocks						
Focussed Decisions	Aim of Concept	Reservior Dev. Scebario	CPF Location	Evacuation	AG Compre	Scope for Saghara	Scope for Otumara Gas	Scope for Oil Facilities (Otumara, Saghara, Opuama)
Strategic Alternatives	Sustain Oil +AG	NFA	Otumara	Single conduit to FY	ESP	ESP	Expand Existing AG compression	Fill Ullage
	Flares Down	NFA+STA	Saghara	Two-conduits to FY	MPP	MPP	AG compression	Expand
	Min. CAPEX	NFA+STA+LTA1	Opuama	Gas Injection	AG Compre	AG Compre	ESP	
	Aggressive execution	NFA+STA+LTA2	Escraavos	Local Power Generation	Free Flow	Free Flow	MPP	
	Grow Oil+AG Production	Shut In 2008	FY	ELPS (Escravos)				
	Grow NAG sales			Chevron				
	Grow AG sales							

The surface elements are categorized as:

- Location of the Central Processing Facility (CPF)
- Options for evacuating gas from the CPF
- Options for Saghara gas evacuation
- Options for Otumara gas processing

Table 2.3: Feasible Development Scenarios

OTUMARA-SAGHARA-OPUAMA			
Strategic Alternatives	**Resevior Dev.case**	**Description**	**Scenarios**
Sustain Oil and AG proction Post 2008 **Use of Existing Facilities- Min. Capex Scenario** **Aggressive Execution**	**NFA** **NFA+STA**	ulitise existing pipelines and facilities in Opuama, Saghara or Utumara for multiphase flow and AG compression.	Scenario 1 (Base Scenario) : Multiphase boost Opuama, bulk free flow Saghara; Install 30 mmscf/day Compression/Treatment, 12" line Export to ELPS **Scenario 2:** Multiphase boost Opuama, Multiphase free flow Saghara; lease 15 mmscf/day gaslift, Install 15 mmscf/day export Compression and 30 mmscf/day Export Treatment; 12" Line Export to ELPS (Lease- Buy) **Scenario 3:** Multiphase boost Opuama, bulk free flow Saghara; lease 15 mmscf/day Compression, Lease 15 mmscf/day export Compressor, lease 15 mmscf/d gas treatment, 12" Line Export to ELPS (Lease Lease) **Scenario 4:** AG booster in Opuama, Free flow Saghara to Otumara CPF. Install a 30 Mmscf/d compression and treatment facility in Otumara, 12" pipeline to to ELPS **Scenario5: S**pike Gas in Opuama, new LP gas line from Opuma-Otumara Free flow Saghara to Otumara CPF. Install a 30 mmscf/day gas compressor and treatment for Otumara, 12" pipeline to ELPS. **Scenario 6:** Multiphase boost Opuama, bulk free flow Saghara; Install 30 mmscf/day Compression/Treatment, 12" line Export to Forcados Yokri **Scenario 7:** Multiphase boost Opuama, bulk free flow Saghara; Install 15 mmscf/day Compression for lift gas, 15 mmscf/d low pressure booster , 12" line Gas Export to Chevron
Grow oil and AG Production (Case 1)	**NFA+STA+LTA1**	Define LTA1 as using the Ullage created in the cases above due to decline in production for the NFA case. Create a driliing sequence to fill in the ullage in the system.	**Pre-investment for FOD included in above options; additional investment (where needed), to be justified by FOD.**
Grow oil and AG Production (Case 2)	**NFA+STA+LTA2**	Unconstrained LTA case may require the drilling of new wells in Otumara and unconstrained development of UADs and PAFs around the Otumara fields.	**No Unconstrained Development case considered.**

2.6: Envisaged sustainability

The envisaged sustainability is categorized as follows:

2.6.1: Economic sustainability

Saghara field has substantial reserves of associated gas. There are proven reserves that can economically and commercially support the project. The Saghara AGS project will, in the long run, contribute substantially to Nigeria's revenue from petroleum.

2.6.2: Technical sustainability

The Saghara AGS Project (which is part of Otumara field) is technically sustainable because SPDC has proven oil and gas technology and adheres strictly to Nigerian national and international engineering design and construction standards. Technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized during project execution.

2.6.3: Environmental sustainability

Facilities and pipeline construction techniques vary according to the environment, and are guided by Regulatory and Engineering Design standards. Pipelines in marshy/swampy areas and water crossings would have a yard-applied concrete coating over the external, anti-corrosion coating. 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.

CHAPTER THREE
PROJECT/PROCESS DESCRIPTION

3.1: Introduction

The Saghara AG Solutions Project involves mothballing of Saghara flow station and re-routing of Saghara wells back to Otumara Flowstation while the remaining Saghara oil wells will be comingled at low pressure and allowed to flow freely (with the associated gas) to Otumara Flowstation. Some of the existing facilities, (generators & export pumps) within the flow station will be decommissioned and preserved. The project does not involve drilling of new oil wells. The work comprises of engineering review and verification, procurement of materials, construction and commissioning of a new bulkline (6” x 5km) and testline (4” x 5km) for Saghara flowstation to Otumara flowstation including all associated tie-ins and manifold works.

The above scope will enable re-routing of Otumara wells currently producing to Saghara flowstation to Otumara flowstation. The works will be carried out in the Saghara flowstation and only existing flowline Right of Way (RoW) will be used for the construction works. Therefore there will be no requirement for land acquisition. The scope also includes installation of 21km long fibre optic cable from Saghara wells to Otumara CPF for **d**ata transmission from the wells (downhole data gathering) and communication with the wells (ability to control instruments on the wellheads)**.**

The detailed work to be performed is as follows:

- Detailed design engineering, review and verification.
- Receipt, load out and transportation to site of all required materials from SPDC warehouses in Port Harcourt and Warri.
- Clearing, excavation, pipe laying & welding, backfilling, land reinstatement, pre-commissioning, commissioning and start-up work.
- Installation of pipeline manifolds and other end facilities (Pig Launchers and Receivers, etc).
- Decommissioning, preservation and re-routing of all Saghara and Otumara wells to Otumara flowstation
- Project management and control of the entire project Health, Safety, Security and Environmental Management of all activities

The pipeline is routed mainly through Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest. The pipeline will have anti-corrosion coating, and weight coating for most of the route. The pipeline shall be provided with permanent pig launching and receiving facilities at Otumara, Saghara and ELPS tie-in point at the NGC manifold respectively.

Facility Construction Scope:

- Installation of a new bulking manifold
- Tie-ins.
- Installation of process piping, vent, drain lines and flush line along with supports.

- Installation of process piping / valves from tie-in points along with pipe supports.
- Mothballing and in-situ preservation of existing Saghara flowstation and the 8" oil delivery line from Saghara to Trans-Forcados Pipeline (TFP).

3.2: Project Objectives

The strategic objectives of this project are:

- Align with government's aspirations by contributing about 100MMscf/day of gas to the domestic gas network.
- Achieve Flares down and thus minimize impact on the environment and enhance the socio-economic development of the host communities in the area through sustainable development of the project over its life cycle
- Secure already developed reserves
- Generate revenue via gas sales
- Maintain SPDC's License to Operate (LTO)
- Maintain SPDC's reputation among our joint venture partners and the Nigerian government
- Provide electrification to the three host communities – Ugborodo, Deghele and Ugboegungun

3.3: Project Location

The Saghara field is located in OML 43 (Warri South LGA, Delta State) in the greater Forcados area in the coastal swamp depobelt of the western Niger Delta. The field was discovered in 1970 and to date a total of 8 wells have been drilled in the field, of which two (wells 4 and 6) have been abandoned. Production in the field started in 1972. Oil is produced to Saghara flowstation with nominal capacity of 30,000 barrels of oil per day (gross).

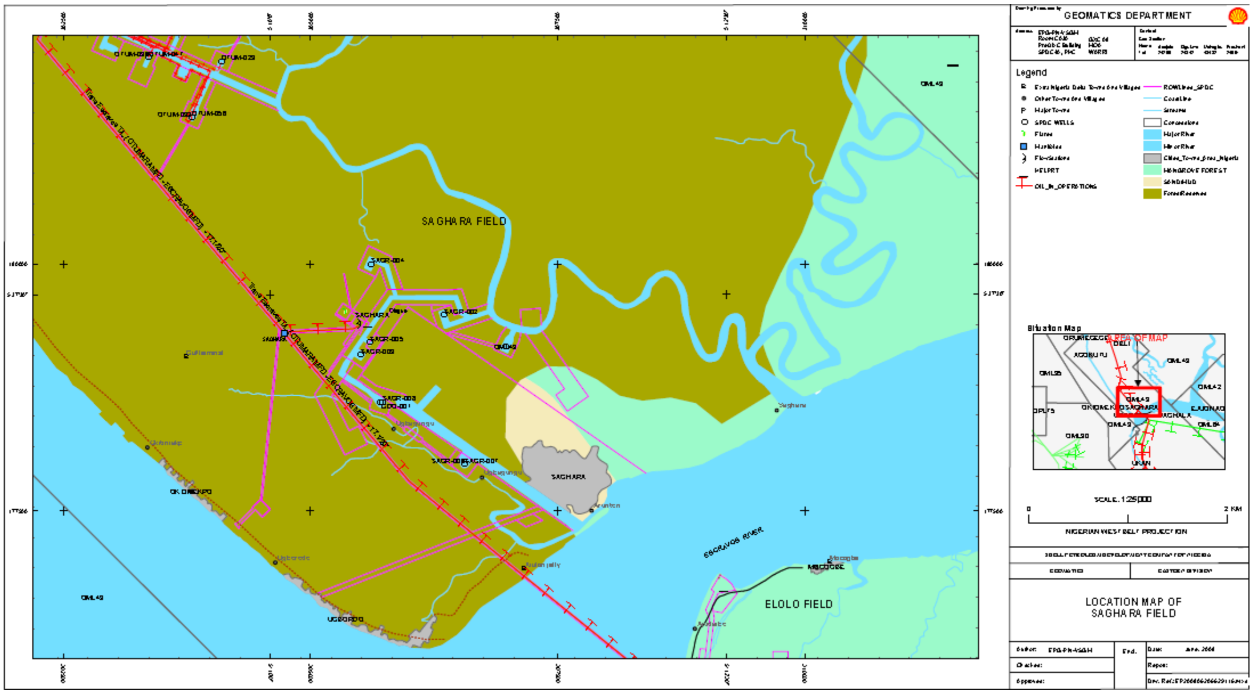

Fig 3.1: Map of Saghara Field

Fig 3.2: Aerial view of Saghara Flowstation

3.4: Project Pre-Construction Activities

- The project pre-construction activities include but are not limited to the following:
- EIA studies.
- Conceptual and detailed design of the Saghara mothball facilities (manifold) and pipelines.
- Land Acquisition
- Geotechnical/Topographic surveys

Land Acquisition

To minimize the attendant environmental impact and minimized SPDC footprint, the projects activities are being planned within existing facilities and RoW as such there will be no requirement for additional land acquisition The option of using existing RoW and already acquired land for the pipelines was given a high priority to reflect the 'lean and green' approach, involving minimum or no new land acquisition.

Conceptual and Detailed Design

The facilities and pipelines shall have a design life-span of 25 years. All pipelines (test and bulk lines) shall conform to design and engineering codes.

Evaluation of combined stresses on the pipeline shall be carried out for the assurance of mechanical strength in conformance with relevant codes. In addition, detailed stress analysis shall be carried out during the detailed design. The detailed design also covers plant layout, surveys, soil investigation, foundation and piping tie-ins including interface to the existing facilities. The design will be a fit-for-purpose design.

To analyse pipeline systems, the following loads are taken into consideration as a minimum.

- Internal pressure loads (hoop stress).
- Sustained Loads (soil loads, soil frictional force, self weight)
- Live (axial) Loads (vehicle traffic)
- Thermal Loads (changes in operating/installations temperatures)
- Test Loads (hydrostatic testing)
- Vortex induced Fatigue
- Equivalent Stresses

Facilities Bulkline and Testlines (Flowlines) Construction

This section describes the construction activities for the proposed Saghara facility, bulklines and testlines. These shall include:

- Pipeline route surveys and soil investigations as necessary.
- Site preparation activities
- Construction of 2” x 5km corrosion inhibition lines from Otumara CPF to Saghara flowstation manifold

- Installation of 4” x 5km oil testline lines from Saghara flowstation inlet manifold to Otumara flowstation inlet manifold
- Installation of 6” x 5km oil bulkline lines from Saghara flowstation inlet manifold to Otumara flowstation inlet manifold
- Re-routing of 4” x 5km oil flowline lines from Saghara wells to Otumara flowstation inlet manifold
- Installation of 4” and 6” pig launching and receiving facilities and tie-in at Saghara flowstation
- Installation of 21km fibre optic cable from Otumara CPF to Escravos through Saghara flowstations. Fibre optic cable shall be installed along the same pipeline trench.
- Tie-ins to existing inlet manifolds/hook-ups.
- Installation of cathodic protection system
- Hydrotesting
- Pre-commissioning and commissioning activities
- Decommissioning, Mothballing and Site restoration

Details of Mothballing procedure include:

- Plant Shutdown
- Inspection and Technical Audit of facilities
- Decision on extent of preservation
- Engineering work for preservation
- Planning and Management of Mothballed facility

The facilities and bulk/testlines, which shall have a design life of 25 years, shall be constructed in accordance with SPDC’s standard construction specifications and relevant government and other regulatory standards. Construction will be carried out in a way that will minimise and reduce negative impact on the environment. All wastes generated throughout the life-cycle of the project shall be managed in accordance with approved industry regulations and EIA guidelines.
Bulklines/testlines in marshy/swampy areas and at water crossings shall have a yard applied tape wrapping over the anti-corrosion priming. The wrapping shall be done in a pipe yard before transportation to the site. The handling, loading and stacking of wrapped pipes shall be carried out strictly in accordance with the SPDC standard specifications.

Site Preparation Activities
Site preparation activities will include the following:

- Pre–mobilisation and Mobilization
- Survey works and geotechnical Investigations
- Site clearing of RoW

- Ditching/Excavation (Escravos river crossing), laying and backfilling of bulk/testlines/Fibre Optic Cables within Saghara and Otumara fields.
- Dredging, piling and concrete works
- Installation of headers, manifolds/tie-ins
- Site clean up and restoration
- Demobilization

Equipment/Personnel to be deployed to the Work

The following equipment will be deployed for the work:

- Surveying equipment - Theodolite, levelling instrument and echo sounder used for measuring the riverbed elevation
- Tugboats, Work barges
- House boats for personnel accommodation
- Swamp buggies and dry plants as applicable
- Personnel boat carriers
- Small equipment and tools
- Staff strength of about 60 persons

Mobilization to Site

The selected SPDC Contractor shall mobilize all personnel equipment and materials to the site, ready to start work after completion of all necessary pre-mobilisation requirements (equipment, personnel certifications and HSE documentation) necessary for commencement of site construction activities. The following Items of utilities, infrastructure and logistics will be undertaken as part of mobilisation for the Saghara AGS Project:

Accommodation/Labour Camp: Prior to the commencement of construction activities, temporary, fully serviced accommodation shall be provided by the contractor on site, within SPDC acquired area. This will limit human traffic significantly, thus minimizing accident potential.

Power Generation and Distribution: Diesel generating set(s) of adequate capacity shall be installed, to provide required electricity/energy during construction. Noise and emissions shall be managed to stay within the allowable limits and SPDC shall ensure contractor's compliance, through effective supervision and audits.

Supplies to the Construction Site: Supplies of food, materials, consumables, fuel, water etc shall be by barge through the inland waterways. Associated environmental impacts from water transportation (erosion of river banks, disruption of fishing activities, etc.) will be managed to best practices (see Chapter 6). The intention is to minimize disruption to social life in the project area.

Site Surveys

The boundaries of all sites shall be indicated by means of coloured survey pillars. The SPDC Contractor shall re-open the site boundaries and stay within the boundary lines and avoid causing any damage to, or placing any obstruction upon the survey pillars and third party property outside the boundaries. A benchmark shall be provided by SPDC at each site, which shall be referenced to Lowest Low Water Level (LLWL) datum. A tide, flood, or river gauge shall be established on site and tied to SPDC lease pillars (benchmarks) that are in-situ. In tidal areas, gauge reading shall be made at least every half hour during soundings or depth measurement.

Site Clearing

Site clearing, bush clearing and de-stumping shall be limited to the RoW for the pipelines and cables. Debris shall be piled next to, but within, the boundaries of the area of each site cleared. Areas within SPDC's RoW will be cleared prior to excavation and laying of pipeline. Top soil stripping and segregation shall be performed prior to trenching on the right of way center line to facilitate effective reinstatement.

3.5: Construction Activities

Excavation/ Pipe laying and Tie-ins

Prior to ditching, metal detectors will be utilized to probe for the identification and location of existing flowlines, pipelines along the flowline RoW. Positions of such flowlines, pipelines shall be properly marked out as part of the pre-ditching investigations. The actual positions of the identified lines shall be done using reflective yellow buoys (on water) or pegs (on land). During excavation and pipe laying activities in the field, the following would be observed:

- The pipe trench shall follow the pipeline route surveyed/opened;
- The trench shall be excavated to minimum widths in relation to pipe sizes;
- Mechanical equipment shall be used for the excavation;
- The finished trench shall be free of roots, stones or other hard objects, which may damage the pipe or pipe coating;
- Provision shall be made for dewatering, as may be required;
- The pipe shall be lowered into the trench such that it lies naturally, and is continually supported along its entire length in the bottom of the trench. Where the floatation method is used, the pipe shall be floated into position and lowered into place with adequate floats or pontoons as necessary;
- After the pipe is in position, the floats shall be carefully removed to prevent damaging to the coating, and
- The pipe shall be filled with filtered, clean water for flushing and pressure testing.

Tie-ins

It is required to carry out a tie-in to join two strings in straight line or at angles with prefabricated bends. Strings are tied together with a special tie-in spread including flexi-float pontoon equipped with a central lifting frame. Once the string is welded, X-ray will be carried out and field joints installed. After completion of the tie-in operation, the pipe is lowered on the trench bottom, by releasing the cable winch and after positioning, the lowering and laying can start. Minimum top of pipe cover in swamp area: 1.20 m. Floats are then removed ready to be used again for another string installation.

After successful lowering of the pipe, the trench shall be backfilled in layers, and uniformly compacted. The backfill material (free of stones, sticks, roots, debris and any other material which might possibly damage the pipe wrapping and/or initiate corrosion) shall be crowned (heaped up) along the trench line to a height of between 20 and 30 cm above the adjacent ground surface.

During the course of backfilling and re-vegetation, the following precautions shall also be taken:

- Where tracked equipment is used for backfilling operations, such equipment shall not be allowed to traverse along, across or over the installed pipe;
- Re-vegetation shall be carried out as soon as practicable after completion of backfilling in areas outside the RoW; the cleared areas around the pipeline route shall be re-vegetated with indigenous species
- All possible measures shall be taken to enhance the reinforcement of mangrove forest and other vulnerable areas to prevent any undesirable successional changes;
- Soil stabilization measures will be undertaken to encourage the re-growth of vegetation and the topsoil (surface material that would have been stripped and set aside prior to excavation) shall be reinstated.

Ditching / Excavation / Dredging

Ditching, trenching and dredging activities shall be preceded with centre line survey to define actual alignment of the flowlines and probing to identify location of all existing facility interfaces and possible crossings. Excavation around existing facility crossing shall be carried out manually while mechanical excavation will be utilized in all other areas.

Several minor creek crossings and one major river crossing shall be performed as part of the bulkline/flowline construction and the dredging technique to be used and handling of dredge spoil shall be designed to minimize impact to the environment. Dredging is required for only major river crossings. Minimum depth cover shall not be less than 1m below natural bottom level of river or creek bed.

Welding and Radiography (Non Destructive Testing)

This activity shall involve welding of the bulklines, flowlines, tie-ins and hook ups. The floatation method shall be used where the pipeline is laid from a single laybarge moving through a channel (burial trench) cut along the right of way. The line pipes shall be procured with capped bevel ends with pipe storage barge moored next to the laybarge. After welding of pipes, the pipelines shall be coated with three-layer polyethylene coating to provide external corrosion

protection. Field joints shall be coated with shrinkable sleeves. All welds shall be 100% radiographed as per code requirement. Ultrasonic testing and radiography shall be in accordance with ASME codes. All fillet welds shall be tested using dye penetration test.
All personnel involved in non-destructive testing shall be qualified to a recognized International Standard. Visual inspection and100% radiography (non-destructive testing) of the welds shall be done as the welding progresses. Weld repairs shall be carried out where necessary, prior to Pipeline pressure testing. Waste generated from welding and NDT activities shall be contained and safely disposed. Successful welds shall be laid on already prepared trenches and the as – laid survey documented.

Installation of a new bulking manifold
Fabrication of new manifolds and launchers would be done off site and transported for installation at the flowstation. Following the tie-in/hook up process the manifold will be integrated with the existing facility required for mothballing the Saghara flowstation.

Pre-commission/commissioning
The initial pre-commissioning activities are the none-operational checks and cold alignments of individual items of equipment or materials. They are carried out by a team formed of construction and pre commissioning personnel. All checks shall be recorded on a Pre-Commissioning Checklists with action points noted and action party identified.
For the pre-commissioning, the following activities shall be carried out on each element as a minimum:

- Check test certificates, inspection certificates and performance test certificates
- Check construction phase certificates
- Check hydro test recorder chart
- Visual check

All pre-commissioning activities of the manifold, launchers, and pipeline systems shall be carried out in accordance with Shell DEP 31.40.50.30-Gen. Pre-commissioning activities shall include but not limited to following filling, cleaning, gauging, pigging and hydrostatic testing, dewatering and drying.

Hydrotesting
The bulklines and flowlines shall be hydrostatically tested after construction in accordance with Shell guidelines to prove the strength and integrity of the lines. The test water for the various pipelines shall be from ground water (borehole within the area) and shall be evacuated to Forcados Terminal through the flowstation. If anti-corrosion agents are to be introduced into the hydrotest water, they will be subjected to toxicity test in DPR accredited laboratories and only those certified by DPR will be employed. The minimum duration for the hydrostatic pressure test shall be a 4 hours strength test followed by a 24 hours leak tightness test. The strength test is a specific procedure to verify that the pipeline meets the requirements for mechanical strength and

the leak tightness test is a specific procedure to verify that the pipeline meets the requirements for tightness.

3.6: Operations and Maintenance

Operation Philosophy

The pipelines and their associated facilities will be operated in accordance with operational procedures developed through SPDC extensive experience. The project will be managed by fully trained and qualified personnel who are conversant with SPDC's HSE policy guidelines.

Operation of the Saghara field will be unmanned and managed remotely from the central processing facility at Otumara. The operational philosophy shall be based on an automated operation and minimal intervention requirements for maintenance and operations.

Maintenance Philosophy

Upkeep of Structures

Maintenance and inspection activities will be based on periodic inspection to determine the condition of structures and performance of their protection systems. Refurbishment activity to restore the integrity of structures will be based on their condition. Coating systems applied to structures will be replaced on a time based maintenance schedule.

Containment of Hydrocarbons

Maintenance and inspection activity will be based on periodic inspections to determine the condition of all elements of the process fluid containment envelope. Inspection will be related not only to the containment envelope, but also to any protective coatings applied thereon. Inspection programmes for certifiable pressure vessels, pressure / vacuum relieving devices will be inspected to meet the requirements of the Minerals Oils (Safety) regulations of Nigeria. Refurbishment activity to restore the integrity to the envelope will be based on their condition. Where appropriate, economic systems to mitigate the effects of corrosion shall be put in place and their effectiveness routinely monitored.

Control and Protection

Control and protection systems will be based on periodic inspections / calibration / testing of both their input and output functions as detailed in the Maintenance Job Routes (MJR).

Hazard Detection Systems

Maintenance of hazard detection systems will be based on periodic inspection / calibrations /testing of both their input and output functions. Non-availability of hydrocarbon production caused by such inspections / calibrations / test will be accounted for in the production plan.

3.7: Decommissioning and Mothballing (Preservation)

The Saghara AGS project specific strategy for the decommissioning scope of the project is as follows:

- Existing oil wells from Saghara field will be free flowed from the existing Saghara manifold to Otumara CPF via the new 4” and 6” bulklines to be laid. The remainder of equipment in the existing flowstation shall be decommissioned and preserved for future use.
- Mothballing and in-situ preservation of existing Saghara flowstation and the 8” oil delivery line from Saghara to Trans-Forcados Pipeline (TFP)

The decommissioning and mothballing exercise shall be carried out with skill and due diligence to avoid spill of hazardous liquids and damage to the environment. At the end of the exercise, various wastes (liquids/solids) are sorted and segregated according to their types and then disposed of according to SPDC waste disposal and environmental guidelines.

Site Restoration and clean up.

After all segregated wastes have been satisfactorily disposed of; re-vegetation of the pipeline RoW shall be carried out using previously excavated materials. Top soil for impacted areas shall be reinstated with soil from unimpacted vicinity. Plant species nursed during the site preparation stage shall be replanted on the cleared sections of the RoW. Spoil dumps wined during dredging of river crossings shall be utilized to backfill the river crossing trenches. On completion of construction activities, reinstatement/restoration of any area disturbed during the work including temporary access ways, storage areas shall be fully remediated.

3.8: Oil Spill Contingency Plan

Shell Petroleum Development Company’s (SPDC) oil spill contingency plan shall be applied to the project. The spill contingency plan shall be based upon the location and volume of potential spill and shall address the possibilities of spill in the emergency plan. The spill contingency plan clearly identifies the actions necessary in the event of an oil spill including communication network, the individual responsibilities of key personnel and the procedures for reporting to the authorities and arranging the logistics of extra resources needed for clean-up work. Finally, the plan shall address the disposal of contaminated waste generated by spill.

3.9: Project Schedule

The current activity schedule for the Saghara AGS Project is shown in Figure 3.3 below. First gas is expected from the node by 2014

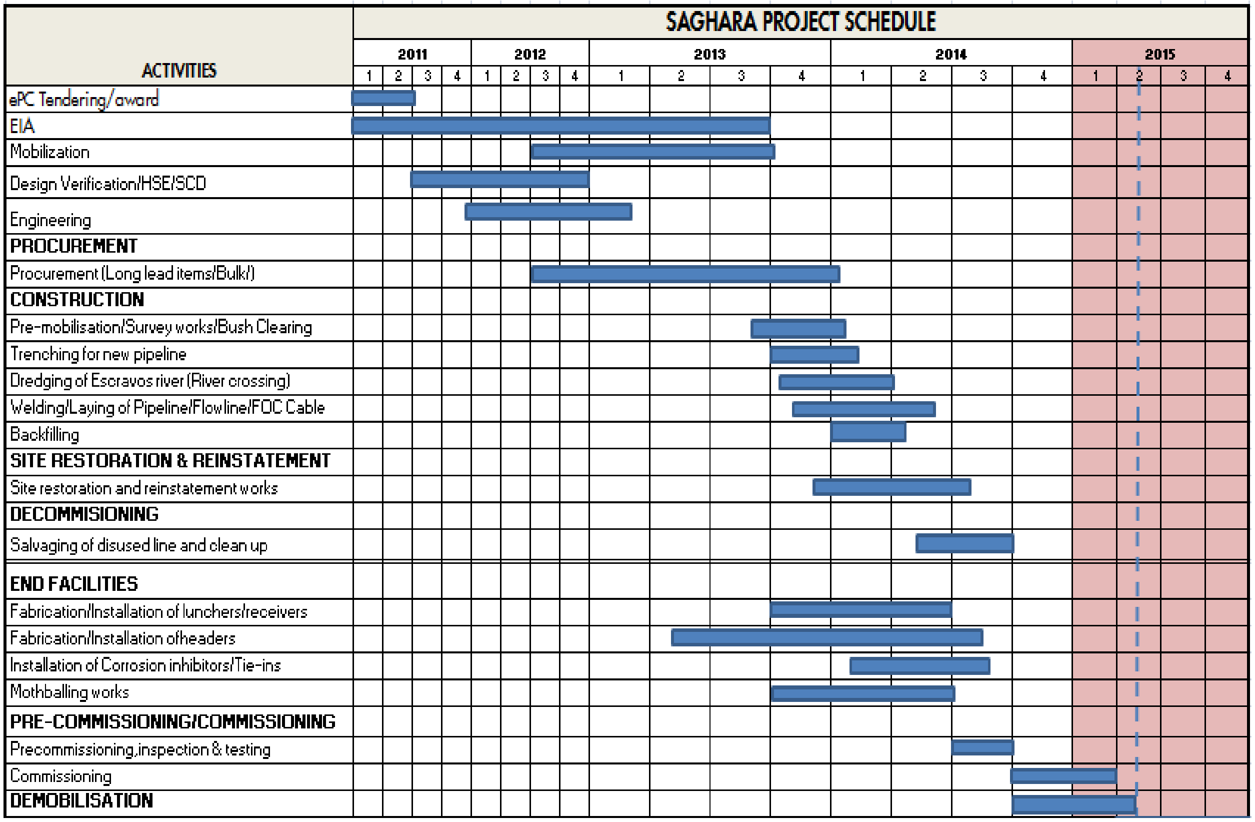

Fig. 3.3: Saghara AGS Project Schedule

Table 3.1 Potential waste expected from the Saghara AGS Project

Waste Type	**Control /Management Measures**
Cement	- Cement residues and returns will be well utilized for all concrete works.
Sewage	-It is envisaged that the maximum number of personnel at project site at any one time will be about 100 persons. Sanitary sewage produced at site will be treated on the house boat treatment plant as per DPR standard. The water can be re-used for flushing the system. Regular compliance monitoring will be carried out.
Industrial and domestic wastes	-Industrial and domestic wastes will be segregated according to the currently operated segregation scheme which distinguishes between food waste, paper waste, scrap metals, chemical waste, medical waste etc. These will be sent to SPDC respective waste disposal facilities.
Oil	-Oily water discharges shall be controlled to less than 20ppm oil in water by oil/water separators, interceptors and saver pit systems.

Drainage Discharges

Drainage discharges will occur from a number of sources including:

- Surface run offs;
- Storm water drainage systems;
- Bunded areas beneath fuel or chemical storage areas;
- Overflow drains on diesel fuel tank system.

The first two sources contain non-oily water and are therefore discharged into the river. However, the storm water drainage systems in addition will be connected with a sump and oil interceptor for accidental oil contamination before being discharged into the river. The other discharges that contain oil or chemicals will be routed to saver pits and oily water treatment systems for adequate recovery.

CHAPTER FOUR
DESCRIPTION OF THE ENVIRONMENT

4.1: Study approach

The purpose of this environmental description is to provide qualitative and quantitative baseline information on the existing status of the project area against which future departures as a result of the emplacement of the proposed project facilities will be weighed. The presentation given here represents a summary of the baseline report. The methodology for field and laboratory analyses are not included herein but are contained in the Appendix 2 of this report. The field data were gathered between August 15 and 20, 2012, representing the Wet Season, and from January 15 - 21, 2013, for the Dry Season. Laboratory analyses were carried out by Martlet Environmental Research Laboratory Ltd, Benin City, a Laboratory duly accredited by both the DPR and the FMEnv.

4.1.1: Quality Assurance/Quality Control (QA/QC)

The quality assurance programme covers all aspects of the study, including sample collection, handling, laboratory analysis, data coding and manipulation, statistical analysis, presenting and communicating results.

4.1.2: Sample Collection and Handling

This was carried out as far as possible in accordance with FMEnv (1995) and DPR (1991, as amended 2002) Guidelines and Standards (Part (VIII) D(2) (Sampling & Handling of Samples)). Where logistic and safety considerations precluded strict compliance with the above guidelines and standards, other proven, scientifically acceptable methods of sample collection and handling were used.

4.1.3: Laboratory Analyses

The methods of analysis used were those specified in DPR/FMEnv Guidelines and Standards and other International Analytical Standards such as APHA for water quality. With proper, sustained calibration of the instrument and the use of standardised observational procedures, equipment errors were brought to acceptable minimum. Trace metal analysis was done using Atomic Absorption Spectrophotometer duly calibrated using standards. Physicochemical parameters were determined using Spectrophotometer and Orion ISE Meter Model 710A, duly calibrated with standards, as well as Flame Photometer. Organics were analysed using Agilent 6890N Gas Chromatograph.

4.1.4: Statistical Analysis

Statistical analysis (mean and standard deviation) is applied to all data to even-out potential errors. Errors in field data include those resulting from the instrument and those introduced by the observer. However, other errors arise from the method of sampling. Errors often arise from two-stage sampling or sub sampling, or even from the fact that the samples collected may not representative samples of the medium.

4.1.5: Data Coding and Manipulation

Environmental Impact Assessment (EIA) studies in most developing countries where reliable data banks are non-existent, invariably involve acquisition of large amounts of baseline data. To ensure preservation of the integrity of data collected, data coding forms for use in the field were designed in such a way that field data could be directly entered into computer data sheets.

Since their analysis may be required in legal proceedings, it is essential to establish sample authenticity. Samples must be properly sealed and labelled. All data collected were labelled and the following information provided among others:

- Identification code or sample number
- Date and time of sampling
- Description of sample
- Methods of sampling
- Particulars of any photographs taken.

All movements of samples were included on the chain of custody record book. Basic information was recorded together with results of analysis, in the results record book.

4.2: Scope of Work

The scope of work for this Environmental Description includes but not limited to the following:

Literature Review

This covered Biophysical, Social and Health conditions in the project areas.

Details of Environmental Description

Details of the workscope are presented in Appendix 1.

4.3: Sampling Location

The maps showing the study area and the sampling locations are given in Figure 4.1. Because the two projects (Otumara AGS and Saghara AGS) are one project and closely linked, the EIA studies were conducted together. Sampling stations and labelling therefore began in Saghara Field and ended in Otumara Field as shown in Table 4.1. The sampling points were geo-referenced using Global Positioning System (GPS). The coordinates of the sampling locations are presented in Appendix I.

Table 4.1: Sampling Stations and Codes

SAGHARA	**OTUMARA**	**SAGHARA**	**OTUMARA**
SURFACE WATER	**SURFACE WATER**	**SEDIMENT**	**SEDIMENT**
SW1	SW8	SD1	SD8
SW2	SW9	SD2	SD9
SW3	SW10	SD3	SD10
SW4	SW11	SD4	SD11
SW5	SW12	SD5	SD12
SW6	SW13	SD6	SD13
SW7	SW14	SD7	SD14
SWC1	SW15	SDC1	SD15
SWC2	SW16	SDC2	SD16
SOIL	**SOIL**	**VEGETATION**	**VEGETATION**
SS1	SS8	VG1	VG8
SS2	SS9	VG2	VG9
SS3	SS12	VG3	VG12
SS4	SS13	VG4	VG13
SS5	SS14	VG5	VG14
SS6	SS15	VG6	VG15
SS7	SS16	VG7	VG16
SS10	SS17	VG10	VG17
SS11	SS18	VG11	VG18
SS12 (CONTROL)	SS19		VG19
	SS20		VG20
	SS21		VG21
	SSC3		VGC3
AIR QUALITY	**AIR QUALITY**	**BORE HOLE**	**BORE HOLE**
AQ1	AQC2 (CONTROL)	GW4	BHGW
AQ2	AQ9	GW5	GW1
AQ3	AQ10	GW6	GW2
AQ4	AQ11	GW7	GW3
AQ5	AQ12		
AQ6	AQ13		
AQ7 Control	AQ14		
AQ8			

The overriding considerations in the selection of sampling points included ecological features, geographical location of communities/settlements which are within a kilometer on either side of the pipeline network and a 5 km radius of a major facility such as the field flow stations, Manifolds, CPF, and areas of interest from satellite imageries and situating control points in undisturbed areas outside the project area but within the same ecological zone.

4.4: Study Area and its Topography

The Otumara field is situated on the coast, North of Chevron's Escravos development. The field has been developed by slot dredging and the areas are traversed by SPDC and third party pipelines. The project area has generally flat terrain with elevated land bounding the eastern margin. The elevation is less than 10 m above sea level while the slope is below 2^o. Dredging activities and dumping of dredge spoil have slightly raised the banks of the slots. However, the landscape is usually water-logged during the wet season mainly because of rain and tidal ranges on the rivers which vary from 0.3 m to 1.3 m. Although the areas are generally freshwater swamp, they are drained by the Escravos River in the East and Saghara Creek in the West with the Saghara Creek flowing into the Escravos River which ultimately enters the Atlantic Ocean. Sea water intrusion is prevalent on the Southwest margin of the area along slots and creeks. During the wet season, saltwater intrusion into the freshwater zone is retarded because of the considerable volume of freshwater discharged into the area via the Creeks and Rivers as rainfall runoff. Naturally, this result in the displacement of the saline water-freshwater interface further downstream.

4.5: Meteorology, Air Quality and Noise Studies

The climatic information for the project area is based on the analysis of long term historical data collected for the study area by the Federal Meteorological Services Department, Oshodi between 1995 and 2006. Meteorological data were also collected during the fieldwork in the project areas as shown in the sampling map. The sampling locations are as listed in Table 4.2a and Table 4.2b below for Wet and Dry Seasons respectively.

Wind speed and Direction

The project area is under the Tropical Wet climate zone. Analysis of climatic data obtained from synoptic stations in Warri show the prevailing wind directions as presented in Fig.4.1b. The wind rose shows that Southerly and Southwesterly and Easterly winds are the most predominant. While the Southerlies recorded higher wind speeds ranging between 2 and 6 m/s frequently, the easterlies were generally below 2 m/s. The South Easterlies, Northwesterlies and the others are rather less frequent. More detailed examination of the records shows that the Southwesterly is predominant between March and October which roughly coincided with the rainy season. On the other hand, the Northeasterlies were rather frequent between November and February during the dry season. The Southeasterlies and North Westerly were more evenly distributed throughout the year. The microclimate in this area was largely determined by these trade winds in a complex manner. The predominance of Easterlies and Westerlies may be due to the influence of the sea. Average wind speeds measured at the sampling points are presented in Table 4.2a and Table 4.2b representing the Wet and the Dry Seasons respectively.

Wind velocities were observed to be very low at all the sites monitored. The measured wind speed range for all sampling points was 0.8 – 1.4 m/s in the Wet Season, and from 0.8 – 2.0 m/s in the Dry Season. The observed low wind velocity is worrisome, because wind speed determines the ability of the atmosphere to dilute and disperse the emitted pollutants.

The wind directions were found to be Southwesterly at all the sampling points during the Wet Season and Northeasterly in the Dry Season.

Relative Humidity

The historical average Relative Humidity for the project area is presented in Fig.4.1a. The figure shows that relative humidity values are high all year round with an average of 80.5% which is typical of equatorial climate. Humidity values naturally exceed 85% during the rainy season under the influence of moisture laden southwesterly. The daily variation of relative humidity is intricate. Usually it is highest in the morning and drops to a low value just before dusk. The drop is very significant during the dry season, as can be seen in the minimum Relative humidity values in the chart. Recorded values during field work ranged from 62% to 75.2% in the Wet Season, and from 70% to 87% in the Dry Season. These measured values did not correlate with the historical data average. The departure of the measured data from the historical values is attributable to the heavy rainfall experienced during the field study in January, 2013.

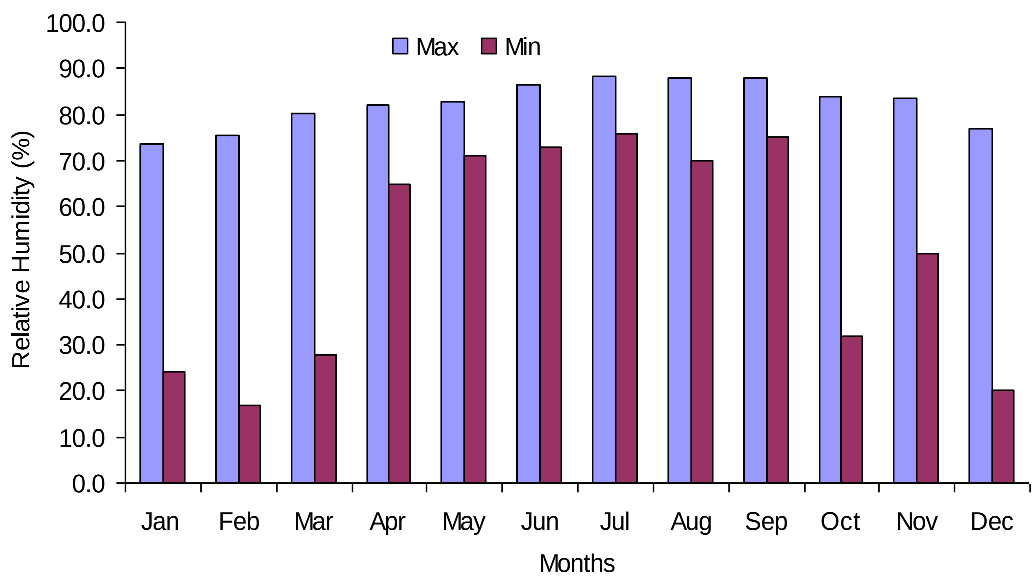

Fig. 4.1a: Average Relative Humidity for Warri Synoptic Station

(Rainfall Source; Nigerian Meteorological Agency, Oshodi, Lagos)

Rainfall

The project area is located within the equatorial belt that experiences rainfall for most of the year. Eleven year historical climatic data covering 1995 to 2006 confirms that rainfall is recorded year round. The average monthly rainfall is presented in Fig.4.1c. The figure, however, shows that over 90% rainfall is recorded between the months of March and November. Rainfall in the area has a typical bimodal distribution which peaks in July, drops slightly in August, rises again in September and drops off. The mean annual rainfall often exceeds 2450 mm.

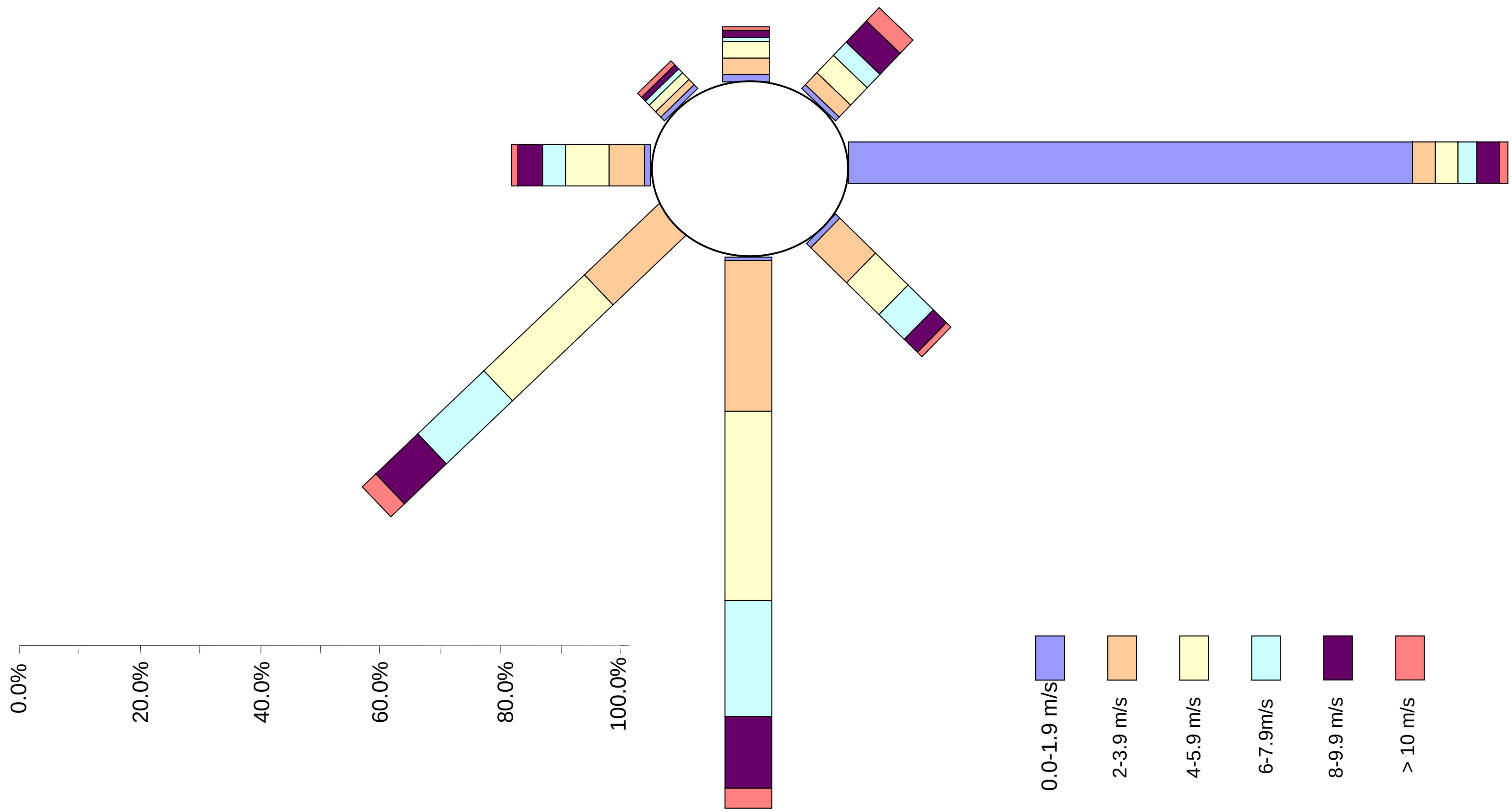

Fig. 4.1b: Wind rose of 11 (1995-2006) year historical data of wind speed and direction for Warri synoptic station

Table 4.2a: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (August. 2012)

Location ID	**Geolocation**		**Temp.**	**Rel. Hum**	**Wind speed**	**Wind Direction**
	Northings	**Eastings**	**^{0}C**	**%**	**m/s**	
AQC1Saghara	186262	303028	31.0	70.0	0.8	South Westerly
AQ1 Saghara	179170	305892	29.8	70.1	1.0	South Westerly
AQ2 Saghara	179858	304966	31.0	72.0	0.8	South Westerly
AQ3 Saghara	179064	304767	28.5	75.2	1.2	South Westerly
AQ4 Saghara	179845	305641	28.5	65.0	1.4	South Westerly
AQ5 Saghara	178429	306884	30.5	66.1	1.2	South Westerly
AQ6 Saghara	177860	304648	28.8	72.0	1.1	South Westerly
AQ7 Saghara	180480	304582	31.5	68.3	1.2	South Westerly
AQ8 Saghara	180652	305985	27.8	62.0	1.2	South Westerly
Mean			29.7	68.97	1.1	

Table 4.2b: Ambient Temperature, Relative Humidity, Wind Speed and wind Direction within the Study Fields (January. 2013)

Location ID	**Geolocation**		**Temp.**	**Rel. Hum**	**Wind speed**	**Wind Direction**
	Northings	**Eastings**	**^{0}C**	**%**	**m/s**	
AQC1Saghara	186262	303028	31.0	70.0	0.8	North Easterly
AQ1 Saghara	179170	305892	33.8	78.1	1.6	North Easterly
AQ2 Saghara	179858	304966	34.0	81.0	1.6	North Easterly
AQ3 Saghara	179064	304767	33.8	85.5	1.1	North Easterly
AQ4 Saghara	179845	305641	34.6	80.4	1.1	North Easterly
AQ5 Saghara	178429	306884	30.5	81.5	1.4	North Easterly
AQ6 Saghara	177860	304648	35.0	87.0	2.0	North Easterly
AQ7 Saghara	180480	304582	33.5	81.8	1.3	North Easterly
AQ8 Saghara	180652	305985	34.8	82.5	1.2	North Easterly
Mean			33.4	80.87	1.34	

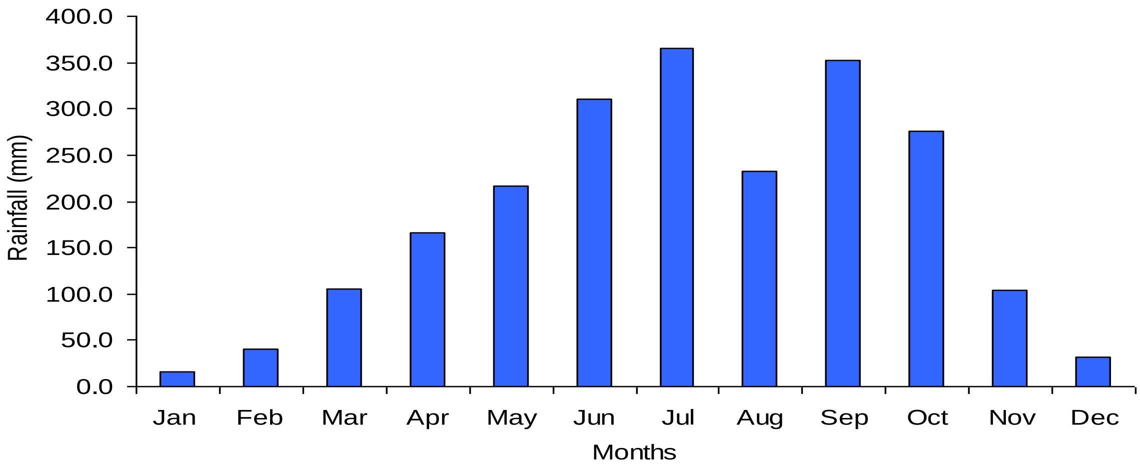

Fig. 4.1c: Average Monthly Rainfall distribution for Warri Synoptic Stations
(Source; Nigerian Meteorological Agency, Oshodi, Lagos)

Temperature
Fig. 4.1d shows the 10-year average maximum, minimum and the mean monthly temperatures for the project area. Temperatures are usually high and vary little year round which is typical of the equatorial belt. The mean temperature for the hottest months February/March was 34^{o}C while that of the coolest month (August) was 28^{o}C. The average temperature difference between the hottest and coolest months was about 3^{o}C while the mean daily temperatures variation was over twice that (at about 6.5^{o}C). Air Temperatures recorded during the field work (Tables 3.2.1a, b), were between 28.5 ^{o}C and 31.5^{o}C for the Wet Season, 30.5 ^{o}C and 35 ^{o}C for the Dry Season. Most of the readings were taken between 10.00 am and 5.00 pm when daily temperatures are at their highs. These temperatures are typical of this region during this period of the year. As expected for a tropical climate, high atmospheric temperatures were measured at all the sampling locations.

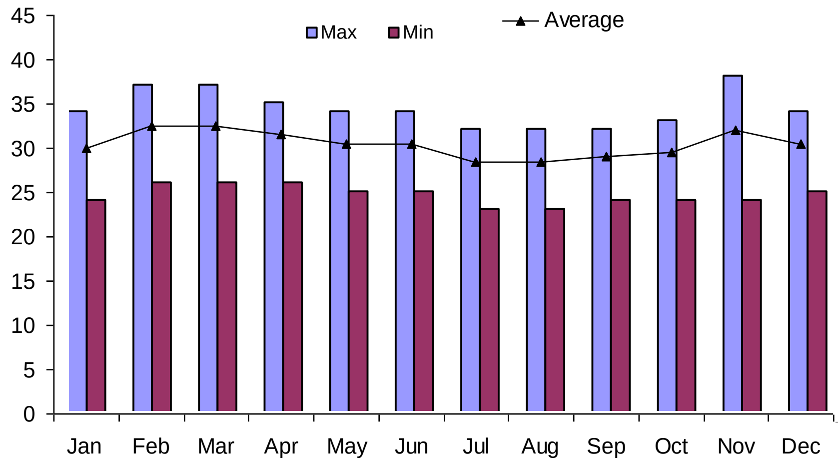

Fig. 4.1d: Average Monthly Temperatures for Warri Synoptic Station
(Source; Nigerian Meteorological Agency, Oshodi, Lagos)

4.6: Air Quality and Noise

The following air pollution parameters were monitored during field work:

(a) Noise level
(b) Total Suspended Particulates (TSP)
(c) Suspended Particulate Matter (SPM)
(d) Nitrogen Dioxide (NO_2)
(e) Carbon Monoxide (CO)
(f) Sulphur Dioxide (SO_2)
(g) Ammonia (NH_3)
(h) Volatile Organic Compounds (VOC/HCs)
(i) Methane (CH_4)
(j) Hydrogen Sulphide (H_2S)

Sampling Points

Selection of the sampling points was based on the following criteria:

(a) Accessibility
(b) Location of sensitive or vulnerable receptors (Communities) relative to the location of the facilities.
(c) Security of the operating staff and equipment.

The observed noise and air quality conditions at the study points are shown in Tables 4.2c and Table 4.2d for Wet and Dry Seasons respectively.

Table 4.2c: Measured Air Quality/Noise Parameters at the Monitoring Points (August, 2012 - Wet Season)

Location ID	Geolocation		Noise level	SPM	TSP	Air Quality ppm						
	Northings	Eastings	dB(A)	ug/m^3		NO_x	SO_x	CO	H_2S	NH_3	CH_4	VOC
AQ1 Saghara	305892	179170	62.8	1.02	1.38	0.09	0.01	1.68	0.01	0.01	0.01	1.80
AQ2 Saghara	304966	179858	56.1	1.20	1.65	0.07	0.01	2.03	0.01	0.01	0.01	7.70
AQ3 Saghara	179064	304767	55.0	1.23	1.61	0.04	0.12	1.34	0.01	0.01	0.01	0.70
AQ4 Saghara	305641	179845	56.2	0.74	1.12	0.07	0.01	1.99	0.01	0.01	0.01	11.4
AQ5 Saghara	306884	178429	65.2	0.62	0.98	0.04	0.01	4.54	0.01	0.01	0.01	1.60
AQ6 Saghara	177860	304648	58.0	0.80	1.04	0.06	0.20	1.18	0.01	0.01	0.01	1.02
AQ7 Saghara	304582	180480	60.0	1.12	1.46	0.06	0.01	1.84	0.01	0.01	0.01	2.10
AQ8 Saghara	305985	180652	48.5	0.86	1.04	0.08	0.01	1.99	0.01	0.01	0.01	6.90
AQC1 Saghara	303028	186262	54.0	1.62	2.00	0.23	0.09	0.23	0.01	0.01	0.01	6.20
Field means			**57.3**	**1.02**	**1.36**	**0.08**	**0.05**	**1.87**	**0.01**	**0.01**	**0.01**	**4.38**
FMEnv Giudelines & Standards			90		250	0.04-0.06	0.010.10	10 - 20	0.006	0.29	-	-
DPR Giudelines & Standards					60-90	0.06	0.04-0.06	10	-	-	-	-
WHO Giudelines & Standards				100-150	150-230	0.08 0.11*	0.175*	10				

***=10minutes Sampling time, ** = 1 hr Sampling time**

Table 4.2d: Measured Air Quality/Noise Parameters at the Monitoring Points (January, 2013 - Dry Season)

Location ID	Geolocation		Noise level	SPM	TSP	Air Quality (ppm)						
	Northings	Eastings	dB(A)	ug/m^3		NO_x	SO_x	CO	H_2S	NH_3	CH_4	VOC
AQ1 Saghara	305892	179170	58.9	14.06	26.10	0.200	0.01	2.18	0.01	0.01	2.04	10.57
AQ2 Saghara	304966	179858	61.0	22.14	30.01	0.068	0.02	2.33	0.01	0.01	0.01	11.92
AQ3 Saghara	304767	179064	58.6	18.36	26.40	0.064	0.03	2.28	0.01	0.01	0.01	14.64
AQ4 Saghara	305641	179845	56.1	11.89	23.08	0.064	0.29	2.69	0.01	0.01	0.01	16.22
AQ5 Saghara	306884	178429	68.5	34.10	55.02	0.062	0.01	5.40	0.01	0.01	0.01	21.46
AQ6 Saghara	304648	177860	62.0	24.60	49.34	0.048	0.01	4.68	0.01	0.01	0.01	18.52
AQ7 Saghara	304582	180480	68.0	13.89	18.14	0.079	0.060	0.01	0.01	0.01	3.00	12.01
AQ8 Saghara	305985	180652	62.0	9.56	14.09	0.090	0.160	0.01	0.01	0.01	4.00	9.54
AQC1 Saghara	303028	186262	68.4	12.16	22.6	0.26	0.11	0.33	0.01	0.01	0.01	16.20

Location ID	Geolocation		Noise level	SPM	TSP	Air Quality (ppm)						
	Northings	Eastings	dB(A)	ug/m^3		NO_x	SO_x	CO	H_2S	NH_3	CH_4	VOC
Field means			**62.6**	**17.86**	**29.4**	**0.10**	**0.098**	**2.84**	**0.01**	**0.01**	**1.01**	**14.56**
FMEnv Giudelines & Standards			90		250	0.04-0.06	0.010.10	10 - 20	0.006	0.29	-	-
DPR Giudelines & Standards					60-90	0.06	0.04-0.06	10	-	-	-	-
WHO Giudelines & Standards				100-150	150-230	0.08 0.11**	0.175*	10				

*=10minutes Sampling time, ** = 1 hr Sampling time

Total Suspended Particulates (TSP) and Suspended Particulate Matter (SPM)

These two terminologies are often used interchangeably, but there is some subtle difference as reflected in Tables 4.2c and Table 4.2d. It appears to be a matter of size. Tiny airborne particles or aerosols that are less than 100 micrometers are collectively referred to as Total Suspended Particulates (TSP). These particles constantly enter the atmosphere from many sources, see Fig.4.1e. Suspended Particulate Matter (SPM) on the other hand, constitute the sum of all solid and liquid particles suspended in air, ranging in size from 0.1 micrometer to about 30 micrometer in diameter, many of which are hazardous. This complex mixture contains for instance dust, pollen, soot, smoke, and liquid droplets.

Ambient particulate matter is responsible for harmful effects on health, even in the absence of other air pollutants. Both fine and coarse particles have been shown to affect health, in particular the respiratory system. Fine particles are more dangerous than coarse particles. Apart from the size of the particles, other specific physical, chemical, and biological characteristics that can influence harmful health effects include the presence of metals, PAHs, other organic components, or certain toxins.

The results in Tables 4.2c and Table 4.2d, show negligible levels of particulates at all sampled points (compared to National and WHO limits in Tables 4.2c and Table 4.2d). SPM ranged from 0.62-1.62 µg/m^3 in the Wet Season to 9.56-34.10 µg/m^3 in the Dry Season, whereas TSP ranged from 0.98-2.0 µg/m^3 in the Wet Season to 14.09-55.02 µg/m^3 in the Dry season. These ranges were well within Regulatory Limits, indicating the receiving atmospheric environment had not been compromised by the flowstation operations.

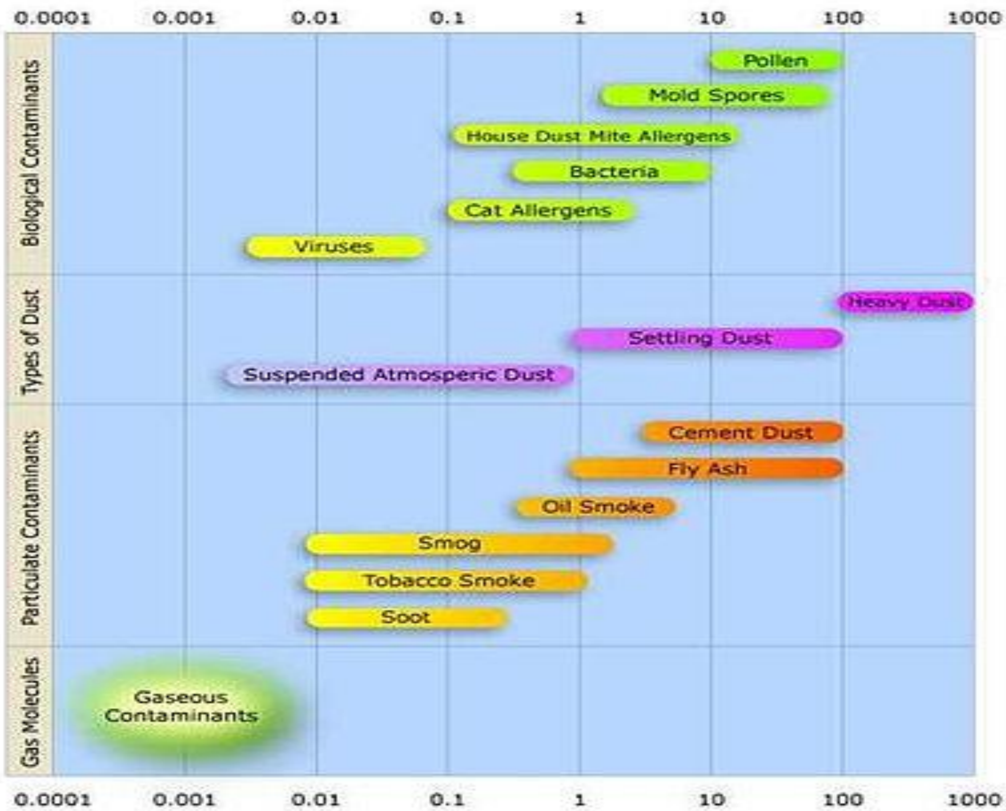

Fig.4.1e: Diagram showing the size distribution in micrometres of various types of atmospheric particulate matter. It also shows the different types of particulates in the atmosphere (Source: *Wikipedia*)

Sulphur Dioxide (SO_2)

In discussing air quality results, one must be mindful of the *averaging sampling time.* Much higher concentrations are tolerable over shorter averaging time, like 10 minutes used in this study, than longer averaging times stipulated in the Regulatory Standards. For this reason, the WHO (2005) stated that *"controlled studies with exercising asthmatics indicate that some asthmatics experience changes in pulmonary function and respiratory symptoms after periods of exposure as short as 10 minutes. Based on this evidence, it is recommended that a value of 500 $\mu g/m^3$ (0.175 ppm) for SO_2 should not be exceeded over averaging period of 10 minutes."* On the basis of the WHO Guideline, it can be deduced that the SO_2 concentration of 0.2 ppm measured at AQ6 during the wet season, and 0.29 ppm measured at AQ4 during the dry season, are non-compliant with National and International limits. This sampling point AQ4 is about 400 meters North East and downwind of Saghara Flowstation and may have been influenced by the exhaust emissions from internal combustion engines. Fortunately, there is no Community within 2 km of this sampling point.

Nitrogen Dioxide (NO_2)

Many chemical species of nitrogen oxides (NOx) exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide (NO_2), Nitrous Oxide, N_2O being a major contributor to global atmospheric warming potential. On a global scale, emissions of nitrogen oxides from natural sources far outweigh those generated by human activities. Natural sources include intrusion of stratospheric nitrogen oxides, bacterial and volcanic action, and lightning. Because natural emissions are distributed over the entire surface of the earth, however, the resulting background atmospheric concentrations are very small. The major source of anthropogenic emissions of nitrogen oxides into the atmosphere is the combustion of fossil fuels in stationary sources, (gas flares, heating, power generation) and in motor vehicles (internal combustion engines).

Results in Table 4.2c and Table 4.2d show that concentrations at sampling points AQ1 (0.20 ppm, Dry Season) and AQC1 (0.23 ppm, Wet Season), were above the Regulatory Daily Hourly Range of 0.04-0.06 ppm. Given that the measured concentrations were averaged over a period less than 5 minutes, these values do not necessarily translate to non-compliance, because a 15-minute concentration of 2716 $\mu g/m^3$ (1.44 ppm) was recorded for a home with an unvented gas space heater, without any detectable negative health effect (Koontz *et.al*. 1988). However, such exceedances should be of concern because even though averaging times were short, it is probable that such conditions could remain for much longer periods. This same observation is also applicable to comments made on SO_2 above. Although no host communities are within 2 km of Saghara Flowstation, if these concentrations persist for longer periods, they could pose occupational health hazards for SPDC staff.

Noise

The baseline outdoor noise levels within and around the proposed project areas are shown in Table 4.2c and Table 4.2d. Noise level measurements were made at the same points as air quality. A mean noise range of 48.5 – 65.2 dB(A) was measured in the Wet Season and 56.1 – 62.6 dB(A) in the Dry Season. Noise levels were generally higher in the Dry Season, than in the Wet Season, as would be expected, due to higher ambient temperatures and outdoor activities during the Dry Season. All noise measurements were within the Regulatory Guideline of 90 dB(A).

Table 4.2e: Summary Comparison of the Mean Field Concentrations of Air Quality Indicators

PARAMETER	Saghara Dry Season Field Mean (Jan, 2013)	Saghara Field Wet Season Field Mean (Aug, 2012)	FMEnv	DPR
SPM [ug/m^3]	18.6	1.02	250.0	150.0 – 230.0
TSP [ug/m^3]	30.3	1.36		
SO_x (as SO_2) [ppm]	0.11	0.05	0.1	0.04 – 0.06
NO_x (as NO_2) [ppm]	0.08	0.08	0.04 – 0.06	0.08
CO [ppm]	3.26	1.87	10.0	26.0
H_2S [ppm]	0.01	0.01	0.006`	-
CH_4 ppm	1.14	0.01	-	-
VOC ppm	14.36	4.38	-	-
CO_2 ppm	-	-	-	-
NH_3 [ppm]	0.01	0.01	0.29	-
Noise [dBA]	62.6	57.3	90	-

Table 4.2e shows comparison of the results for the Wet and dry seasons. As would be expected, owing to temperature effect, all the measured parameters were higher in the dry season, than in the wet season.

Table 4.2f: Nigerian Ambient Air Quality Standard

Pollutants	Time of Average	Limit
Particulates	Daily average of hourly values 1hr.	250 µg/m^3 600* µg/m^3
SO_x as SO_2	Daily average of hourly values 1 hour Daily average of 3 hourly values	0.01 ppm (26 µg/m^3) 0.1 ppm (260 µg/m^3)
NO_x as NO_2	Daily average of hourly values (range)	0.04 - 0.06 ppm (75 - 113 µg/m^3)
Carbon Monoxide	Daily average hourly values (range)	10 - 20 ppm (11.4 - 22.8 µg/m^3)
Petrochemical Oxidants		0.06 ppm
Non - Methane Hydrocarbon	Daily average of 8 - hourly values	160 µg/m^3

*Note: Concentrations not to be exceeded for more than once a year.

Table 4.2g: World Health Organization (WHO) Guidelines for Maximum Exposure to the major pollutants and some possible effects if these recommendations are exceeded

Pollutant	Possible Effects	WHO Guidelines
Sulphur dioxide (SO_2)	Worsening respiratory illness from short term exposure, increased respiratory symptoms, including chronic bronchitis, from long-term exposures	40-50 µg/m^3 (annual mean); 100-150 µg/m^3 (Daily average)
Suspended Particulate Matter (SPM)	Pulmonary effects are associated with the combined exposure to SPM and SO_2	Black: 40-60 µg/m^3 (Annual mean). 100-150 µg/m^3 (Daily average) Total SPM: 60-150 µg/m^3 (Annual mean); 150-230 µg/m^3 (Daily average)
Nitrogen dioxide (NO_2)	Effects on lung function in persons suffering from asthma from short-term exposures	150 µg/$m^3$for 24 hr mean; 400 µg/m^3: Not to be exceeded
Carbon Monoxide (CO)	Reduced oxygen - carrying capacity of blood	10 µg/m^3 (for 8 hr); not to be exceeded.

Source: WHO Air Quality Guidelines for Europe 2010

Table 4.2h: Natural Atmospheric Concentration of Some Greenhouse gases

Gases	Concentrations
CO_2	340 ppmv
CH_4	2 ppm v
N_2O	0.3 ppm v
CO	0.05 - 0.2 ppmv
O_3	0.2 –10 ppmv
NH_3	4 ppbv
NO_2	1 ppbv
SO_2	1 ppbv
H_2S	0.05 ppbv

Source: Andersen-Sellers & Robinson (1986)

Notes: ppmv = parts per million by volume, ppbv = parts per billion by volume

Table 4.2i: Evolution of Atmospheric Concentrations of Key Greenhouse gases influenced by Human Activities

Parameter	CO_2	CH_4	N_2O
Pre-industrial atmospheric concentration (1750 - 1800)	280 ppmv	0.7 ppmv	270 ppbv
Current atmospheric concentration 2010	388.5 ppmv	1.87 ppmv	323 ppbv
Current rate of annual atmospheric accumulation	1.8 ppmv (0.5%)	0.015 ppmv (0.9%)	0.8 ppbv (0.25%)
Atmospheric life time (years)	(50 - 200)	10	150

Source: IPCC 2011

Tables 4.2c – 4.2i show the Nigerian Ambient Air Quality Standard, WHO Noise Exposure Guidelines, Natural Atmospheric Concentration of Some Greenhouse Gases and the Evolution of Atmospheric Concentrations of Key Greenhouse Gases influenced by Human Activities.

4.7: Soil and Land Use

4.7.1: Soil quality

Soil Physical and Chemical Characteristics

Both physicochemical and microbiological characteristics of the soil of Saghara field were carried out over two seasons (wet and dry) and at two strata (0-15 cm and 15-30 cm). Ten surface and subsurface samples were collected including control. Results of the field and laboratory analysis are presented in Tables 4.3a and 4.3b for the dry and wet season respectively. A summary of the wet and dry season results along with the DPR target and intervention values is presented in Table 4.3c. During the dry season, pH ranged from 2.89 – 6.52 with a mean of 4.94 at the surface, which was not significantly different from the subsurface values ranging from 2.86 – 6.53 with a mean of 4.69. The control had a pH of 4.77 at the surface and 5.29 at the subsurface. Similar trend was observed in the wet season where the soil pH was also acidic. The pH ranged from 2.6 – 5.7 with a mean of 4.69 at the surface, but at the subsurface it ranged from 2.3 – 6.2 with a mean of 4.63. The control station had a pH of 4.7 and 3.9 at the surface and subsurface respectively. The results show that the soil of the study area is generally acidic, the subsoil being slightly more acidic than the top soil. The pH exhibited little seasonal variation, being slightly more acidic during the wet season. Acidic pH is not unusual in mangrove ecosystems of the world including the Niger Delta (Anderson 1966, van Breemen, 1996; Ohimain 2004, Ohimain *et al.* 2004).

During, the dry season, exchangeable acidity (EA) ranged from 0.4 – 4.2 meq/100g (mean = 2.01 meq/100g) at the soil surface and 0.1 – 2.8 meq/100g (mean = 1.38 meq/100g) at the subsurface. The dry season control had EA of 1.0 meq/100g at the surface and 0.5 meq/100g at the subsurface. During the wet season, EA ranged from 1.3 – 7.8 meq/100g with a mean of 3.04

meq/100g at the surface soil, and 0.8 – 6.4 meq/100g with a mean of 2.24 at the subsurface. The control sample had an EA of 2.0 meq/100g at the surface and 1.7 meq/100g at the subsurface. With these results, EA was slightly higher at the soil subsurface than surface and slightly higher during the wet than dry season. Typical values for exchangeable acidity normally range from 0.5 meq/100g to 1.5 meq/100g. The results obtained in both seasons fell within this range. Exchangeable cations analyzed in the soil include sodium, potassium, magnesium and calcium. During the dry season, Na ranged from 9.40 – 15.58 meq/100g with a mean of 11.92 meq/100g at the soil surface and 7.73 – 13.03 meq/100g with a mean of 10.84 meq/100g at the subsurface. The sodium concentration in the control was 9.9 meq/100g at the surface and 5.8 meq/100g at the subsurface. The concentration of K ranged from 4.75 – 9.41 meq/100g with a mean of 8.01 meq/100g at the surface, whereas at the subsurface it was 3.9 – 9.28 meq/100g with a mean of 7.06 meq/100g. The control had a K concentration of 8.07 meq/100g and 4.14 meq/100g at the surface and subsurface strata respectively.

Calcium ranged from 10.46 – 17.33 meq/100g with a mean of 13.46 meq/100g at the surface and 9.02 – 15.16 meq/100g with a mean of 12.582 meq/100g at the subsurface. The Ca concentration of samples collected from the control was 13.3 meq/100g and 8.55 meq/100g at the surface and subsurface strata respectively. The Mg content of the soil ranged from 8.07 – 14.9 meq/100g with a mean of 10.56 meq/100g at the surface and 8.48 – 13.24 meq/100g with a mean of 10.36 meq/100g at the subsurface strata. The control had Mg concentration of 10.94 meq/100g and 6.3 meq/100g at the surface and subsurface respectively. During the wet season, Na ranged from 0.24 – 5.83 meq/100g with a mean of 1.51 meq/100g at the soil surface and 0.25 – 5.79 meq/100g with a mean of 1.55 meq/100g at the subsurface. The sodium concentration in the control was 0.94 meq/100g at the surface and 0.54 meq/100g at the subsurface. The concentration of K ranged from 0.49 – 2.31 meq/100g with a mean of 1.36.meq/100g at the surface, whereas at the subsurface it was 0.44 – 2.45 meq/100g with a mean of 1.55 meq/100g. The control had a K concentration of 2.03 meq/100g and 2.34 meq/100g at the surface and subsurface strata respectively. Calcium ranged from 3.56 – 8.45 meq/100g with a mean of 4.86 meq/100g at the surface and 2.31 – 8.40 meq/100g with a mean of 4.44 meq/100g at the subsurface. The Ca concentration of samples collected from the control was 5.51 meq/100g and 4.92 meq/100g at the surface and subsurface strata respectively.

The Mg content of the soil ranged from 1.24 – 3.68 meq/100g with a mean of 2.23 meq/100g at the surface and 1.2 – 3.58 meq/100g with a mean of 1.84 meq/100g at the subsurface. The control had Mg concentration of 1.98 meq/100g and 1.3 meq/100g at the surface and subsurface respectively. Among the cations, calcium was dominant followed by sodium and magnesium, while the potassium was the least. Sodium, calcium, magnesium and potassium in the dry season were about 5-10 times higher than that of the wet season. Also, the surface soil samples were slightly higher than the subsurface samples. These spatial and seasonal variations are expected due to the combined effects of rainfall and evaporation.

Table 4.3a: Physicochemical properties of Saghara soil during the dry season

S/N	Parameters	Units	Level	SAG	SAG	SAG	SAG	SAG	SAG	SAG	SAG	SAG	MIN	MAX	MEAN	Control
			Cm	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS10	SS11				
1	pH		0-15	4.86	5.64	4.95	6.52	5.47	4.66	4.65	2.89	4.84	2.89	6.52	4.942	4.77
			15-30	4.63	5.66	4.19	6.53	3.58	4.71	5.25	2.86	4.79	2.86	6.53	4.689	5.29
2	EC	µS/cm	0-15	570	1440	3240	730	7750	1340	1390	19240	9770	570	19240	5052.222	12510
			15-30	220	440	6490	620	1680	940	900	18350	12930	220	18350	4730.000	2710
3	Org. C	%	0-15	2.02	0.86	5.35	1.04	1.3	3.26	5.2	5.35	4.15	0.86	5.35	3.170	3.89
			15-30	1.46	0.43	5.04	0.38	0.53	3.07	4.82	5.21	3.6	0.38	5.21	2.727	3.47
4	Total N.	%	0-15	0.24	0.1	0.64	0.06	0.16	0.39	0.62	0.64	0.5	0.06	0.64	0.372	0.39
			15-30	0.18	0.05	0.6	0.05	0.06	0.37	0.58	0.63	0.43	0.05	0.63	0.328	0.42
5	Na	meq/100g	0-15	12.8	11.8	9.4	13.18	10.17	11.7	11.9	15.58	10.71	9.4	15.58	11.916	9.9
			15-30	11.52	11.74	7.73	11.95	10.1	9.58	11.42	13.03	10.53	7.73	13.03	10.844	5.8
6	K	‘’	0-15	9.14	8.51	4.75	9.41	9.36	8.23	9.07	7.16	7.09	4.75	9.41	8.080	8.07
			15-30	8.22	8.38	3.9	8.53	7.36	3.9	8.15	9.28	5.86	3.9	9.28	7.064	4.14
7	Ca	‘’	0-15	15.5	13.06	10.46	15.6	12.09	12.91	12.1	17.33	12.12	10.46	17.33	13.463	13.3
			15-30	14.1	12.43	9.02	14.38	11.02	10.27	15.16	15.15	11.71	9.02	15.16	12.582	8.55
8	Mg	‘’	0-15	13.08	9.41	8.07	12.04	9.01	8.74	8.28	14.9	11.5	8.07	14.9	10.559	10.94
			15-30	12.56	9.01	8.81	10.53	8.48	9.83	13.24	10.82	9.93	8.48	13.24	10.357	6.3
9	EA	‘’	0-15	3.1	2	1.7	0.4	1.6	1	4.2	2.4	1.7	0.4	4.2	2.011	1
			15-30	2.8	1.4	0.9	0.1	0.9	0.4	2.8	2.1	1	0.1	2.8	1.378	0.6
10	Cl^-	mg/kg	0-15	154	146	705	142	127	112	117	125	102	102	705	192.222	3540
			15-30	109	119	570	98	107	104	107	116	74	74	570	156.000	2700
11	PO_4	‘’	0-15	33.6	33.1	25.4	37.7	36.4	26.9	27	35.5	45	25.4	45	33.400	24.9
			15-30	22.3	30.9	24.7	35.1	33.3	25.5	26.3	34.5	44	22.3	44	30.733	23.4
12	NH_4N	‘’	0-15	6.9	2.8	4.1	3.3	2.2	4.7	3.8	6.9	26	2.2	26	6.744	6.1
			15-30	6.5	1.6	3.6	3.1	1.3	2.6	2.5	5.7	21	1.3	21	5.322	5.3

S/N	Parameters	Units	Level Cm	SAG SS1	SAG SS2	SAG SS3	SAG SS4	SAG SS5	SAG SS6	SAG SS7	SAG SS10	SAG SS11	MIN	MAX	MEAN	Control
13	**NO_2^-N**	‘’	0-15	11.5	7.2	7.6	8.4	7.2	7.5	9.9	10.4	6.3	6.3	11.5	8.444	9.1
			15-30	4.8	3	5.6	6.4	3.2	3.2	8.3	7.9	3.4	3	8.3	5.089	4.6
14	**NO_3^-N**	‘’	0-15	13.6	9.9	9.6	10.9	8	10.3	11	12.7	7.7	7.7	13.6	10.411	10.7
			15-30	6.1	3.9	7.6	7.8	4.3	5.2	10.6	9.1	6.6	3.9	10.6	6.800	5.8
15	**SO_4**	‘’	0-15	207	112	640	98	176	210	360	680	1118	98	1118	400.111	2402
			15-30	118	320	506	84	124	180	264	607	1112	84	1112	368.333	2310
16	**Silt**	**%**	0-15	2.8	2.3	2.5	2.8	2.9	3.4	2.5	2.3	2	2	3.4	2.611	2.6
			15-30	3	2.6	2.7	3	4.4	3.6	3.7	2.5	3	2.5	4.4	3.167	3.4
17	**Clay**	‘’	0-15	9.3	6.8	5.1	6.5	6.9	5.8	6.1	5.5	5	5	9.3	6.333	7.2
			15-30	7.7	4.3	6.7	6.1	5.2	5.3	5.9	5.2	5.3	4.3	7.7	5.744	6.5
18	**Sand**	‘’	0-15	89.9	90.9	92.4	90.7	90.2	90.8	91.4	92.2	93	89.9	93	91.278	90.2
			15-30	89.3	93.1	90.6	90.9	90.4	91.1	90.4	92.3	91.7	89.3	93.1	91.089	90.1
19	**THC**	**mg/kg**	0-15	77.9	31.6	23.2	65.8	33.7	27.9	77.4	85.9	76.8	23.2	85.9	55.578	16.3
			15-30	63.2	11.6	15.3	64.2	25.3	19.5	69.5	77.9	72.6	11.6	77.9	46.567	14.7
20	**TPH**	‘’	0-15	0.053	0.061	0.046	0.062	0.143	0.161	0.129	0.08	0.113	0.046	0.161	0.094	0.033
			15-30	0.044	0.042	0.039	0.049	0.091	0.119	0.12	0.079	0.095	0.039	0.12	0.075	0.024
21	**PAH**	‘’	0-15	0.031	0.049	0.011	0.031	0.092	0.092	0.061	0.071	0.102	0.011	0.102	0.060	0.018
			15-30	0.025	0.021	0.007	0.022	0.089	0.072	0.054	0.068	0.086	0.007	0.089	0.049	0.012
22	**Benzene**	**µg/kg**	0-15	0.006	0.004	0.006	0.007	0.006	0.007	0.005	0.004	0.005	0.004	0.007	0.006	0.002
			15-30	0.002	0.003	0.002	0.002	0.004	0.004	0.003	0.003	0.004	0.002	0.004	0.003	ND
23	**Toluene**	‘’	0-15	0.003	ND	ND	0.002	ND	0.003	ND	ND	ND	0.002	0.003	0.003	ND
			15-30	0.002	ND	ND	0.001	ND	0.001	ND	ND	ND	0.001	0.002	0.001	ND
24	**Ethylbenzene**	‘’	0-15	0.002	ND	ND	ND	ND	ND	ND	ND	ND	0.002	0.002	0.002	ND
			15-30	0.001	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.001	0.001	ND
25	**Xylene**	‘’	0-15	0.004	0.002	0.003	0.004	0.003	0.003	0.001	0.002	0.005	0.001	0.005	0.003	0.003

S/N	Parameters	Units	Level Cm	SAG SS1	SAG SS2	SAG SS3	SAG SS4	SAG SS5	SAG SS6	SAG SS7	SAG SS10	SAG SS11	MIN	MAX	MEAN	Control
			15-30	0.003	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.003	0.001	0.003	0.002	0.001
26	**Phenol**	‘’	0-15	0.003	0.003	0.003	0.003	0.003	0.004	0.001	0.004	0.002	0.001	0.004	0.003	0.003
			15-30	0.001	0.001	0.002	0.002	0.001	0.003	0.001	0.002	0.001	0.001	0.003	0.002	0.001
	Fe	**mg/kg**	0-15	98.8	129.1	130.7	133	133.6	126.8	102.6	129.2	127.9	98.8	133.6	123.52	128.3
			15-30	98.8	129.2	130.1	155.8	132.5	132.2	101.1	117.8	113.4	98.8	155.8	123.43	121.3
	Cu	“	0-15	12.2	20.6	4.2	16	7.4	4.8	15.3	12.5	16.6	4.2	20.6	12.18	18.4
			15-30	20.6	19.5	3.1	11.1	7.6	4.2	14.9	43	14.3	3.1	43	15.37	14.1
	Mn	“	0-15	19.3	11.8	16.1	14.4	15	16.3	57.9	26.4	16.3	11.8	57.9	21.50	15.4
			15-30	8.4	11.6	16	17.8	16.2	15.5	56.8	8	10.2	8	56.8	17.83	11.1
	Zn	“	0-15	20.3	10.2	14	12.9	14	15.1	17.5	13.6	19.7	10.2	20.3	15.26	15.7
			15-30	14.6	9.6	14.8	11.5	14.4	15.4	16.9	15	14.3	9.6	16.9	14.06	10.6
	Cd	“	0-15	0.48	0.19	0.14	0.13	0.19	0.08	0.67	0.3	0.38	0.08	0.67	0.28	0.28
			15-30	0.55	0.17	0.14	0.12	0.23	0.1	0.65	0.17	0.17	0.1	0.65	0.26	0.16
	Cr	“	0-15	ND	ND	1.36	ND	1.33	1.32	0.81	1.2	1.37	0.81	1.37	1.23	1.35
			15-30	0.06	ND	1.37	ND	1.38	1.33	0.77	ND	0.09	0.06	1.38	0.83	0.02
	Pb	“	0-15	9	12.6	2.6	16.4	8.6	8.3	14.9	13.7	15.8	2.6	16.4	11.32	13.6
			15-30	26.2	12.4	1.7	19.9	10.1	7.6	14.2	13.3	13.1	1.7	26.2	13.17	12.8
	Ni	“	0-15	11.1	3.4	2.9	3	3.2	2.2	15.6	7	1.1	1.1	15.6	5.50	2.4
			15-30	12.7	3.9	3.3	2.8	3.1	2.3	14.9	4	0.6	0.6	14.9	5.29	1.1
	V	“	0-15	9.6	2.9	2.4	2.6	2.8	2	13.4	6.2	0.9	0.9	13.4	4.76	0.5
			15-30	10.8	3.4	3	2.4	2.7	2.1	12.9	3.5	3	2.1	12.9	4.87	3.2
	Hg	“	0-15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
			15-30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Ba	“	0-15	0.007	0.005	0.004	0.008	0.004	0.005	0.005	0.004	0.004	0.004	0.008	0.01	0.004
			15-30	0.004	0.001	0.003	0.005	0.002	0.003	0.003	0.005	0.003	0.001	0.005	0.00	0.002

Table 4.3b: Physicochemical properties of Saghara soil during the wet season

Param.	Units	Level	SAG SS1	SAG SS2	SAG SS3	SAG SS4	SAG SS5	SAG SS6	SAG SS7	SAG SS10	SAG SS11	MIN	MAX	MEAN	control
pH		0-15	5.5	4.4	4.7	4.1	2.6	5.6	5.7	4.8	4.8	2.6	5.7	4.69	4.7
		15-30	5.4	3.6	6.2	4.8	2.3	5.1	5.2	5.3	3.8	2.3	6.2	4.63	3.9
EC	**µS/cm**	0-15	700	610	770	780	3010	270	370	2670	2030	270	3010	1245.56	2050
		15-30	800	630	730	610	2990	510	520	2630	1900	510	2990	1257.78	2100
Org. C	**%**	0-15	1.53	3.74	0.93	3.74	5.8	1.46	1.51	1.56	3	0.93	5.8	2.59	3.5
		15-30	1.44	2.96	0.52	3.68	5.44	1.34	1.44	1.08	2.45	0.52	5.44	2.26	2.49
Total N.	**%**	0-15	0.3	0.78	0.19	0.75	1.18	0.3	0.65	0.3	0.58	0.19	1.18	0.56	0.6
		15-30	0.32	0.58	0.04	0.64	1.11	0.28	0.31	0.21	0.47	0.04	1.11	0.44	0.51
Na	**meq/100g**	0-15	1.63	0.72	0.64	2.52	0.24	0.53	0.67	5.83	0.82	0.24	5.83	1.51	0.94
		15-30	1.61	1.29	0.56	2.61	0.25	0.54	0.61	5.79	0.71	0.25	5.79	1.55	0.54
K	‘’	0-15	0.98	0.87	0.79	1.57	0.49	1.57	1.63	2.03	2.31	0.49	2.31	1.36	2.03
		15-30	1.01	2.45	0.75	1.59	0.44	1.55	1.9	2.01	2.28	0.44	2.45	1.55	2.34
Ca	‘’	0-15	4.23	3.68	3.67	5.64	3.56	4.51	4.6	8.45	5.43	3.56	8.45	4.86	5.51
		15-30	4.2	2.31	3.28	4.58	4.58	3.64	4.1	8.4	4.89	2.31	8.4	4.44	4.92
Mg	‘’	0-15	1.98	2.9	2.45	2.36	1.24	1.7	1.83	3.68	1.89	1.24	3.68	2.23	1.98
		15-30	1.92	2.2	1.28	1.48	1.78	1.45	1.65	3.58	1.2	1.2	3.58	1.84	1.3
EA	‘’	0-15	1.5	3.4	1.7	1.3	7.8	1.8	1.9	6.5	1.5	1.3	7.8	3.04	2
		15-30	1.2	1.4	1.5	1.1	5.6	0.8	1	6.4	1.2	0.8	6.4	2.24	1.7
Cl^-	**mg/kg**	0-15	266	142	261	281	694	90	95	2560	1953	90	2560	704.67	2100
		15-30	270	149	271	141	690	178	187	2530	1809	141	2530	691.67	1900
PO_4	‘’	0-15	19.2	34	31.6	39.6	48	34	35	29.6	31.2	19.2	48	33.58	32.2
		15-30	16.4	31.2	26.4	27.6	22.8	27.6	28.2	22.8	28	16.4	31.2	25.67	29
NH_4N	‘’	0-15	18.4	18.8	11	19.8	16.8	17.6	17.1	16.4	13.2	11	19.8	16.57	15.4
		15-30	16.8	18	11	19.4	7	12.8	13.1`	5.2	11	5.2	19.4	12.65	12
NO_2^-N	‘’	0-15	2.8	9.2	6.6	9.2	10.4	5.2	6.1	7.6	8	2.8	10.4	7.23	9
		15-30	1	5.6	3.2	8	4.6	4.6	4.5	3.2	4.2	1	8	4.32	4.4

Param.	Units	Level	SAG SS1	SAG SS2	SAG SS3	SAG SS4	SAG SS5	SAG SS6	SAG SS7	SAG SS10	SAG SS11	MIN	MAX	MEAN	control
NO_3^-N	‘’	0-15	5.2	18.2	15.6	19.6	20	8.2	11.1	13.2	16.2	5.2	20	14.14	15.8
		15-30	4	12.6	10.6	18.2	18	3.2	4.1	8.6	9.2	3.2	18.2	9.83	9
SO_4	‘’	0-15	118	920	1428	1845	724	916	940	336	232	118	1845	828.78	261
		15-30	112	840	1114	1706	608	806	810	314	196	112	1706	722.89	201
Silt	**%**	0-15	1.7	3.3	1.4	1.8	3.6	2.1	2.4	2.8	2.3	1.4	3.6	2.38	2.4
		15-30	2.2	2	3	3.4	2	2.3	2.2	3	2.6	2	3.4	2.52	2.5
Clay	‘’	0-15	5.4	9.3	9.7	11.9	6.3	5	6.1	9.3	6.8	5	11.9	7.76	6.9
		15-30	4.9	12.6	10.1	7.4	5.1	3.8	4.2	7.7	4.3	3.8	12.6	6.68	4.4
Sand	‘’	0-15	92.9	87.4	88.9	86.3	90.1	92.9	93.1	87.9	90.9	86.3	93.1	90.04	94.1
		15-30	92.9	85.4	86.9	89.4	92.9	93.9	94.4	89.3	93.1	85.4	94.4	90.91	95.1
THC	**mg/kg**	0-15	76	87.4	51.3	78.4	52.7	51.6	60.2	150.1	70.5	51.3	150.1	75.36	75.5
		15-30	51.3	59.1	40.3	59.6	51.6	35.9	40.4	50.2	60.5	35.9	60.5	49.88	65.2
TPH	‘’	0-15	0.059	0.064	0.046	0.026	0.021	0.032	0.036	0.041	0.051	0.021	0.064	0.04	0.056
		15-30	0.061	0.861	0.05	0.1029	0.026	0.04	0.042	0.046	0.052	0.026	0.861	0.14	0.55
PAH	‘’	0-15	0.078	0.034	0.041	0.027	0.041	0.036	0.043	0.053	0.049	0.027	0.078	0.04	0.51
		15-30	0.072	0.036	0.049	0.031	0.032	0.038	0.044	0.054	0.051	0.031	0.072	0.05	0.53
Benzene	**µg/kg**	0-15	0.002	0	0.002	0.003	0	0.002	0.003	0.005	0.004	0	0.005	0.00	0.004
		15-30	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.001	0.003	0.00	0.001
Toluene	‘’	0-15	ND	ND	ND	ND	ND	ND	ND	ND	ND	0	0	ND	ND
		15-30	ND	ND	ND	ND	ND	ND	ND	ND	ND	0	0	ND	ND
Ethylbenzene	‘’	0-15	ND	ND	ND	ND	ND	ND	ND	ND	ND	0	0	ND	ND
		15-30	ND	ND	ND	ND	ND	ND	0.001	ND	ND	0.001	0.001	ND	ND
Xylene	‘’	0-15	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.003	0.00	0.001
		15-30	0.002	0.001	0.001	0.002	0.002	0.001	0.001	0.003	0.001	0.001	0.003	0.00	0.001
Phenol	‘’	0-15	0.003	0.004	0.002	0.005	0.007	0.002	0.003	0.005	0.002	0.002	0.007	0.00	0.002
	'	15-30	0.002	0.003	0.004	0.004	0.003	0.007	0.006	0.003	0.004	0.002	0.007	0.00	0.003

Param.	Units	Level	SAG SS1	SAG SS2	SAG SS3	SAG SS4	SAG SS5	SAG SS6	SAG SS7	SAG SS10	SAG SS11	MIN	MAX	MEAN	control
Fe	**mg/kg**	0-15	201.6	198.1	200.4	206.9	205.5	195.1	196.9	196.8	196.7	195.1	206.9	199.78	197.1
		15-30	202.9	199.2	201.1	203.3	203.9	203.4	203.5	203.6	204.4	199.2	204.4	202.81	205.3
Cu	"	0-15	1.02	2.54	1.06	3.17	1.86	1.2	1.95	4.16	3.23	1.02	4.16	2.24	3.26
		15-30	1.08	2.4	0.76	2.84	1.9	1.06	2.51	4.18	3.57	0.76	4.18	2.26	3.58
Mn	"	0-15	3.58	3.42	3.49	3.58	3.26	3.37	3.48	3.54	3.4	3.26	3.58	3.46	3.45
		15-30	3.51	3.37	3.47	3.42	3.52	3.43	3.51	3.52	3.39	3.37	3.52	3.46	3.42
Zn	"	0-15	8.64	10.2	10	10.2	9.97	10.8	12.5	14.1	8.18	8.18	14.1	10.51	7.94
		15-30	8.35	9.56	10.6	9.84	10.3	11	13.3	15.5	8.09	8.09	15.5	10.73	7.63
Cd	"	0-15	0.08	0.11	0.14	0.18	0.18	0.07	0.12	0.36	0.07	0.07	0.36	0.15	0.08
		15-30	0.07	0.1	0.14	0.2	0.25	0.13	0.12	0.43	0.05	0.05	0.43	0.17	0.06
Cr	"	0-15	1.5	1.51	1.52	1.57	1.49	1.48	1.54	1.54	1.5	1.48	1.57	1.52	1.52
		15-30	1.54	1.49	1.53	1.56	1.55	1.49	1.51	1.55	1.6	1.49	1.6	1.54	1.64
Pb	"	0-15	1.72	2.54	0.56	3.99	1.87	1.81	2.22	3.44	2.9	0.56	3.99	2.34	2.92
		15-30	1.45	2.61	0.36	2.54	2.17	1.66	2.24	3.62	2.62	0.36	3.62	2.14	2.66
Ni	"	0-15	1.18	0.64	1.06	1.29	1.2	0.81	0.95	0.4	4.59	0.4	4.59	1.35	4.63
		15-30	1.21	0.74	1.21	1.43	1.13	1.02	0.26	0.32	4.51	0.26	4.51	1.31	4.52
V	"	0-15	0.83	0.54	0.87	0.87	0.79	0.71	0.81	0.34	3.18	0.34	3.18	0.99	3.24
		15-30	0.84	0.61	0.84	1.13	0.81	0.91	0.95	0.27	3.55	0.27	3.55	1.10	3.63
Hg	"	0-15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
		15-30	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ba	"	0-15	0.004	0.005	0.001	0.002	0.003	0.001	0.002	0.002	0.005	0.001	0.005	0.00	0.002
		15-30	0.002	0.002	0.004	0.001	0.004	0.002	0.002	0.006	0.004	0.001	0.006	0.00	0.003

Table 4.3c: Summary of Saghara soil physicochemical properties

				Dry Season				Wet season				DPR Intervention Limits
S/N	**Parameters**	**Units**	**Level**	**MIN**	**MAX**	**MEAN**	**control**	**MIN**	**MAX**	**MEAN**	control	
			cm									
1	**pH**		0-15	2.89	6.52	4.942	4.77	2.6	5.7	4.69	4.7	5.5-6.5
			15-30	2.86	6.53	4.689	5.29	2.3	6.2	4.63	3.9	
2	**EC**	**µS/cm**	0-15	570	19240	5052.222	12510	270	3010	1245.56	2050	
			15-30	220	18350	4730.000	2710	510	2990	1257.78	2100	
3	**Org. C**	**%**	0-15	0.86	5.35	3.170	3.89	0.93	5.8	2.59	3.5	
			15-30	0.38	5.21	2.727	3.47	0.52	5.44	2.26	2.49	
4	**Total N.**	**%**	0-15	0.06	0.64	0.372	0.39	0.19	1.18	0.56	0.6	
			15-30	0.05	0.63	0.328	0.42	0.04	1.11	0.44	0.51	
5	**Na**	**meq/100g**	0-15	9.4	15.58	11.916	9.9	0.24	5.83	1.51	0.94	
			15-30	7.73	13.03	10.844	5.8	0.25	5.79	1.55	0.54	
6	**K**	‘’	0-15	4.75	9.41	8.080	8.07	0.49	2.31	1.36	2.03	
			15-30	3.9	9.28	7.064	4.14	0.44	2.45	1.55	2.34	
7	**Ca**	‘’	0-15	10.46	17.33	13.463	13.3	3.56	8.45	4.86	5.51	
			15-30	9.02	15.16	12.582	8.55	2.31	8.4	4.44	4.92	
8	**Mg**	‘’	0-15	8.07	14.9	10.559	10.94	1.24	3.68	2.23	1.98	
			15-30	8.48	13.24	10.357	6.3	1.2	3.58	1.84	1.3	
9	**EA**	‘’	0-15	0.4	4.2	2.011	1	1.3	7.8	3.04	2	
			15-30	0.1	2.8	1.378	0.6	0.8	6.4	2.24	1.7	
10	**Cl^-**	**mg/kg**	0-15	102	705	192.222	3540	90	2560	704.67	2100	
			15-30	74	570	156.000	2700	141	2530	691.67	1900	
11	**PO_4**	‘’	0-15	25.4	45	33.400	24.9	19.2	48	33.58	32.2	
			15-30	22.3	44	30.733	23.4	16.4	31.2	25.67	29	

				Dry Season				Wet season				DPR Intervention Limits
S/N	**Parameters**	**Units**	**Level**	**MIN**	**MAX**	**MEAN**	**control**	**MIN**	**MAX**	**MEAN**	control	
			cm									
12	**NH_4N**	‘’	0-15	2.2	26	6.744	6.1	11	19.8	16.57	15.4	
			15-30	1.3	21	5.322	5.3	5.2	19.4	12.65	12	
13	**NO_2^-N**	‘’	0-15	6.3	11.5	8.444	9.1	2.8	10.4	7.23	9	
			15-30	3	8.3	5.089	4.6	1	8	4.32	4.4	
14	**NO_3^-N**	‘’	0-15	7.7	13.6	10.411	10.7	5.2	20	14.14	15.8	
			15-30	3.9	10.6	6.800	5.8	3.2	18.2	9.83	9	
15	**SO_4**	‘’	0-15	98	1118	400.111	2402	118	1845	828.78	261	
			15-30	84	1112	368.333	2310	112	1706	722.89	201	
16	**Silt**	**%**	0-15	2	3.4	2.611	2.6	1.4	3.6	2.38	2.4	
			15-30	2.5	4.4	3.167	3.4	2	3.4	2.52	2.5	
17	**Clay**	‘’	0-15	5	9.3	6.333	7.2	5	11.9	7.76	6.9	
			15-30	4.3	7.7	5.744	6.5	3.8	12.6	6.68	4.4	
18	**Sand**	‘’	0-15	89.9	93	91.278	90.2	86.3	93.1	90.04	94.1	
			15-30	89.3	93.1	91.089	90.1	85.4	94.4	90.91	95.1	
19	**THC**	**mg/kg**	0-15	23.2	85.9	55.578	16.3	51.3	150.1	75.36	75.5	
			15-30	11.6	77.9	46.567	14.7	35.9	60.5	49.88	65.2	
20	**TPH**	‘’	0-15	0.046	0.161	0.094	0.033	0.021	0.064	0.04	0.056	5000
			15-30	0.039	0.12	0.075	0.024	0.026	0.861	0.14	0.55	
21	**PAH**	‘’	0-15	0.011	0.102	0.060	0.018	0.027	0.078	0.04	0.51	
			15-30	0.007	0.089	0.049	0.012	0.031	0.072	0.05	0.53	
22	**Benzene**	**µg/kg**	0-15	0.004	0.007	0.006	0.002	0	0.005	0.00	0.004	
			15-30	0.002	0.004	0.003	ND	0.001	0.003	0.00	0.001	
23	**Toluene**	‘’	0-15	0.002	0.003	0.003	ND	0	0	ND	ND	
			15-30	0.001	0.002	0.001	ND	0	0	ND	ND	

				Dry Season				Wet season				DPR Intervention Limits
S/N	Parameters	Units	Level	MIN	MAX	MEAN	control	MIN	MAX	MEAN	control	
			cm									
24	**Ethylbenzene**	‘’	0-15	0.002	0.002	0.002	ND	0	0	ND	ND	
			15-30	0.001	0.001	0.001	ND	0.001	0.001	ND	ND	
25	**Xylene**	‘’	0-15	0.001	0.005	0.003	0.003	0.001	0.003	0.00	0.001	
			15-30	0.001	0.003	0.002	0.001	0.001	0.003	0.00	0.001	
26	**Phenol**	‘’	0-15	0.001	0.004	0.003	0.003	0.002	0.007	0.00	0.002	
			15-30	0.001	0.003	0.002	0.001	0.002	0.007	0.00	0.003	
	Fe	**mg/kg**	0-15	98.8	133.6	123.52	128.3	196.7	195.1	206.9	199.78	
			15-30	98.8	155.8	123.43	121.3	204.4	199.2	204.4	202.81	
	Cu	“	0-15	4.2	20.6	12.18	18.4	3.23	1.02	4.16	2.24	
			15-30	3.1	43	15.37	14.1	3.57	0.76	4.18	2.26	
	Mn	“	0-15	11.8	57.9	21.50	15.4	3.4	3.26	3.58	3.46	
			15-30	8	56.8	17.83	11.1	3.39	3.37	3.52	3.46	
	Zn	“	0-15	10.2	20.3	15.26	15.7	8.18	8.18	14.1	10.51	720
			15-30	9.6	16.9	14.06	10.6	8.09	8.09	15.5	10.73	
	Cd	“	0-15	0.08	0.67	0.28	0.28	0.07	0.07	0.36	0.15	
			15-30	0.1	0.65	0.26	0.16	0.05	0.05	0.43	0.17	
	Cr	“	0-15	0.81	1.37	1.23	1.35	1.5	1.48	1.57	1.52	380
			15-30	0.06	1.38	0.83	0.02	1.6	1.49	1.6	1.54	
	Pb	“	0-15	2.6	16.4	11.32	13.6	2.9	0.56	3.99	2.34	530
			15-30	1.7	26.2	13.17	12.8	2.62	0.36	3.62	2.14	
	Ni	“	0-15	1.1	15.6	5.50	2.4	4.59	0.4	4.59	1.35	
			15-30	0.6	14.9	5.29	1.1	4.51	0.26	4.51	1.31	
	V	“	0-15	0.9	13.4	4.76	0.5	3.18	0.34	3.18	0.99	
			15-30	2.1	12.9	4.87	3.2	3.55	0.27	3.55	1.10	

				Dry Season				Wet season				DPR Intervention Limits
S/N	**Parameters**	**Units**	**Level**	**MIN**	**MAX**	**MEAN**	**control**	**MIN**	**MAX**	**MEAN**	control	
			cm									
	Hg	"	0-15	ND	ND	ND	ND	ND	ND	ND	ND	
			15-30	ND	ND	ND	ND	ND	ND	ND	ND	
	Ba	"	0-15	0.004	0.008	0.01	0.004	0.005	0.001	0.005	0.00	
			15-30	0.001	0.005	0.00	0.002	0.004	0.001	0.006	0.00	

During the dry season Electrical conductivity (EC) ranged from 570 – 19,240 µS/cm with a mean of 5052 µS/cm at the soil surface, whereas at the subsurface it ranged from 220 –18,350 with a mean of 4730 µS/cm. The control sample had an EC of 12,510 µS/cm at the surface and 2710 µS/cm at the subsurface. In the wet season, EC ranged from 270 – 3010 µS/cm with a mean of 1245 µS/cm. The control sample had an EC of 2050 µS/cm at the surface and 2100 µS/cm at the subsurface. Sulphate and chloride appear to be the major anionic species in the study area. During the dry season, chloride ranged from 102 – 705 mg/kg with a mean of 192 mg/kg at the soil surface, whereas it was 74 – 570 mg/kg with a mean of 156 mg/kg at the subsurface. The control had chloride concentration of 3540 mg/kg at the surface and 2700 mg/kg at the subsurface. In the wet season, it ranged from 90 - 2560 mg/kg with a mean of 704 mg/kg at the surface and 141 -2530 mg/kg with a mean of 691 mg/kg at the subsurface. The control had chloride concentration of 2100 mg/kg at the surface and 1900 mg/kg at the subsurface. The salinity was highest at the control site. Generally, chloride was slightly higher in the wet season than dry season and also higher at the top soil than the subsoil. Increased salt water inundation of the soils may have caused this pattern of salinity variation in the soil.

During the dry season, sulphate was 98 -1118 mg/kg with a mean of 400 mg/kg at the surface and 84 – 1112 mg/kg at the subsurface with a mean of 368 mg/kg. The control had sulphate concentration of 2402 mg/kg at the surface and 2310 at the subsurface. During the wet season, it was 118 – 1845 mg/kg (mean = 828 mg/kg) at the surface and 112 – 1706 mg/kg (mean = 722 mg/kg) at the subsurface. The control had sulphate concentration of 261 mg/kg at the surface and 201 at the subsurface. Like chloride, sulphate was higher in the wet season and at the surface. Increased tidal water inundation of the soils may have caused this pattern of variation in the soil.
Phosphate was generally low in both seasons and strata. During the dry season, phosphate ranged from 25.4 -45 mg/kg with a mean of 33.40 mg/kg at the surface, whereas at the subsurface, it was 22.3 – 44 mg/kg with a mean of 30.7 mg/kg. The control had a phosphate concentration of 24.9 mg/kg at the surface and 23.4 mg/kg at the subsurface. In the wet season, phosphate was 19.2 -48 mg/kg with a mean of 33.58 mg/kg at the surface and 16.4 – 31.2 mg/kg with a mean of 25.67 mg/kg at the subsurface. The control sample had a phosphate concentration of 32.2 mg/kg at the surface and 29 mg/kg at the subsurface. Phosphate did not exhibit significant differences across the two seasons and between the two soil strata.

Nitrogen related parameters analyzed include total nitrogen (TN), ammonium, nitrite and nitrate. During the dry season, TN ranged from 0.06 – 0.64 % with a mean of 0.37% at the soil surface. At the subsurface, it was 0.05 – 0.63% with a mean of 0.33 %. The control had a TN of 0.39 % at the surface and 0.42 % at the subsurface. During the wet season, TN was significantly higher ranging from 0.29 – 1.18% (mean = 0.56 %) at the surface and 0.04 – 1.11 % (mean = 0.54%) at the subsurface. The control had a TN concentration of 0.60% and 0.51% at the surface and subsurface respectively. The higher total nitrogen in the wet season and in the top soil layer could be linked to faster biodegradation activities in the wet season and at the top layer.

Hydrocarbon related parameters analyzed over the two seasons and along the two strata include THC, TPH, PAH, BTEX, TOC and phenol. TOC ranged from 0.86 – 5.35 % (mean = 3.17%) at the surface and 0.38 – 5.21 % (2.73%) at the subsurface during the dry season, whereas during the wet season, it was 0.93 – 5.8 (mean = 2.59). During the dry season, THC ranged from 23.2 – 85 mg/kg with a mean of 55.58 mg/kg at the surface soil level and 11.6 – 77.9 mg/kg with a mean of 46.57 mg/kg at the subsurface. The THC level at the control was significantly lower than that of the main samples; it was 16.3 mg/kg at the surface and 14.7 mg/kg at the subsurface. The wet season THC was higher than that of the dry season ranging from 51.3 -150.1 mg/kg (75.36 mg/kg) at the surface soil and significantly lower at the subsoil ranging from 35.9 – 60.5 mg/kg mean = 49.88 mg/kg). The wet season control had a THC concentration of 75.5 mg/kg and 65.2 mg/kg at the surface and subsoil respectively. Notwithstanding, TPH was several orders lower than the THC and was generally <1 mg/kg at all the sampling points in both seasons. This value was several orders lower than the 5000 mg/kg DPR intervention level. Other hydrocarbon related parameters including PAH, BTEX and phenol was similarly <1 mg/kg at all the sampling points in both seasons.

Eleven heavy metal parameters were analyzed. During the dry season, iron was the dominant heavy metal occurring at a concentration of 98.8 - 133.6 mg/kg with a mean of 123.52 mg/kg at the surface and mean of 123.43 mg/kg at the subsurface. High levels of iron are not unusual in mangrove ecosystems of the world including the Niger Delta (Anderson 1966, van Breemen, 1996; Ohimain 2004, Ohimain *et al*. 2004). The next abundant heavy metal in the area is manganese ranging from 11.8 – 57.9 mg/kg (mean = 21.5 mg/kg) at the surface and 8 – 56.8 mg/kg (mean = 17.83 mg/kg) at the subsurface. The control was 15.4 mg/kg at the surface and 11.1 mg/kg at the subsurface. The other heavy metal concentrations ranged from <0.001 - <1.0 mg/kg (Hg, Cd, Ba), 1.0 – 10.0 mg/kg (Cr), and 11 – 20 (Cu, Zn, Pb, Ni, V). The concentrations of all the metals were higher at the surface except Cu and Pb that were higher at the subsurface. Apart from iron that was slightly higher during the wet season, all the other parameters were significantly lower perhaps due to dilution effects of the rains and tides.

Mechanical analysis of the soil revealed that sand ranged from 89.9 -93% (mean = 91.28 %) at the surface and 91.7 – 93.1 % (mean = 91.1%) at the subsurface. Clay was 5.0 – 9.3 % (mean = 6.33%) at the surface and 4.3 – 7.7 % (mean = 5.74%) at the subsurface, while silt accounted for the remainder. With these properties, the texture of the soils of the study area could be described as sandy according to USDA soil classification. Because of the high porosity and permeability of sandy formation, contaminants can easily migrate though these formations.

Soil Microbiology

Microbiological parameters considered include Total Heterotrophic Bacteria (THB) and Hydrocarbon Utilizing Bacteria (HUB), Total Fungi (TF) and Hydrocarbon Utilizing Fungi (HUF) (Tables 4.3d and 4.3e). During the dry season, the population of THB ranged from 3.8 – 8.6 x 10^5 cfu/g at the soil surface and 3.6 – 8.2 x 10^5 cfu/g in the subsurface. The control station had a THB population of 5.6 x 10^5 cfu/g at the surface and 6.1 x 10^5 cfu/g at the subsurface. During the wet season, THB was slightly higher ranging from 6.5 - 9.9 x 10^5 cfu/g in the surface and 5.1 – 9.6 x 10^5 cfu/g in the subsurface. The control station had a THB population density of 9.1 x 10^5 cfu/g at the surface and 4.2 x 10^5 cfu/g at the subsurface. The population of HUB during the dry season, ranged from 1.7 – 3.2 x 10^3 cfu/g in the surface and 1.2 – 3.1 x 10^3 cfu/g in the subsurface. During the wet season, it was 2.8 - 5.5 x 10^5 cfu/g in the surface soil and 1.5 – 4.7 x 10^3 cfu/g in the subsurface. The HUB population of the control sample was 5.1 x 10^3 cfu/g at the surface and 4.5 x 10^3 cfu/g at the subsurface. HUB makes up about 1 % of the THB, which suggest non-pollution from petroleum sources. Generally, the population of microbes was slightly higher in the top soil due to more availability of oxygen, organic matter and other nutrients. The predominant genera of bacteria isolated from the soil of the study area were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Micrococcus* and *Staphylococcus*. During the dry season, TF was lower than THB with population ranging from 0.9 - 2.9 x 10^4 cfu/g in the soil surface and 0.6 - 3.0 x 10^4 cfu/g in the subsurface. During the wet season, TF ranged from 1.0 – 2.5 x 10^4 cfu/g in the surface and 0.8 – 2.0 x 10^4 cfu/g in the subsurface. HUF population ranged from 0.2 (non-significant) - 2.0 x 10^2 cfu/g in the soil surface and 0.1 (non-significant) – 1.6 x 10^2 cfu/g in the subsurface. The control soil sample had TF population of 2.5 x 10^4 cfu/g at the surface and 2.0 x 10^4 cfu/g at the subsurface; HUF population was 1.8 x 10^2 cfu/g at the soil surface and 0.9 x 10^2 cfu/g at the subsurface. Hence, HUF is <1% of the TF. This suggests that the study area has not been contaminated. Predominant fungal genera in the study area are *Mucor*, *Penicillium* and *Aspergillus*.

Table 4.3d: Soil microbial population during the dry season

CODE	Level	THB 10^5 cfu/g	THUB 10^3 cfu/g	Most Predominant Bacterial Isolate	TF 10^4 cfu/g	HUF 10^2 cfu/g	Most Predominant Fungal Isolate
SAG SS 1	0 - 15	7.2	2.5	*Bacillus sp, Micrococcus sp, Enterobacter sp*	2.7	1.0	*Penicillium sp,*
SAG SS 1	15-30	7.0	2.3	*Micrococcus sp, Bacillus sp, Pseudomonas sp*	2.3	0.9	*Aspergillus sp, Penicillium sp*
SAG SS 2	0 - 15	6.8	3.1	*Staphylococcus sp, Bacillus sp, Pseudomonas sp*	2.1	0.7	*Penicillium sp, Mucor sp*
SAG SS 2	15-30	6.5	2.8	*Bacillus sp, Staphylococcus sp,*	1.9	0.5	*Aspergillus spp, Mucor sp*
SAG SS 3	0 - 15	8.6	3.3	*Enterobacter sp , Pseudomonas sp, Staphylococcus sp,*	1.7	1.8	*Penicillium sp*
SAG SS 3	15-30	8.2	3.0	*Staphylococcus sp, Pseudomonas sp*	1.4	1.6	*Mucor sp, Penicillium sp*
SAG SS 4	0 - 15	6.4	2.9	*Pseudomonas sp, Enterobacter sp, Bacillus sp*	1.1	1.1	*Aspergillus sp, Penicillium sp*
SAG SS 4	15-30	5.9	2.6	*Micrococcus sp, Bacillus sp,*	0.8	0.8	*Aspergillus spp, Mucor sp*
SAG SS 5	0 - 15	7.3	3.1	*Bacillus sp, Micrococcus sp, Pseudomonas sp*	1.3	0.6	*Penicillium sp, Aspergillus spp*
SAG SS 5	15-30	6.9	2.8	*Pseudomonas sp, Staphylococcus sp, Enterobacter sp*	1.0	0.4	*Mucor sp, Aspergillus spp*
SAG SS 6	0 - 15	6.5	3.1	*Bacillus sp, Pseudomonas sp, Nocardia sp, Bacillus sp, Pseudomonas sp*	2.9	1.8	*Penicillium sp, Mucor sp*
SAG SS 6	15-30	6.2	2.9	*Pseudomonas sp, Micrococcus sp, Bacillus sp*	3.0	1.5	*Penicillium sp*
SAG SS 7	0 - 15	3.8	2.1		0.9	0.7	*Penicillium sp, Aspergillus spp*
SAG SS 7	15-30	3.6	1.9	*Staphylococcus sp, Pseudomonas sp*	0.6	0.5	*Mucor sp, Penicillium sp*
SAG SS 9	0 - 15	4.4	1.7	*Bacillus sp, Micrococcus sp,*	1.1	0.8	*Aspergillus spp, Mucor sp*
SAG SS 9	15-30	4.1	1.2	*Bacillus sp Pseudomonas sp, Nocardia sp*	0.8	0.5	*Aspergillus spp, Mucor sp*
SAG SS 10	0 - 15	6.9	3.3	*Bacillus sp, Pseudomonas sp, Micrococcus sp,*	1.7	1.1	*Mucor sp, Aspergillus sp, Penicillium sp*
SAG SS 10	15-30	5.8	3.1	*Micrococcus sp, Staphylococcus sp*	1.4	0.9	*Penicillium sp, Mucor sp*
SAG SS 11	0 - 15	7.9	3.2	*Pseudomonas sp, Bacillus sp,*	1.0	0.0	*Penicillium sp, Aspergillus sp, Mucor sp*
SAG SS 11	15-30	6.8	2.7	*Bacillus sp, Pseudomonas sp, Nocardia sp Bacillus sp, Pseudomonas sp, Nocardia sp*	1.4	0.0	*Aspergillus spp, Mucor sp*
control	0 - 15	5.6		*Bacillus sp, Pseudomonas sp, Nocardia sp*	1.5	1.4	*Aspergillus spp, Mucor sp*
	15-30	6.1		*Bacillus sp, Pseudomonas sp, Nocardia sp*	2.1	1.3	*Aspergillus spp, Mucor sp*

Table 4.3e: Soil microbial population during the wet season

CODE	Level	THB 10^5 cfu/g	THUB 10^3 cfu/g	Predominant Bacterial Isolates	THF 10^4 cfu/g	THUF 10^2 cfu/g	Predominant Fungal Isolates
SAGSS1	0 - 15	7.2	2.8	*Micrococcus sp, Bacillus sp*	1.4	1.1	*Trichoderma sp, Aspergillus sp*
SAGSS1	15-30	6.9	2.5	*Pseudomonas sp, Staphylococcus sp*	1.0	0.9	*Aspergillus sp, Penicillium sp*
SAGSS2	0 - 15	8.1	4.0	*Bacillus sp., Micrococcus sp*	2.0	0.5	*Trichoderma sp, Aspergillus sp, Penicillium sp.*
SAGSS2	15-30	7.7	3.6	*Enterobacter sp, Bacillus sp, Pseudomonas sp*	1.7	0.3	*Trichoderma sp, Aspergillus sp*
SAGSS3	0 - 15	9.2	5.1	*Bacillus sp, Micrococcus sp*	1.5	2.0	*Trichoderma sp, Penicillium sp*
SAGSS3	15-30	8.9	4.7	*Staphylococcus sp, Bacillus sp*	1.2	1.7	*Aspergillus sp, Penicillium sp*
SAGSS4	0 - 15	6.6	3.2	*Pseudomonas sp. Staphylococcus sp*	1.0	1.2	*Aspergillus sp, Mucor sp*
SAGSS4	15-30	6.1	2.9	*Micrococcus sp, Bacillus sp*	0.8	0.9	*Penicillium sp, Aspergillus sp*
SAGSS5	0 - 15	8.2	3.7	*Bacillus sp, Pseudomonas sp., Enterobacter sp*	1.4	0.2	*Penicillium sp, Aspergillus sp*
SAGSS5	15-30	7.9	3.3	*Bacillus sp, Pseudomonas sp., Enterobacter sp*	1.0	0.1	*Aspergillus sp, Penicillium sp,*
SAGSS6	0 - 15	6.5	3.0	*Pseudomonas sp, Staphylococcus sp., Bacillus sp.*	1.6	1.3	*Aspergillus sp ,Penicillium sp*
SAGSS6	15-30	6.1	2.9	*Enterobacter sp, Bacillus sp. Micrococcus sp*	1.3	1.0	*Aspergillus sp, Mucor sp, Penicillium sp sp*
SAGSS7	0 - 15	8.4	5.5	*Bacillus sp, Pseudomonas sp., Enterobacter sp*	2.5	1.7	*Aspergillus sp, Mucor sp, Penicillium sp sp*
SAGSS7	15-30	5.1	1.5	*Pseudomonas sp. Staphylococcus sp*	1.5	0.8	*Aspergillus sp, Penicillium sp*
SAGSS10	0 - 15	8.3	4.5	*Bacillus sp, Micrococcus sp*	2.1	1.4	*Penicillium sp*
SAGSS10	15-30	8.0	4.4	*Bacillus sp, Micrococcus sp*	1.9	1.2	*Penicillium sp*
SAGSS11	0 - 15	9.9	4.9	*Bacillus sp, Pseudomonas sp.Staphylococcus sp*	2.5	1.8	*Aspergillus spp,Penicillium sp, Mucor sp.*
Control	0 - 15	9.1	5.1	*Bacillus sp, Pseudomonas sp., Enterobacter sp*	2.5	1.8	*Aspergillus sp, Mucor sp, Penicillium sp*
	15-30	4.2	2.1	*Bacillus sp., Micrococcus sp*	1.0	0.9	*Aspergillus sp, Mucor sp,*
SAGSS11	15-30	9.6	4.5	*Bacillus sp., Enterobacter sp*	2.0	1.6	*Penicillium sp*

4.7.2: Land Use and Agriculture

Land Use refers to the various uses to which the land in Otumara project area is put into. This was ascertained by observing directly in the field the various land use patterns. The major land use types in Otumara area include mangrove forest, dwelling places, cultivated agricultural lands, fallow lands, oil/gas exploration and production facilities, and communication facilities. A panoramic view of the various land uses in Otumara area is presented in **Plate 4.1**, while a checklist of the various land uses in the area is presented in **Table 4.4.**

Plate 4.1: A Panoramic View of the Various Land Uses in Otumara Area

Table 4. 4: Various Land Uses in Saghara Project Area

Order	**Group**
Agriculture and Fisheries	Agriculture and Fisheries
Forestry and water bodies	swamp forest, mangrove swamp forest, Otumara River
Transport	Roads, water ways, track ways, foot paths,
Utilities/Infrastructure	Telecommunications,
Residential	Settlements/Dwellings,
Community Services	Places of worship, schools, health centres, community hall
Retail Services	Shops, Restaurants and bars
Industry and Business	Well heads and associated oil exploration and production facilities.
Unused Land	Fallow Land, Unused land

Agriculture

Agricultural practices are minimal and carried out by relatively few individuals and at a subsistence level. A few homestead crops (sugar cane, cassava, banana and plantain) were cultivated within the dwelling places.

4.8: Surface Water Quality

Natural waters occur as extremely dilute chemical solutions with very small quantities of dissolved organic and inorganic compounds, and existing in equilibrium with the natural atmospheric gases. The concentration of the dissolved compounds, especially the alkaline earth metals determine whether the water is fresh, brackish or marine. A total of nine (9) water samples including two (2) from control points were collected from water bodies (creeks and dredge slots) within the Saghara Project area. The detailed physico-chemical results of surface waters for both wet and dry seasons are provided in Tables 4.5a and 4.5b while the summary indicating the minimum, maximum, mean and regulatory limits are reported in Table 4.5c. All the water samples in this study were slightly alkaline in nature. The mean pH values of the surface water samples ranged from 7.2 in the wet season to 7.5 in the dry season. The pH of the control station (SWC2) was more alkaline (varying from 7.6 in the wet season to 7.8 in the dry season). These alkaline pH values are typical of brackish water environment, and they fall within the regulatory limits of FMEnv and DPR.

Electrical Conductivity (EC), also called specific conductance, is a measure of the ability of a water sample to convey an electrical current and it is related to the concentration of ionized substances in water. The mean conductivity values recorded in this study ranged from 10534 µS/cm in the wet season to 22945 µS/cm in the dry season. The mean conductivity value was higher in the dry than in the wet season. These values are characteristic of brackish water environments, and the higher dry season values are the results of evaporation and reduced water volume.

Table 4.5a: Wet Season Physicochemical Results of Surface waters within Saghara

S/N	Parameters	Units	SAG SWC 1	SAG SWC2	SAG SW1	SAG SW2	SAG SW3	SAG SW4	SAG SW5	SAG SW6	SAG SW7
1	pH		6.9	7.6	7.1	7.3	7.1	6.9	7.3	6.9	7.3
2	Temp	^{0}C	30.0	26.7	28.7	29.0	28.8	26.4	26.3	26.6	26.2
3	EC	µS/cm	3307	21370	10490	11150	10560	9007	10230	8982	9708
4	Salinity	g/l	1.50	9.66	4.74	5.04	4.78	4.07	4.63	4.06	4.39
5	Colour	Pt.Co	10.5	9.3	10.1	15.3	16.9	10.3	5.8	8.9	11.5
6	Turbidity	NTU	8.5	7.4	7.9	10.4	12.0	7.9	3.5	7.3	9.6
7	TSS	mg/l	9.3	10.9	14.8	18.3	10.7	12.6	10.2	15.8	10.1
8	TDS	‘ ’	1552	10685	5245	5575	5280	4393	5115	4495	4749
9	DO	‘ ’	6.90	7.57	7.09	7.25	7.11	6.92	7.27	6.89	7.28
10	BOD_5	‘ ’	2.30	3.30	3.60	3.30	4.20	1.50	1.80	2.70	5.00
11	COD	‘ ’	15.2	20.8	2.4	8.8	12.8	6.4	8.8	2.4	1.6
12	HCO_3	‘ ’	85.4	134.2	79.3	79.3	85.4	73.2	73.2	97.6	61.0
13	Na	‘ ’	165	170	170	149	152	155	159	130	123
14	K	‘ ’	150.2	161.8	83.2	93.9	92.5	103.1	33.9	120.4	131.9
15	Ca	‘ ’	42.5	40.3	32.8	34.8	30.1	34.3	19.3	20.4	6.3
16	Mg	‘ ’	51.2	54.7	44.8	43.0	43.5	42.6	28.9	32.2	12.4
17	Cl^-	‘ ’	6800	18900	11400	11600	12000	10900	12600	11800	12700
18	PO_4	‘ ’	15.11	10.41	6.20	3.85	5.05	2.41	2.82	2.15	1.65
19	NH_4N	‘ ’	2.65	2.39	1.97	2.23	1.97	2.05	2.22	1.94	1.79
20	NO_2^-N	‘ ’	1.93	0.90	1.26	1.93	1.06	1.01	1.08	1.21	1.03
21	NO_3^-N	‘ ’	3.30	2.89	3.58	2.49	2.46	2.78	4.37	2.53	2.54
22	SO_4	‘ ’	67.1	61.1	62.2	58.9	65.7	77.9	52.6	57.1	82.1
23	THC	‘ ’	0.29	0.29	1.04	1.12	0.02	0.05	0.09	0.32	0.09
24	TPH	mg/l	0.001	0.002	0.002	0.003	0.001	0.002	0.002	0.015	0.569
25	PAH	µg/l	0.001	0.001	0.001	0.001	0.002	0.001	ND	0.001	0.002
26	Benzene	‘ ’	ND	0.001	ND	0.002	0.003	0.002	ND	ND	0.001
27	Toluene	‘ ’	ND	ND	ND	0.001	0.002	0.001	0.001	0.001	ND
28	Ethylbenzene	‘ ’	ND	ND	ND	ND	ND	ND	ND	ND	ND
29	Xylene	‘ ’	0.001	ND	ND	0.002	0.001	0.002	0.002	0.003	ND
30	Phenol	‘ ’	0.001	0.001	0.002	0.001	0.001	0.002	0.006	0.005	0.001
	Heavy metals										
1	Fe	mg/l	0.034	1.22	0.11	0.73	0.86	0.24	3.67	3.73	0.49
2	Cu	“	0.045	0.010	0.076	0.025	0.044	0.051	0.019	0.038	0.048
3	Mn	“	0.021	0.049	0.005	0.032	0.038	0.011	0.159	0.146	0.010
4	Zn	“	0.026	0.042	0.030	0.067	0.059	0.040	0.060	0.053	0.042
5	Cd	“	0.010	0.011	0.090	0.036	0.031	0.029	0.036	0.032	0.031
6	Cr	“	0.016	0.026	0.002	0.014	0.012	0.005	0.070	0.064	0.010
7	Pb	“	0.068	0.102	0.326	0.217	0.109	0.145	0.181	0.145	0.139
8	Ni	“	0.044	0.008	0.177	0.089	0.109	0.064	0.105	0.105	0.060
9	V	“	0.035	0.067	0.141	0.076	0.084	0.050	0.081	0.088	0.049
10	Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Ba	“	0.002	0.003	0.001	0.004	0.002	0.003	0.001	0.004	0.002

Table 4.5b: Dry Season Physicochemical Results of Surface waters within Saghara

S/N	Parameters	Units	SAG SWC1	SAG SWC2	SAG SW1	SAG SW2	SAG SW3	SAG SW4	SAG SW5	SAG SW6	SAG SW7
1	pH		7.75	7.78	7.78	7.8	7.74	7.15	7.14	7.22	7.11
2	Temp	^0C	29.6	29.6	29.6	34.5	34	31.1	32.0	32.4	33.3
3	EC	µS/cm	27710	29600	27700	22400	22410	26700	20800	25200	19080
4	Salinity	g/l	12.53	14.839	12.53	10.13	10.14	12.1	9.41	11.4	8.63
5	Colour	Pt.Co	15.3	20.5	20.9	18.3	15.9	15.6	19.8	15.6	16.3
6	Turbidity	NTU	7.6	9.9	9.8	7.4	7.2	11.4	12.5	10.2	12.4
7	TSS	mg/l	9	10	13	10	12	12.3	14.7	13.4	12.3
8	TDS	‘ ’	14687	14800	14681	11872	11877	14151	11024	13356	10112
9	DO	‘ ’	4.4	5.6	4.3	4.9	4.8	5.3	4.5	5.2	5.3
10	BOD_5	‘ ’	3.5	2.8	2.9	4.2	2.8	2.7	2.2	3.1	3.2
11	COD	‘ ’	66.4	69.5	61.6	71.2	66.4	28.0	38.8	55.2	52.0
12	HCO_3	‘ ’	281	287	220	220	189	146	116	159	79
13	Na	‘ ’	140.9	161.3	153.9	145.9	148.3	145.3	142.7	140.9	156.7
14	K	‘ ’	101.1	159.6	114.3	114.4	118.2	166.1	113.8	153.3	109.5
15	Ca	‘ ’	162	60.7	53.2	49.5	56.4	52.4	49.8	54.9	42.4
16	Mg	‘ ’	57.9	68.4	55.7	56.9	57	56.7	53.7	56.6	53.5
17	Cl^-	‘ ’	6990	8200	7540	7540	7600	7390	7090	7870	7540
18	PO_4	‘ ’	1.28	5.44	2.31	2.37	1.1	1.48	2.67	2.46	1.95
19	NH_4N	‘ ’	0.04	0.15	0.12	0.07	0.07	0.04	0.09	0.03	0.12
20	NO_2^-N	‘ ’	1.56	2.68	1.76	3.47	2.1	2.04	2.39	2.47	2.20
21	NO_3^-N	‘ ’	2.23	4.31	3.2	4.17	3.18	2.45	3.51	3.34	2.36
22	SO_4	‘ ’	83.8	86.7	86.5	83.2	86.4	85.6	80.3	84.8	77.0
23	THC	‘ ’	0.22	0.33	0.32	0.39	0.23	0.55	1.32	0.60	0.95
24	TPH	mg/l	0.09	0.08	0.092	0.047	0.016	0.099	0.039	0.056	0.040
25	PAH	µg/l	0.042	0.043	0.041	0.02	0.04	0.033	0.010	0.019	0.008
26	Benzene	‘ ’	0.004	0.01	0.06	0.018	0.003	0.001	0.001	ND	0.001
27	Toluene	‘ ’	0.002	0.001	0.001	0.001	0.003	ND	ND	ND	ND
28	Ethylbenzene	‘ ’	0.001	0.001	0.003	0.004	0.001	ND	ND	ND	ND
29	Xylene	‘ ’	0.002	0.001	0.001	0.002	0.004	0.003	0.001	ND	0.002
30	Phenol	‘ ’	0.012	0.015	0.009	0.015	0.006	0.007	0.002	0.001	0.004
Heavy metals											
1	Fe	mg/L	0.25	0.05	0.07	0.061	0.083	0.060	0.049	0.052	0.014
2	Cu	“	0.062	0.043	0.114	0.118	0.155	0.049	0.056	0.042	0.012
3	Mn	“	0.051	0.01	0.016	0.038	0.092	0.017	0.008	0.013	0.018
4	Zn	“	0.072	0.03	0.058	0.035	0.012	0.018	0.016	0.023	0.035
5	Cd	“	ND	0.011	0.002	0.004	0.004	0.001	0.003	ND	ND
6	Cr	“	ND	ND	0.044	0.072	0.082	0.003	0.002	0.003	ND
7	Pb	“	0.034	0.042	0.041	0.026	0.039	0.161	0.152	0.289	0.171
8	Ni	“	ND	0.02	0.03	0.052	0.051	0.042	0.039	0.022	0.034
9	V	“	ND	0.05	0.011	0.034	0.03	0.037	0.034	0.019	0.030
10	Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Ba	“	ND	ND	ND	ND	ND	0.002	0.001	0.005	0.003

The salinity values are of the brackish water range, with higher dry season values. The Total Dissolved Solids were also high, and typical of the brackish water environment. Salinity is not a problem in brackish water environment because the life forms are generally adapted to high salinity.

Table 4.5c: Summary of the Physicochemical Results of Surface waters within Saghara

Parameters	Units	**WET SEASON**				**DRY SEASON**				**DPR/ *FMEnv**
		Min	Max	Mean	**SWC2**	Min	Max	Mean	SWC2	
pH		6.9	7.6	7.2	7.6	7.11	7.8	7.5	7.78	6.5-9.2/ 6.5-8.5*
Temp	^{0}C	26.2	30.0	27.6	26.7	31.1	33.3	32.2	29.6	30
EC	µS/cm	3307	21370	10534	21370	19080	26700	22945	29600	
Salinity	‰	1.50	9.66	4.76	9.66	8.63	12.1	10.4	14.839	
Colour	Pt.Co	5.8	16.9	11.0	9.3	15.6	19.8	16.8	20.5	
Turbidity	NTU	3.5	12.0	8.3	7.4	10.2	12.5	11.6	9.9	1.0*
TSS	mg/l	9.3	15.8	12.5	10.9	12.3	14.7	13.2	10	<10*
TDS	‘ ’	1552	10685	5232	10685	10112	14151	41055	14800	1500/ 500*
DO	‘ ’	6.92	7.57	7.14	7.57	4.5	5.3	5.08	5.6	7.5*
BOD_5	‘ ’	1.50	4.20	3.08	3.30	2.2	3.2	2.8	2.8	0*
COD	‘ ’	1.6	20.8	8.8	20.8	28	55.2	43.5	69.5	
HCO_3	‘ ’	85.4	134.2	85.4	134.2	79	159	125	287	
Na	‘ ’	123	170	156.3	170	140.9	156.7	146.4	161.3	
K	‘ ’	33.9	161.8	107.9	161.8	109.5	166.1	135.7	159.6	
Ca	‘ ’	6.3	42.5	29.0	40.3	42.4	54.9	49.9	60.7	200
Mg	‘ ’	12.4	54.7	39.3	54.7	53.5	56.7	55.3	68.4	150
Cl^-	‘ ’	6800	12700	12078	18900	7090	7870	7473	8200	600/ 250*
PO_4	‘ ’	1.65	15.11	5.52	10.41	1.48	2.67	2.14	5.44	<5*
NH_4N	‘ ’	1.79	2.65	2.13	2.39	0.03	0.12	0.07	0.15	
NO_2^-N	‘ ’	0.90	1.98	1.27	0.90	2.04	2.47	2.275	2.68	
NO_3^-N	‘ ’	2.46	3.58	2.99	2.89	2.36	3.51	2.915	4.31	10*
SO_4	‘ ’	52.6	82.1	65.0	61.1	77	85.6	81.93	86.7	
THC	‘ ’	0.05	1.12	0.37	0.29	0.55	1.32	0.86	0.33	
TPH	mg/l	0.001	0.569	0.066	0.002	0.039	0.099	0.059	0.08	0.3
PAH	µg/l	0.001	0.002	0.001	0.001	0.008	0.033	0.018	0.043	
Benzene	‘ ’	0.001	0.003	0.002	0.001	0	0.001	0.001	0.01	
Toluene	‘ ’	0.001	0.002	0.001	ND	ND	ND	ND	0.001	
Ethylbenzene	‘ ’	ND	ND	ND	ND	ND	ND	ND	0.001	
Xylene	‘ ’	0.001	0.003	0.002	ND	0.001	0.003	0.002	0.001	
Phenol	‘ ’	0.001	0.003	0.002	0.001	0.001	0.007	0.003	0.015	
Fe	mg/l	0.034	3.67	1.23	1.22	0.014	0.06	0.044	0.05	1/1*
Cu	“	0.010	0.076	0.040	0.010	0.012	0.056	0.04	0.043	1.5/0.1*
Mn	“	0.005	0.159	0.052	0.049	0.008	0.018	0.014	0.01	0.5-5/ 0.05-0.5*
Zn	“	0.026	0.067	0.047	0.042	0.016	0.035	0.023	0.03	15/5.0*
Cd	“	0.010	0.090	0.034	0.011	0.001	0.003	0.002	0.011	0.01*
Cr	“	0.002	0.070	0.024	0.026	0.002	0.003	0.003	ND	0.05*
Pb	“	0.068	0.326	0.159	0.102	0.161	0.289	0.193	0.042	0.05*
Ni	“	0.008	0.177	0.085	0.008	0.022	0.042	0.034	0.02	0.05*
V	“	0.035	0.141	0.075	0.067	0.019	0.037	0.03	0.05	0.01*
Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	0.001*
Ba	“	0.001	0.004	0.002	0.003	0.001	0.005	0.003	ND	1.0*

** Limits for potable water sources (FMEnv)*

The colour of water determines the depth to which light is transmitted. This in turn, controls the amount of primary productivity that is possible by controlling the rate of photosynthesis of the algae present (Chapman, 1996). The mean colour values recorded in this study ranged between 11.0 Pt-Co in the wet season and 16.8 Pt-Co units in the dry season. Natural waters can range from <5 in very clear waters to 300 Pt-Co units in dark peaty waters (Chapman, 1996). The control locations for both dry and wet seasons were not different from the other stations.

Dissolved Oxygen (DO) is essential to all forms of aquatic life, including those organisms responsible for the self – purification processes in natural waters. The mean DO values recorded in this study ranged from 7.14 mg/l in the wet season to 5.08 mg/l in the dry season. Concentrations below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish (Chapman, 1996). On the other hand, Biochemical Oxygen Demand (BOD) is a measure of the putrescible organic matter in a water body. The mean BOD values ranged from 3.08 mg/l to 2.8 mg/l in the wet and dry seasons respectively. A river can self – purify itself if the BOD is below 4, but not if it is greater than 4 mg/l. In the absence of National regulatory limits for these parameters for aquatic life, the EU standard was used. For fisheries and aquatic life, the EU sets a BOD standard of 3 – 6 mg/l (Radojevic and Bashkin, 1999).

The COD is a measure of the oxygen equivalent of the organic matter in water sample that is susceptible to oxidation by a strong oxidizing agent. It is widely used to measure the organic strength of water samples. The mean COD values ranged from 8.8 mg/l to 43.5 mg/l in the wet and dry seasons respectively. The higher COD values recorded for the dry season can be explained by the higher rate of decomposition and mineralization of introduced organic matters. However, Okpokwasili and Odokuma (1993) recorded higher wet season BOD and COD in the New Calabar River in the Niger Delta. The presence of Bicarbonates (HCO_3^-) influences the hardness and alkalinity of water. Bicarbonate values ranged between 85.4 and 125 mg/l in the wet and dry seasons respectively. Bicarbonate concentrations in surface waters are usually <500 mg/l, and commonly <25 mg/l (Chapman, 1996). The control values for the wet and dry seasons were 134.5 mg/l and 287 mg/l respectively.

Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg), the earth metals in solution constitute the exchangeable cations. In this study, the mean concentration of sodium ranged between 146.4 mg/l in the dry season and 156.3 mg/l in the wet season; potassium (107.9 – 135.7 mg/l), calcium (29.0 – 49.9 mg/l) and magnesium (39.3 – 55.3 mg/l). These values are characteristic of brackish water environment and not different from values obtained for the control station for both the wet and dry seasons. The order of dominance is as follows: Na > K > Mg > Ca.

Chloride had mean values ranging between 7473 mg/l in the dry season and 12078 mg/l during the wet season. Chloride is not considered as being harmful to human health. Chloride values above 250 mg/l produce a salty taste which makes the water unpalatable. Chloride values in the control were as high as 18900 mg/l in the wet season because of its nearness to the coast and brackish nature. High chloride values are harmful to plants; some damages may occur at levels as low as 70 – 250 mg/l (Radojevic and Bashkin, 1999).

Phosphate values ranged from 2.14 mg/l in the dry season to 5.52 mg/l in the wet season. Sulphate concentrations in natural water are usually between 2 and 80 mg/l; high concentration (>400 mg/l) may make water unpleasant to drink. Nitrogen compounds are of interest to environmentalists because they are both essential nutrients, beneficial to living organisms, and pollutants with potentially harmful consequences. Ammonia, nitrate and nitrite are indicators of nitrogen loading of waters. The mean nitrate and nitrite values recorded in this study ranged from 3.20 – 3.34 mg/l and 1.76 – 2.47 mg/l respectively. Higher values were recorded during the dry season. The ammonium nitrogen values were low, ranging from 0.03 – 0.12 mg/l in dry and wet seasons respectively. The levels of Total Hydrocarbon (THC), Total Petroleum Hydrocarbon (TPH), Polycyclic Aromatic Hydrocarbon (PAH), BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and Phenol recorded in this study were low, indicating an environment not polluted by petroleum hydrocarbons. The mean THC values ranged between 0.33 and 0.37 mg/l, TPH values ranged between 0.059 and 0.066 mg/l, while PAH values ranged from 0.001 to 0.018 µg/l. The BTEX and Phenol values ranged from 0.00 to 0.003 µg/l and 0.002 to 0.003 µg/l respectively. These values are below the regulatory limits.

Natural waters contain very small quantities of several essential metals including zinc (Zn), copper (Cu), Cadmium (Cd), lead (Pb), iron (Fe), Nickel (Ni), chromium (Cr), manganese (Mn), barium (Ba), vanadium (V) and mercury (Hg). These metals, also called trace or heavy metals are required by plants and animals in minute quantities. They are toxic in relatively high concentrations, persistent, easily assimilated and bio-accumulated in the protoplasm of aquatic organisms. The concentrations of heavy metals in the water samples were generally low and in some cases not detected. All heavy metals had mean values less than the regulatory limits, except for Fe (0.04 – 1.23 mg/l) and Pb (0.159 - 0.193 mg/l) which had values slightly greater than the regulatory limits of DPR (WHO) and FMEnv. High lead levels recorded in this study may be attributed to combustion of lead-containing fuel used in our water crafts (speed boats and barges).

Surface water microbiology

The results of microbiological study for both seasons are shown in Tables 4.5d and 4.5e. Total coliform counts in the surface water ranged from 11 – 35 MPN/100ml in the dry season and 12 – 40 MPN/100ml in the wet season. The control samples had total coliform in the range of 15 – 17 MPN/100ml in the dry and wet seasons. Faecal coliform was virtually absent in the wet season and scanty in the dry season (0 – 2.5 MPN/100ml).

Total heterotrophic bacteria (THB) in the surface water ranged from no growth to 2.8 x 10^4 cfu/ml in the dry season and were slightly higher in the wet season ranging from 6.8 – 8.0 x 10^4 cfu/ml. The control samples had THB in the range of 6.8 – 7.1 x 10^4 cfu/ml in the dry season and 5.8 – 6.2 x 10^4 cfu/ml in the wet season. Hydrocarbon utilizing bacteria (HUB) ranged from 0 – 2.8 x 10^2 cfu/ml in the dry season and 1.1 – 3.7 x 10^2 cfu/ml in the wet season. The HUB in the control station in both dry and wet seasons was within the range reported for the main samples. The HUB consisted of <1% of the THB. The predominant genera of bacteria isolated from the surface water were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Proteus*, *Alcaligenes* and *Staphylococcus*. Fungal population density was at least an order lower than bacteria population. Total fungi were within the range of 0.6 – 6.5 10^3 cfu/ml in the dry season and 0.8 – 1.7 10^3 cfu/ml in the wet season. Hydrocarbon utilizing fungi was virtually non-existent in both seasons. This is suggestive of absence of hydrocarbon contamination.

Table 4.5d: Surface water microbial population in the Dry season

Code	THB	HUB	Predominant Bacterial Isolate	Total Coli Form Count	Faecal colifom	TF	HUF	Predominant Fungal Isolate
	10^4cfu/ml	10^2 cfu/ml		MPN/100 ml	MPN/100ml	10^3 cfu/ml	10 cfu/ml	
SAG SWC1	6.8	1.3	*Pseudomonas sp.,E.coli, Bacillus sp., Enterobacter sp., Proteus sp*	15	1.1	2.3	1.2	*Penicillium sp, Aspergillus sp*
SAG SWC2	7.1	2.5	*Bacillus sp, Enterobacter sp, Pseudomonas sp,*	17	0.0	2.1	1.3	*Penicillium sp, Aspergillus sp*
SAG SW1	8.2	2.0	*Bacillus sp, Enterobacter sp, Pseudomonas sp,*	14	0.0	1.8	1.1	*Penicillium sp, Aspergillus sp*
SAG SW2	7.5	2.1		18	2.2	1.3	1.2	*Penicillium sp, Aspergillus sp*
SAG SW3	7.4	2.2	*Bacillus sp, Enterobacter sp, Pseudomonas sp,*	19	0.0	1.1	1.1	*Penicillium sp, Aspergillus sp*
SAG SW4	7.3	2.8	*Bacillus sp, Enterobacter sp, Pseudomonas sp,*	18	0.0	1.1	0.0	*Penicillium sp, Aspergillus sp*
SAG SW5	8.8	2.0	*Pseudomonas sp.,E.coli, Bacillus sp., Enterobacter sp., Proteus sp*	35	2.5	6.5	1.2	*Penicillium sp*
SAG SW6	6.9	0.5	*Bacillus sp., , Pseudomonas sp*	20	0.0	0.6	1.1	*Penicillium sp, Aspergillus sp*
SAG SW7	5.0	0.0	*Enterobacter sp. Bacillus sp*	11	0.0	0.9	0.0	*Penicillium sp*

Table 4.5e: Surface water microbial population in the wet season

Code	THB	THUB	Most Predominant Bacterial Isolate	Total Coli Form Count	Faecal coliform	TF	HUF	Most Predominant Fungal Isolate
	10^4cfu/ml	10^2 cfu/ml		MPN/100ml	MPN/100ml	10^3 cfu/ ml	10 cfu/ ml	
SAG SWC1	5.8	1.0	*Bacillus sp., Staphylococcus sp.*	17	0.0	0.9	0.0	*Penicillium sp, Aspergillus sp*
SAG SWC2	6.2	0.8	*E. coli, Enterbacter sp, E. coli, Enterbacter sp*	15	2.1	1.2	0.0	*Penicillium sp, Aspergillus sp*
SAG GW1	6.8	1.1	*Bacillus sp., Enterbacter sp*	12	0.0	1.4	1.0	*Aspergillus sp, Penicillium sp,*
SAG SW2	7.1	1.4	*E. coli, Staphylococcus sp.*	14	0.0	0.8	0,0	*Aspergillus sp, Penicillium sp*
SAG SW3	7.3	2.8	*Bacillus sp, Enterobacter sp, Pseudomonas sp,*	18	0.0	1.1	0.0	*Penicillium sp, Aspergillus sp*
SAG SW4	6.8	2.1	*Staphylococcus sp .Bacillus sp.,*	25	0.0	1.5	1.0	*Mucor sp, Aspergillus sp*
SAG SW5	7.9	1.8	*Bacillus sp., Enterobacter sp., Micrococcus sp, Serratia sp.*	20	0.0	1.2	0.0	*Penicillium sp., Aspergillus sp.*
SAG SW6	8.0	1.2	*Bacillus sp., Enterobacter sp., Micrococcus sp.*	40	0.0	2.7	1.0	*Penicillium sp., Aspergillus sp*
SAG SW7	7.5	3.7	*Staphylococcus sp.,Pseudomonas sp, E coli, Enterobacter sp*	17	0.0	1.0	0.0	*Penicillium sp, Aspergillus sp*

4.9: Sediment Physico-chemistry

The physico-chemical properties of the sediment were studied over two seasons (Tables 4.6a and Table 6b). The pH ranged from 4.26 – 5.66 with a mean of 4.90 in the dry season and 5.20 – 6.40 with a mean of 5.70 during the wet season. The control stations had pH of 4.8 – 4.9 in the dry season and was higher in the wet season (6.1 – 6.4). Values of pH in the range of 5.1 – 5.5 and 5.6 – 6.0 are classified as strongly acidic and moderately acidic respectively (Hazelton and Murphy, 2007). Acidic pH is not unusual in mangrove ecosystems of the world including the Niger Delta (Anderson 1966, van Breemen, 1996; Ohimain 2004, Ohimain et al 2004). Exchangeable Acidity (EA) ranged from 1.30 – 2.30 meq/100g in the dry season and 0.60 – 1.80 meq/100g in the wet season. The control station had an EA of 1.7 – 1.9 meq/100g in the dry season and 1.0 – 1.8 meq/100g in the wet season, thus falling in the same range with the main samples. Typical values for exchangeable acidity normally range from 0.5 meq/100g to 1.5 meq/100g.

Electrical conductivity (EC) ranged from 10,370 – 16,200 µS/cm (mean = 14,065 µS/cm) in the dry season and was lower in the wet season ranging from 3960 – 11,920 µS/cm (mean =7327 µS/cm). The control stations have an EC of 8,000- 9,100 µS/cm in the dry season and lower in the wet season 4700 – 4940 µS/cm. The seasonal variation in EC may be caused by rainfall and tidal flooding. The major exchangeable cations in the sediment include sodium, potassium, calcium and magnesium. Sodium concentration ranged from 8.50 – 10.74 meq/100g (mean = 9.58 meq/100g) in the dry season and 5.04 – 7.93 meq/100g (mean = 6.47 meq/100g) in the wet season. The control stations had a Na concentration of 8.6 – 9.5 meq/100g in the dry season and 5.04 – 5.54 meq/100g in the wet season. The lower values of the Na in the wet season may be due to seasonal and tidal influences. Potassium concentration in the sediment ranged from 3.50 - 7.55 meq/100g with a mean of 5.32 meq/100g in the dry season, and was lower in the wet season 0.71 -4.83 (mean = 2.78 meq/100g). The dry season control samples had K concentration of 1.7 – 1.9 meq/100g and 0.71 – 1.22 meq/100g in the wet season. Calcium ranged from 9.08 – 16.40 meq/100g (mean 12.81 meq/100g) in the dry season and 8.61 – 15.3 meq/100g (10.8 meq/100g) in the wet season. The control stations had Ca within the range of the values of the samples for both the dry (9.8 – 10.8 meq/100g) and wet seasons (8.61 8.64meq/100g). Magnesium was similarly higher in the dry season (7.01 – 14.90; mean 10.02 meq/100g) than the wet season (5.48 – 10.70; mean 7.61 meq/100g). The dry season control (8.58 – 8.62 meq/100g) was also higher than the wet season control (6.17 – 6.32 meq/100g). The lower values of the exchangeable cations in the wet season may be due to seasonal and tidal influences.

The major anionic species in the sediment are chloride and sulphate. Chloride was lower in the dry season (107 – 113 mg/kg; mean 109 mg/kg) than the wet season 1233 – 3767 (mean 2338 mg/kg). Chloride in the control ranged from 110 – 121 mg/kg in the dry season and 1609 – 1731 mg/kg in the wet season. Similarly, sulphate was lower in the dry season (200 – 520, mean, 283 mg/kg) than the wet season (350 – 6,120, mean 958 mg/kg). The control sample had sulphate 250 – 320 mg/kg in the dry season and 350 – 428 mg/kg in the wet season. The higher values of sulphate and chloride in the wet season might be due to seasonal and tidal influences.

Total Nitrogen (TN) was 0.58 – 0.81% (mean 0.70%) in the dry season and 0.27 – 0.92% (mean 0.71%) in the wet season. The control samples had a TN of 0.59 – 0.65% in the dry season and 0.27 – 0.95 %in the wet season. There was no seasonal difference in TN. During the dry season, other nitrogen related parameters include ammonium (1.00 – 22.4 mg/kg), nitrite (4.7 – 11.5 mg/kg) and nitrate (6.5 -23.2 mg/kg). In the wet season, they were 12.2 – 19.2 mg/kg, 2.0 – 15.4 mg/kg and 4.0 – 19.8 mg/kg respectively. Phosphate ranged from 3.9 – 8.9 mg/kg in the dry season and 0.4 – 5.6 mg/kg in the wet season. These nutrients are critical for the survival of benthic microorganisms.

Hydrocarbon/organic related parameters studied include TOC, THC, TPH, BTEX, PAH and phenols over the two seasons. The TOC ranged from 4.90 – 6.20% (mean 5.63%) in the dry season and 1.32 – 4.77% (mean 3.60%) in the wet season. The THC ranged from 26.40 – 69.50 mg/kg (mean 49.37 mg/kg) in the dry season and 36.5 – 69.6 mg/kg (55.9 mg/kg) in the wet season. At the control site the THC concentration was 41.2 – 41.5 mg/kg and 52.1 – 53.5 mg/kg in the dry and wet seasons respectively. Total hydrocarbons are derived from petrogenic and vegetable sources. However, TPH consists of hydrocarbons from petroleum sources. During this study, TPH was <2.0 mg/kg in both seasons, which is very low compared to the DPR intervention level of 5,000 mg/kg. All the other hydrocarbon related parameters including BTEX, PAH and phenols occurred in traces and were generally <0.01 in both seasons, suggesting minimum hydrocarbon contamination in the sediment.

Iron, the dominant heavy metal in the sediment ranged from 133.0 – 135.8 mg/kg with a mean of 140.71 mg/kg in the dry season and was higher in the wet season ranging from 194.2 – 212.1 mg/kg with a mean of 207.0 mg/kg. High levels of iron are not unusual in mangrove ecosystems of the world including the Niger Delta (Anderson 1966, van Breemen, 1996; Ohimain 2004, Ohimain *et al.* 2004). In both seasons, some heavy metals ranged from not detected (ND) to 0.1 mg/kg (Cr and Cd), 1 – 10 mg/kg (Ni and V), 11 – 20 (Zn) and 21 – 40 mg/kg (Mn, Cu and Pb).The concentrations of all the heavy metals were lower during the wet season except iron.
Mechanical analysis of the soil revealed that sand ranged from 88.10 – 92.5% (mean 90.29 %). Clay was 6.8 – 11.4 % (mean 8.54) while silt accounted for the remainder. With these properties, the texture of the soils of the study area could be described as sandy according to USDA soil classification. Because of the high porosity and permeability of sandy formation, contaminants can easily migrate though these formations.

Table 4.6a: Physicochemical properties of sediment in Saghara during the dry season

Parameters	Units	SAG SDC1	SAG SDC2	SAG SD1	SAG SD2	SAG SD3	SAG SD4	SAG SD5	SAG SD6	SAG SD7
pH		4.8	4.9	4.8	4.8	4.8	4.9	4.26	5.66	5.11
EC	µS/cm	9100	8000	15900	16200	15100	15400	12150	13340	10370
Org. C	%	6.1	3.84	6.2	6.1	5.94	5.68	5.66	4.94	4.9
Total N.	%	0.59	0.65	0.81	0.8	0.75	0.68	0.68	0.59	0.58
Na	meq/100g	9.5	8.6	9.5	8.5	9.1	8.63	10.58	10.74	10.04
K	‘’	1.7	1.9	3.5	4.6	4.5	3.92	7.55	6.01	7.17
Ca	‘’	10.8	9.8	15.5	16.4	12.6	9.08	12.13	11.93	12.03
Mg	‘’	8.58	8.62	8.94	12.5	14.9	7.01	9.9	7.1	9.76
EA	‘’	1.9	1.7	1.9	2.2	2.3	1.3	1.9	1.6	2.3
Cl^-	mg/kg	121	110	107	113	109	107	110	107	110
PO_4	‘’	9.5	5.8	5.6	5.9	6.1	8.9	5.9	4.5	3.9

Parameters	Units	SAG SDC1	SAG SDC2	SAG SD1	SAG SD2	SAG SD3	SAG SD4	SAG SD5	SAG SD6	SAG SD7
NH_4N	‘ ’	19	18.5	20.1	20.5	22.4	21.1	1.8	1	2.1
NO_2^-N	‘ ’	11.2	10.5	11.5	9.9	8.2	8.4	4.7	10.6	9.6
NO_3^-N	‘ ’	22.1	20.4	23.2	18.5	12.4	9.4	6.5	12.6	10.8
SO_4	‘ ’	320	250	200	230	310	302	220	200	520
Silt	%	4.1	4.7	3.6	3.9	3.7	2.5	3.9	3.6	4.1
Clay	‘ ’	8.1	7.2	6.8	8.7	11.4	6.8	9.7	8.6	7.8
Sand	‘ ’	91.4	92.3	92.5	91.5	90.1	91.6	88.4	89.8	88.1
THC	mg/kg	41.5	41.2	43.2	26.4	29.5	69.5	67.4	54.8	54.8
TPH	‘ ’	0.641	0.164	0.182	0.156	0.127	1.986	0.686	0.394	1.404
PAH	‘ ’	0.002	0.003	0.004	0.008	0.003	0.222	0.118	0.099	0.217
Benzene	µg/kg	0.001	0.001	0.004	0.001	0.005	0.112	0.131	0.069	0.313
Toluene	‘ ’	0.002	0.001	0.001	0.001	0.001	0.006	0.005	0.001	0.007
Ethylbenzene	‘ ’	ND	ND	ND	ND	ND	0.002	ND	ND	0.001
Xylene	‘ ’	0.001	0.001	0.002	0.002	0.001	0.006	0.002	0.001	0.006
Phenol	‘ ’	0.001	0.003	0.001	0.002	0.004	0.031	0.014	0.019	0.036
Fe	mg/kg	124.3	135.4	152.4	135.1	141.2	133.4	133	134.1	155.8
Cu	“	21.5	22.4	20.3	22.1	25.3	28.9	14.7	30.5	27.3
Mn	“	23.4	26.2	21.2	22.3	21.1	21.4	18.2	21.5	2.8
Zn	“	16.1	15.8	14.5	15.2	14.3	14.6	14.3	16.9	16
Cd	“	0.18	0.17	0.19	0.2	0.19	0.16	0.18	0.28	0.19
Cr	“	0.25	0.21	0.22	0.21	0.25	0.3	ND	0.29	0.41
Pb	“	28.8	29.2	31.2	29.4	31.2	32.6	33.2	28.8	24.3
Ni	“	3.1	3.5	4.1	4.5	4.3	4.4	4.1	15.3	4.5
V	“	2.5	2.4	3.3	2.5	2.3	3.7	3.6	13.2	3.9
Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ba	“	0.001	0.001	0.002	0.003	0.002	0.003	0.001	0.004	0.003

Table 4.6b: Physicochemical properties of sediment in Saghara during the wet season

Parameters	Units	SAG SDC1	SAG SDC2	SAG SD1	SAG SD2	SAG SW3	SAG SD4	SAG SD5	SAG SD6	SAG SD7
pH		6.1	6.4	5.3	5.3	5.2	5.9	5.3	5.9	5.7
EC	µS/cm	4940	4700	11000	11870	11920	3960	5550	5360	6640
Org. C	%	4.63	1.32	4.45	4.44	3.69	3.12	2.64	4.77	3.36
Total N.	%	0.95	0.27	0.90	0.85	0.71	0.60	0.51	0.92	0.65
Na	meq/100g	5.04	5.42	6.21	7.93	6.56	5.99	6.79	7.46	6.84
K	‘ ’	0.71	1.22	2.45	4.83	2.45	2.14	3.88	4.28	3.06
Ca	‘ ’	8.61	8.64	8.97	15.3	9.45	12.6	9.30	12.3	12.1
Mg	‘ ’	6.17	6.32	6.81	9.21	7.15	8.62	7.50	8.12	8.60
EA	‘ ’	1.8	1.0	0.6	1.2	1.4	1.6	1.6	0.9	1.6
Cl^-	mg/kg	1731	1609	3767	3801	3711	1233	1728	1600	1861
PO_4	‘ ’	2.8	0.8	1.2	5.6	1.2	3.2	1.2	0.4	1.6
NH_4N	‘ ’	17.0	12.2	16.0	19.2	18.6	18.8	16.6	18.8	12.6
NO_2^-N	‘ ’	9.0	7.6	15.4	4.2	2.0	6.4	7.2	8.2	8.4
NO_3^-N	‘ ’	18.2	14.4	19.8	9.2	4.0	12.8	14.2	16.6	18.2
SO_4	‘ ’	428	350	1134	1202	1104	1242	820	1262	1082
Silt	%	3.1	2.2	2.3	2.9	4.7	2.8	2.9	2.5	2.4
Clay	‘ ’	7.5	6.1	5.8	7.7	11.6	12.3	7.8	6.6	5.9
Sand	‘ ’	89.4	91.7	91.9	89.4	83.7	84.9	89.3	90.9	91.7
THC	mg/kg	53.5	52.1	55.5	48.5	36.5	69.6	56.7	59.1	71.5
TPH	‘ ’	0.196	0.564	0.203	0.196	0.167	0.216	0.326	6.764	1.086
PAH	‘ ’	0.003	0.213	0.068	0.002	0.048	0.021	0.007	0.008	0.022
Benzene	µg/kg	0.002	0.004	0.165	0.055	0.011	0.009	0.279	0.281	0.006
Toluene	‘ ’	0.001	0.002	0.002	0.001	0.002	0.003	0.001	0.001	0.001
Ethylbenzene	‘ ’	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene	‘ ’	0.002	0.003	0.002	0.001	0.002	0.003	0.004	0.003	0.001
Phenol	‘ ’	0.001	0.005	0.003	0.004	0.002	0.008	0.017	0.014	0.001
Fe	mg/kg	194.3	201.6	202.4	210.0	203.5	211.8	211.1	212.9	215.1
Cu	“	2.28	2.46	6.02	5.96	6.13	6.72	5.20	7.10	6.55
Mn	“	3.36	3.35	3.14	3.63	3.04	3.66	3.64	3.68	3.61
Zn	“	3.68	4.01	3.86	10.2	9.12	8.83	8.48	10.2	9.61
Cd	“	0.03	0.04	0.22	0.25	0.24	0.03	0.03	0.05	0.03
Cr	“	1.48	1.43	1.51	1.60	1.48	1.61	1.60	1.62	1.55
Pb	“	3.62	2.98	3.61	6.88	4.97	5.80	5.43	5.07	4.62
Ni	“	0.97	1.21	2.42	1.45	2.86	1.61	1.53	5.56	4.51
V	“	0.71	0.83	1.86	1.13	1.91	1.18	1.11	4.14	3.46
Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ba	“	0.003	0.002	0.001	0.002	0.004	0.001	0.002	0.002	0.003

Table 4.6c: Summary of the physicochemical and microbiological properties of Saghara area

		Dry Season					Wet Season					DPR TARGET – INTERVENTION LIMITS
		Control		Samples			Control		Samples			
Parameters	Units	SAG SDC1	SAG SDC2	MIN	MAX	MEAN	SAG SDC1	SAG SDC2	MIN	MAX	MEAN	
pH		4.8	4.9	4.26	5.66	4.90	6.1	6.4	5.2	6.4	5.7	5.5-6.5
EC	µS/cm	9100	8000	10370.00	16200.00	14065.71	4940	4700	3960	11920	7327	
Org. C	%	6.1	3.84	4.90	6.20	5.63	4.63	1.32	1.32	4.77	3.60	
Total N.	%	0.59	0.65	0.58	0.81	0.70	0.95	0.27	0.27	0.92	0.71	
Na	meq/100g	9.5	8.6	8.50	10.74	9.58	5.04	5.42	5.04	7.93	6.47	
K	‘’	1.7	1.9	3.50	7.55	5.32	0.71	1.22	0.71	4.83	2.78	
Ca	‘’	10.8	9.8	9.08	16.40	12.81	8.61	8.64	8.61	15.3	10.8	
Mg	‘’	8.58	8.62	7.01	14.90	10.02	6.17	6.32	5.48	10.7	7.61	
EA	‘’	1.9	1.7	1.30	2.30	1.93	1.8	1.0	0.6	1.8	1.3	
Cl^-	mg/kg	121	110	107.00	113.00	109.00	1731	1609	1233	3767	2338	
PO_4	‘’	9.5	5.8	3.90	8.90	5.83	2.8	0.8	0.4	5.6	2	
NH_4N	‘’	19	18.5	1.00	22.40	12.71	17.0	12.2	12.2	19.2	16.6	
NO_2^-N	‘’	11.2	10.5	4.70	11.50	8.99	9.0	7.6	2.0	15.4	7.6	
NO_3^-N	‘’	22.1	20.4	6.50	23.20	13.34	18.2	14.4	4.0	19.8	14.2	
SO_4	‘’	320	250	200.00	520.00	283.14	428	350	350	6120	958	
Silt	%	4.1	4.7	2.50	4.10	3.61	3.1	2.2	2.2	4.7	2.9	
Clay	‘’	8.1	7.2	6.80	11.40	8.54	7.5	6.1	6.1	12.3	7.9	
Sand	‘’	91.4	92.3	88.10	92.50	90.29	89.4	91.7	83.7	91.7	89.2	
THC	mg/kg	41.5	41.2	26.40	69.50	49.37	53.5	52.1	36.5	69.6	55.9	
TPH	‘’	0.641	0.164	0.13	1.99	0.71	0.196	0.564	0.167	6.764	1.080	5000

		Dry Season					Wet Season					DPR TARGET – INTERVENTION LIMITS
		Control		Samples			Control		Samples			
Parameters	Units	SAG SDC1	SAG SDC2	MIN	MAX	MEAN	SAG SDC1	SAG SDC2	MIN	MAX	MEAN	
PAH	‘’	0.002	0.003	0.00	0.22	0.10	0.003	0.213	0.002	0.213	0.044	
Benzene	µg/kg	0.001	0.001	0.00	0.31	0.09	0.002	0.004	0.002	0.281	0.090	
Toluene	‘’	0.002	0.001	0.00	0.01	0.00	0.001	0.002	0.001	0.008	0.002	
Ethylbenzene	‘’	ND	ND	0.00	0.00	0.00	ND	ND	ND	ND	ND	
Xylene	‘’	0.001	0.001	0.00	0.01	0.00	0.002	0.003	0.001	0.004	0.002	
Phenol	‘’	0.001	0.003	0.00	0.04	0.02	0.001	0.005	0.001	0.017	0.006	
Fe	mg/kg	124.3	135.4	133.00	155.80	140.71	194.3	201.6	194.2	212.1	207.0	
Cu	“	21.5	22.4	14.70	30.50	24.16	2.28	2.46	2.28	7.10	5.38	
Mn	“	23.4	26.2	2.80	22.30	18.36	3.36	3.35	3.04	3.66	3.46	
Zn	“	16.1	15.8	14.30	16.90	15.11	3.68	4.01	3.68	10.2	7.55	720
Cd	“	0.18	0.17	0.16	0.28	0.20	0.03	0.04	0.03	0.25	0.10	
Cr	“	0.25	0.21	0.21	0.41	0.28	1.48	1.43	1.43	1.62	1.54	380
Pb	“	28.8	29.2	24.30	33.20	30.10	3.62	2.98	2.98	6.88	4.78	530
Ni	“	3.1	3.5	4.10	15.30	5.89	0.97	1.21	0.97	5.56	2.46	
V	“	2.5	2.4	2.30	13.20	4.64	0.71	0.83	0.71	4.14	1.81	
Hg	“	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Ba	“	0.001	0.001	0.00	0.00	0.00	0.003	0.002	0.001	0.004	0.002	

Sediment Microbiology

Microbial analysis was carried out in the sediment of the study area. Total heterotrophic bacteria (THB) in the sediments ranged from 2.4 – 3.3 x 10^4 cfu/g in the dry season and 2.4 – 3.7 x 10^4 cfu/g in the wet season. Hydrocarbon utilizing bacteria (HUB) ranged from 0.3 – 1.8 x 10^2 cfu/g in the dry season and 0.3 – 1.0 x 10^2 cfu/g in the wet season. In both seasons, HUB consisted of <1% of the THB. The population of THB and HUB of the control samples is within the same range reported for the main samples. The predominant genera of bacteria isolated from the sediment were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Proteus*, *Alcaligenes*, *Micrococcus* and *Staphylococcus*. The population of total fungi is an order lower than that of bacteria, ranging from 0.1 – 3.7 x 10^3 cfu/g in the dry season and was slightly lower in the wet season (0.1 – 2.0 x 10^3 cfu/g). The total fungi in the control sample ranged from 1.3 – 1.5 x 10^3 cfu/g in the dry season to 2.9 -3.2 x 10^2 cfu/g in the wet season. Hydrocarbon utilizing fungi (HUF) were scanty in both seasons, ranging from 0 – 62 cfu/g in the dry season to 0 – 30 cfu/g in the wet season. Note that population of microbes <30 cfu/g obtained via pour/spread plate/cultural methods are considered statistically insignificant. Predominant fungal genera in the study area were *Penicillium* and *Aspergillus*.

Table 4.6d: Sediment microbial population density during the dry season

Code	THB	THUB	Predominant Bacterial Isolate	TF	HUF	Predominant Fungal Isolate
	10^4 cfu/g	10^2 cfu/g		10^3 cfu/g	10cfu/g	
SDC1	3.1	1.3	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	3.2	5.0	*Aspergillus sp, Penicillium sp*
SDC2	2.8	1.5	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	4.5	6.0	*Aspergillus sp, Penicillium sp*
SD1	3.3	1.1	*Micrococcus sp, Pseudomonas sp., Enterobacter spStaphyloccocus sp Bacillus sp*	3.7	5.5	*Aspergillus sp, Penicillium sp*
SD2	3.1	1.6	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	3.5	6.2	*Aspergillus sp, Penicillium sp*
SD3	4.2	1.1	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	2.8	5.8	*Aspergillus sp, Penicillium sp*
SD 4	3.3	1.2	*Micrococcus sp., Bacillus sp, Nocardia sp.*	3.1	6.0	*Aspergillus sp, Penicillium sp*
SD 5	3.3	1.0	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	0.1	5.0	*Aspergillus sp Penicillium sp*

Code	THB	THUB	Predominant Bacterial Isolate	TF	HUF	Predominant Fungal Isolate
	10^4 cfu/g	10^2 cfu/g		10^3 cfu/g	10cfu/g	
SD 6	2.6	1.8	*Bacillus sp. Norcardia sp*	3.5	7.1	*Aspergillus sp, Penicillium sp*
	2.4	0.3	*Staphylococcus sp, Pseudomonas sp, Micrococcus sp*	0.1	0.1	*Penicillium sp, Aspergillus sp*

Table 4.6e: Sediment microbial population density during the wet season

Code	THB	HUB	Predominant Bacterial Isolates	TF	HUF	Predominant Fungal Isolates
	10^4 cfu/g	10^2 cfu/g		10^3 cfu/g	10^2 cfu/g	
SAG SDC1	2.9	1.0	*Staphylococcus sp., Pseudomonas sp., Bacillus sp*	0.3	0.0	*Aspergillus sp, Penicillium sp*
SAG SDC2	3.2	1.3	*Micrococcus sp, Bacillus sp,*	0.8	0.2	*Aspergillus sp*
SAG SD1	2.4	0.3	*Staphylococcus sp., Bacillus sp*	0.1	0.1	*Aspergillus sp*
SAG SD2	3.7	0.8	*Staphylococcus sp, Micrococcus sp., Bacillus sp*	0.4	0.1	*Aspergillus sp*
SAG SD3	2.8	1.0	*Norcardia sp., Bacillus sp. Enterobacter sp*	1.3	0.2	*Aspergillus sp, Penicillium sp*
SAG SD4	2.8	0.9	*Bacillus sp, Pseudomonas sp ,Micrococcus sp*	0.2	0.1	*Aspergillus sp*
SAG SD5	2.9	1.0	*Staphylococcus sp., Micrococcus sp, Bacillus sp*	2.0	0.3	*Aspergillus spp*
SAG SD6	3.7	0.7	*Pseudomonas sp, Staphylococcus sp., Bacillus sp.*	0.3	0.0	*Aspergillus sp, Penicillium sp*
SAG SD7	3.3	1.0	*Micrococcus sp, Pseudomonas sp., Enterobacter sp Bacillus sp*	0.1	0.0	*Aspergillus sp*

4.10: Hydrobiology

Hydrobiological investigations covered the species composition, density, community structure and diversity of the biotic or living components (phytoplankton, zooplankton and benthic invertebrates) of the environment and their interactions amongst themselves and with the abiotic or physico-chemical conditions of the environment. The results of field and laboratory investigations of the ecological communities of the study area are presented below. Nine sampling stations, SW1-SW7 and two control points (SWC1 –SWC2) were studied.

Phytoplankton

Phytoplankton flora are microscopic chlorophyll containing plants that are found in aquatic ecosystems where they function as primary producers. Majority of phytoplankton have been used for biological monitoring of the environment since they cannot survive in adverse environmental conditions like high turbidity, anoxic state, extreme salinity and low nutrient level. Major important members of the phytoplankton group include the divisions Chlorophyta (green algae), Cyanophyta or Cyanobacteria (blue-green algae) and Bacillariophyta (diatoms). The wet season phytoplankton flora were represented by thirty three (33) taxa belonging to five divisions, the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids) (Table **4.7a)**.

Table 4.7a: List of Phytoplankton Species

DIVISION	**SPECIES (WET)**	**SPECIES (DRY)**
Bacillariophyta	*Achnanthes delicatula,*	*Achnanthes delicatula*
	Asterionella formosa	*Asterionella Formosa*
	Amphora ovalis	*Amphora ovalis*
	Biddulphia aurita	*Biddulphia aurita*
	Bacillaria paradoxa	*Bacillaria paradoxa*
	Chaetoceros mulleri	*Chaetoceros mulleri*
	Coscinodiscus radiata	*Coccinodiscus radiata*
		Coscinodiscus coincinus
		C. lacustris
	Cyclotella quadricincira	*Cyclotella quadricincira*
	Cyclotella sp	*Cyclotella sp*
	Cymbella affinis	*Cymbella affinis*
	Diploneis ovalis	*Diploneis ovalis*
	D. interrupta	*D. interrupta*
		Fragilaria javanica
	Gomphonema parvulum	*Gomphonema parvulum*
	Melosira granulata	*Melosira granulata*
	Navicula bacillum	*Navicula bacillum*
	Nitzschia closterium	*Nitzschia closterium*
	N. obtusa	*N. Obtusa*
		Odontella regia
	Pleurosigma elongatum	*Pleurosigma elongatum*
		Terpsinoe musica
Cyanophyta	*Anabaena cylindrica*	*Anabaena cylindrica*
	Anabaena sp	*Anabaena sp*
	Chroccocus sp	*Chroccocus sp*
	Oscillatoria limosa	*Oscillatoria limosa*
	Phormidium ambiguum	*Phormidium ambiguum*
	Spirulina major	*Spirulina major*
Dinophyta	*Ceratium hirudinella*	*Ceratium hirudinella*
	Gymnodinum sp	*Gymnodinum sp*
	Peridinium sp	*Peridinium sp*

DIVISION	SPECIES (WET)	SPECIES (DRY)
Chlorophyta	*Scenedesmus quadricauda*	*Scenedesmus quadricauda*
	Closterium parvulum	*Closterium acerosum*
	Volvox africana	*Closterium parvulum*
	Volvox aureus	*Pleurotaenium minutum*
		Volvox africana
Euglenophyta	*Euglena sp*	*Euglena sp*
	Phacus longicauda	*Phacus longicauda*

The Bacillariophyta were represented by 18 species, constituting 48 % of the total flora; this was followed by the Chlorophyta, represented by 4 species, accounting for 26 %. Cyanophyta was represented by 6 species, accounting for 19 % of the phytoplankton flora, while the Dinophyta and Euglenophyta were represented by 3 and 2 species each, constituting 3 % and 4% respectively. This distribution is shown in **Fig. 4.2a**.

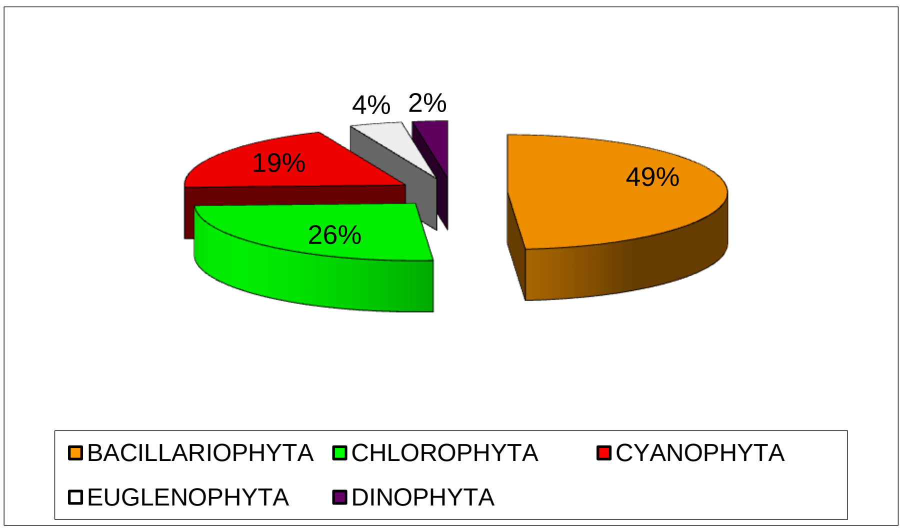

Fig. 4.2a: Percentage Composition of Phytoplankton Divisions in the Wet Season

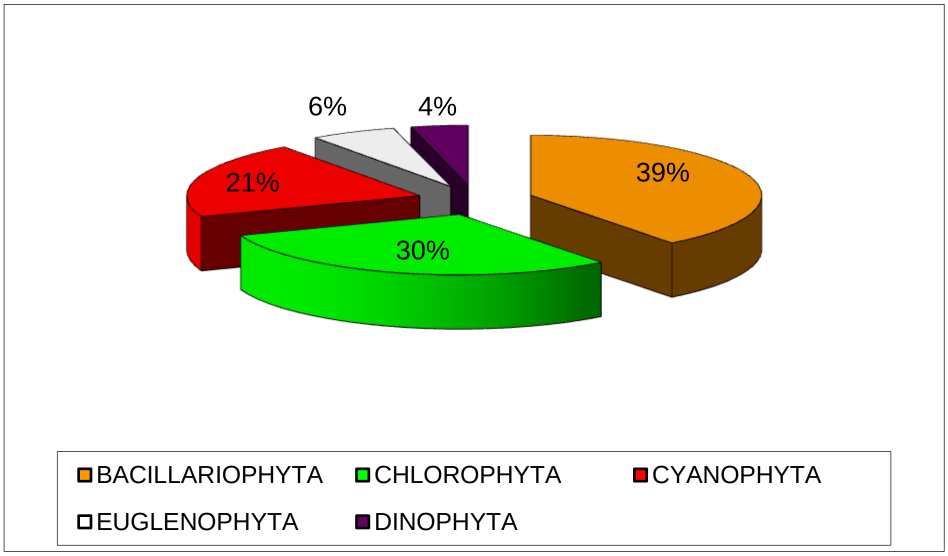

Fig. 4.2b: Percentage Composition of Phytoplankton Divisions in the Dry Season

The dry season phytoplankton community were represented by forty (40) species distributed into similar divisions, the Bacillariophyta (diatoms), Cyanophyta (Blue-green algae), Dinophyta (dinoflagellates) Chlorophyta (green algae) and Euglenophyta (Euglenoids) as in the wet season (Table **4.7a)**. The diatoms still dominated the population, but followed closely by Chlorophyta and Cyanophyta (Fig. 4.2b). Phytoplankton density was higher during the dry season because of increased illumination and photosynthetic activities.

The major phytoplanktonic organisms identified during both seasons are characteristic of brackish and oligohaline (intermediate zone between freshwater and brackish water) environment. These were *Biddulphia aurita*, *Chaetoceros* sp. *Coscinodiscus* spp. and *Tabellaria fenestra* for the diatoms; *Anabaena* sp, and *Oscillatoria* sp for the Cyanophyceae; *Gymnodium* sp for the dinoflagellates, *Closterium*, sp for the Chlorophyta and *Euglena* sp for the euglenoids.
The density of phytoplankton varied among the study stations with the highest density occurring in the control stations during both wet and dry seasons. In all stations, the density was higher in the dry season than in the wet season due to increased illumination resulting in higher photosynthetic activity (Fig 4.2c).

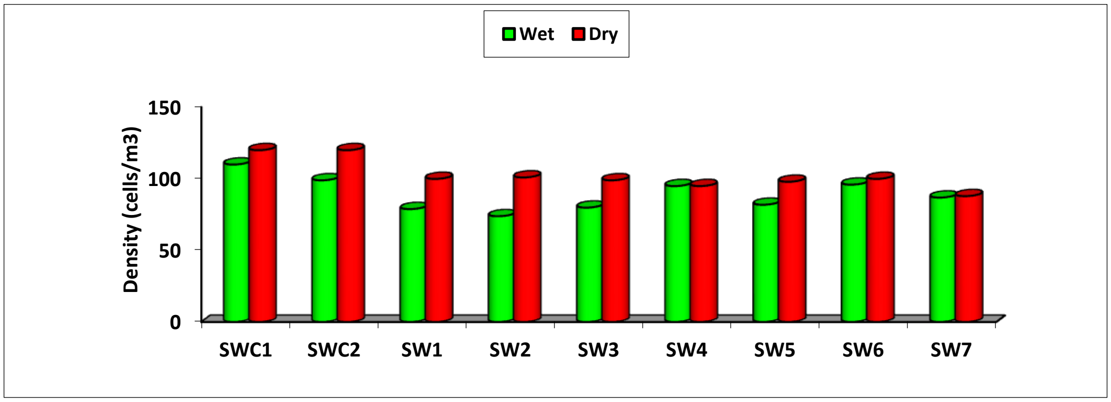

Fig. 4.2c: Spatial variation in the total density of phytoplankton

Zooplankton

These are microscopic animals found mainly in the pelagic zone of water bodies where they depend on water currents and waves for motion. The zooplankton community may be holoplanktonic or meroplanktonic. Zooplankton communities in the tropics consist of the Rotifera, Cladocera, Copepoda and meroplanktonic larvae of benthic and nektonic organisms (Egborge, 1994; Ogbeibu & Egborge, 1995). They are good biological indicators of water quality. Their sensitivity to environmental factors (natural and man-made), makes them of considerable significance in pollution and environmental impact assessment studies.

In this study, 27 zooplankton taxa were recorded for both wet and dry seasons, with more species occurring in the dry (27) than in the wet (24) season. The wet season community comprised 13 species of Cladocera, 4 Copepod taxa, and 7 species of Rotifera (**Table 4.7b)**. The wet season zooplankton fauna were dominated by Cladocera, with 44% composition; this was followed by the Rotifera (29%) while Copepoda accounted for 27% of the zooplankton fauna **(Fig 4.2d).** The density and relative contributions of major taxonomic groups to the total population however differed among the seasons.

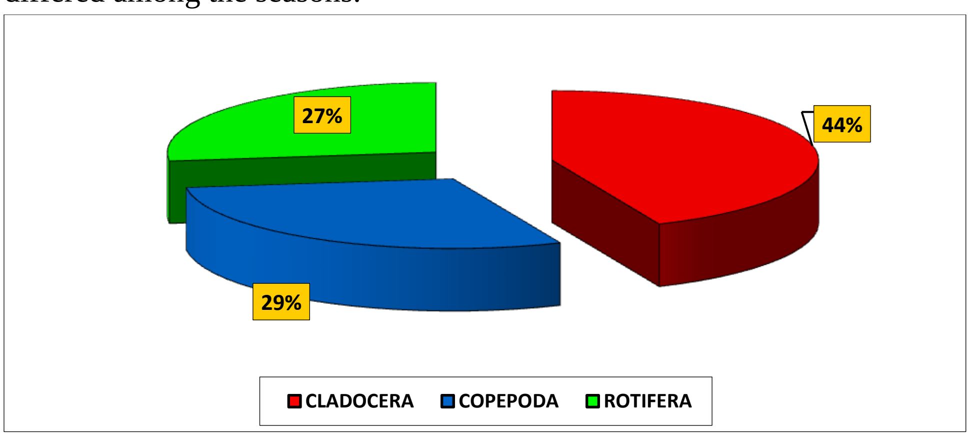

Fig. 4.2d: Percentage Composition of Wet season Zooplanktonic Organisms

The dry season zooplankton fauna were made up of 15 species of Cladocera, 5 species of Copepoda and 7 species of Rotifera. The community was dominated by Cladocera, with 41% composition; followed by the Copepoda (32%), while Rotifera accounted for 27% of the zooplankton population density (**Fig 4.2e).**

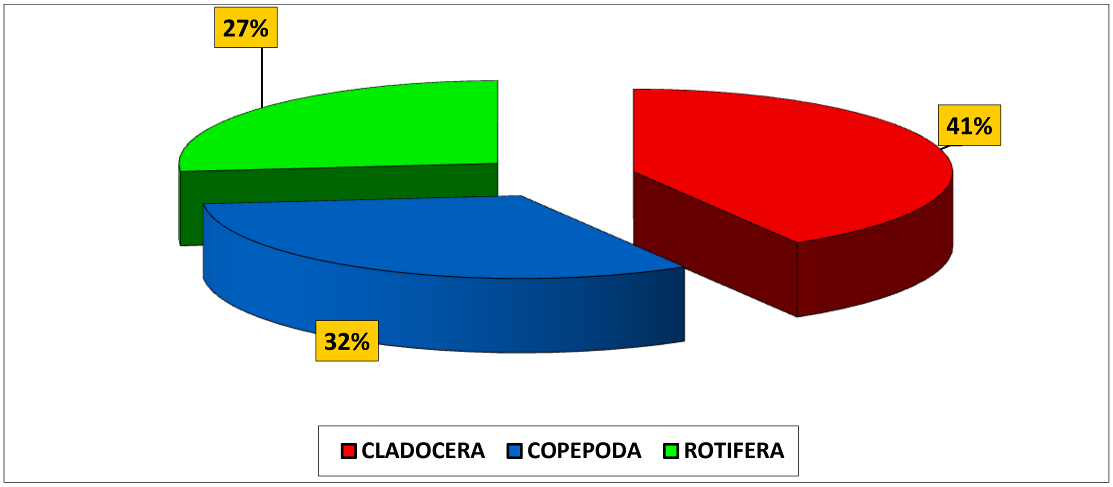

Fig. 4.2e: Percentage Composition of Dry season Zooplanktonic Organisms

The Cladocera were dominated by the family Chydoridae with 5 species in the wet season and 7 in the dry season, while the Rotifera were represented mainly by the family Brachionidae and few lecanids. The Copepoda were only represented by the Order Cyclopoida, a common phenomenon in most brackish waters (Ogbeibu and Oribhabor 2011). However, all species recorded are cosmopolitan (ubiquitous) and have been reported in several studies of ecologically equivalent ecosystems (Ogbeibu and Omoigberale, 2005, Omoigberale and Ogbeibu 2007; Ogbeibu and Oribhabor 2011).

Table 4.7b: Zooplankton composition in the study area

Zooplanktonic Group	**Species (Wet)**	**Species (Dry)**
CLADOCERA		
Family Bosminidae	*Bosmina longirostris*	*Bosmina longirostris*
	Bosminopsis deitersi	*Bosminopsis deitersi*
Family Chydoridae	*Alona affinis*	*Alona affinis*
	Alonella excisa excisa	*Alonella excisa excisa*
	Chydorus sphaericus	*Chydorus sphaericus*
	C. parvus	*C. parvus*
		C. eurynotus
	Euryalona orientalis	*Euryalona orientalis*
	Kurzia longirostris	*Kurzia longirostris*
Family Daphnidae	*Ceriodaphnia cornuta*	*Ceriodaphnia cornuta*
	Daphnia sp	*Daphnia* sp

Zooplanktonic Group	**Species (Wet)**	**Species (Dry)**
Family Moinidae	*Moina micrura*	*Moina micrura*
	Moinodaphnia mecleayi	*Moinodaphnia mecleayi*
Family Sididae	*Diaphanosoma excisum*	*Diaphanosoma excisum*
		Penilia sp
COPEPODA	*Eucyclops serrulatus*	*Eucyclops serrulatus*
	Mesocyclops sp	*Mesocyclops* sp
	Microcyclops varicans	*Microcyclops varicans*
	Thermocyclops decipiens	*Thermocyclops decipiens*
		Thrermocyclops neglectus
ROTIFERA		
Family Asplanchnidae	*Asplanchna priodonta*	*Asplanchna priodonta*
Family Brachionidae	*Brachionus calyciflorus*	*Brachionus calyciflorus*
	B. caudatus	*B. caudatus*
	B. quadridentata	*B. quadridentata*
	Keratella sp	*Keratella* sp
Family Lecanidae	*Lecane curvicornis*	*Lecane curvicornis*
	L. (Monostyla) quadridentata	*L. (Monostyla) quadridentata*

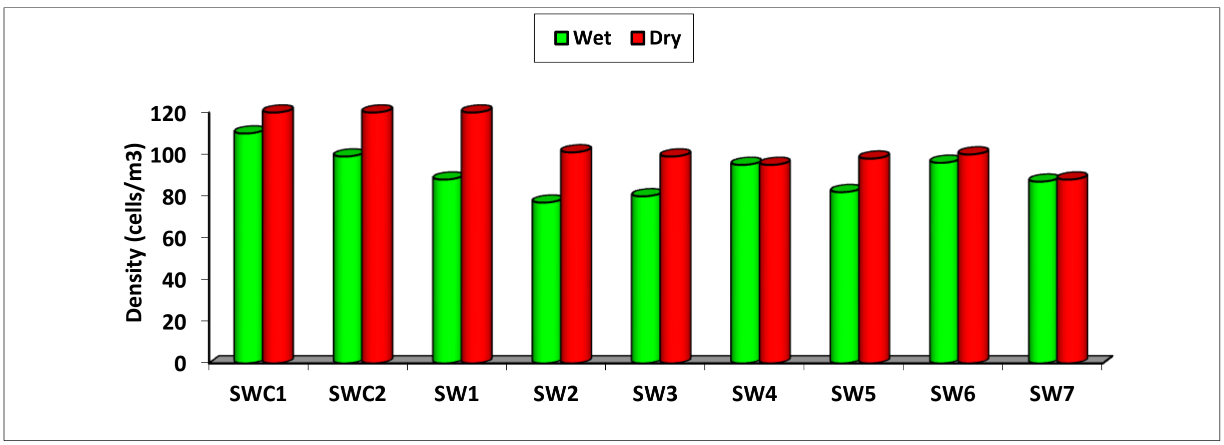

Fig. 4.2f: Spatial variation in the total density of Zooplankton

Spatially, the density of zooplankton varied among the study stations from a total density of 175 individuals/m^3 in SW2 to 230 individuals/m^3 in the control station (SWC1). Local variations in density of zooplankton can be influenced by inherent variability and patchiness in zooplankton distribution, and also food abundance and physico-chemical variables (Ogbeibu and Oribhabor 2011).

Macroinvertebrates

Benthic macroinvertebrates are those organisms which are over 1.0 mm in size, living on or in the substrate. They may be in-fauna (living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids, chironomids and bivalve molluscs) **(**Plates 4.2a and Plate 4.2b), or epifauna (living on the surface, either, crawling as mobile benthic inhabitants or attached to different types of substrates (Plates 4.2c and Platre 4.2d). These organisms are economically and ecologically important. They have been used as bioindicators in pollution/impact assessment studies (Webber, 1973; Lee *et al*, 1978; Tsui & McCart, 1981; Ogbeibu & Victor, 1989, Ogbeibu & Oribhabor, 2002; Omoigberale & Ogbeibu 2010, Ogbeibu *et al.*, 2010). The Annelida, Arthropoda (Decapoda and Insecta) and Mollusca constitute majority of the benthic macroinvertebrates of brackish environments.

In this study, 28 benthic macroinvertebrate taxa belonging to the Crustacea (13), Mollusca (6), Annelida (4) and Insecta (5)) were recorded for the both wet and dry seasons (Table 4.7c). Of these, the Crustacea, mainly represented by the decapods, constituted 65% of the total benthic taxa encountered. This was followed by the Mollusca (18%) during the wet season. The percentage compositions of the various benthic groups for both wet and dry seasons are illustrated in Fig 4.2g and Fig 4.2h. There was no significant disparity in the wet and dry season distribution and percentage composition of major taxonomic groups.

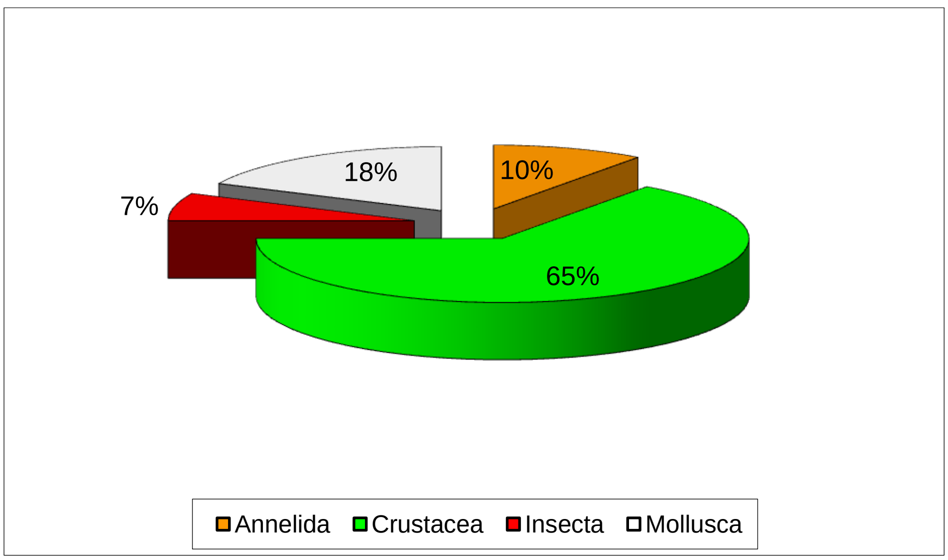

Fig. 4.2g: Percentage Composition of Wet Season Macrobenthic Fauna

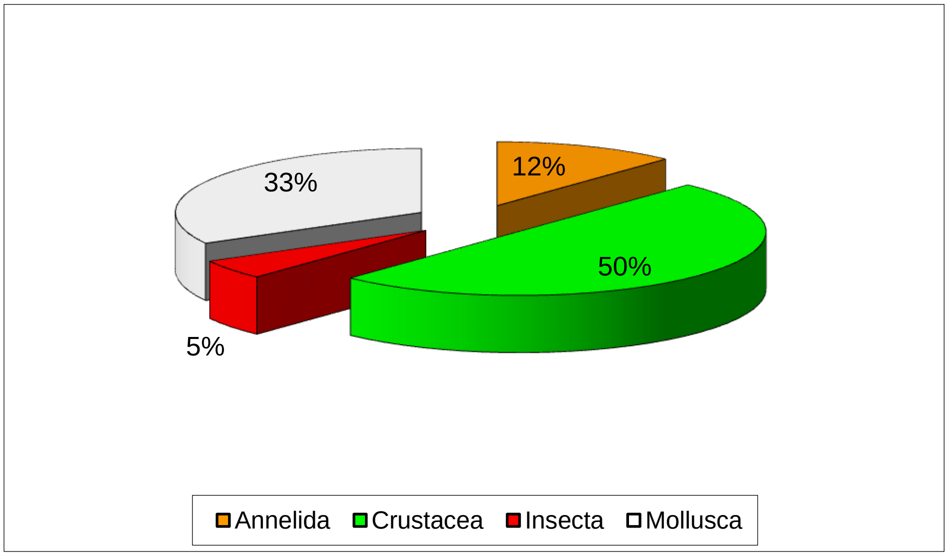

Fig. 4.2h: Percentage Composition of Dry Season Macrobenthic Fauna

Table 4.7c: Macroinvertebrates Species composition

GROUP	SPECIES OF WET AND DRY SEASONS	COMMON NAME
ARTHROPODA		
Crustacea	*Alpheus pontederiae*	Snapping shrimp
	Balanus sp	
	Callinectes amnicola	Swimming crab
	Cardisoma armatum	Rainbow crab
	Clibanarius sp	Hermit Crab
	Cthamalus dentatus	
	Macrobrachium macrobrachion	
	Mysis sp	
	Palaemon maculatus	
	Sesarma elegans	Mangrove crabs
	Sesama huzardi	Mangrove crabs
	Sesarma alberti	Mangrove crabs
	Uca tangeri	Fiddler crab
MOLLUSCA		
Gastropoda	*Littorina* sp	
	Nerita glabrata	
	Pachymelania aurita	
	Thais sp	
	Tympanotonus fuscatus	Mud-flat Periwinkle
Bivalvia	*Crassostrea gasar*	Oysters
ANNELIDA: Polychaeta	*Capitella* sp	
	Nereis pelagica	

GROUP	SPECIES OF WET AND DRY SEASONS	COMMON NAME
	Notomastus aberans	
	Eiseniella tetrahedral	
INSECTA	*Baetis* sp	Mayfly Larva
	Coenagrion sp	Dragonfly Larva
	Chironomus sp	
	Libellula sp	
	Tubifex sp	

Plate 4.2a: *Cardisoma armatum* (rainbow crab)

Plate 4.2b: ***Uca tangeri*** **(Fidler crab)**

Plate 4.2c: ***Balanus*** **sp (attached to wellhead base)**

Plate 4.2d: *Thais* sp (attached to mangrove root)

The variation in the density of benthic macroinvertebrate fauna among the stations is depicted in figure 4.2j. Faunal density (No/m^2) was higher in the dry season than in the wet season in almost all stations. The polychaetes (Annelida), crustaceans and molluscs were more prominent in the more brackish control station (SWC2) than in the fresher zones of lower salinity, while the Insecta were more prominent in SWC1 with the lowest salinity (Table 4.7c).

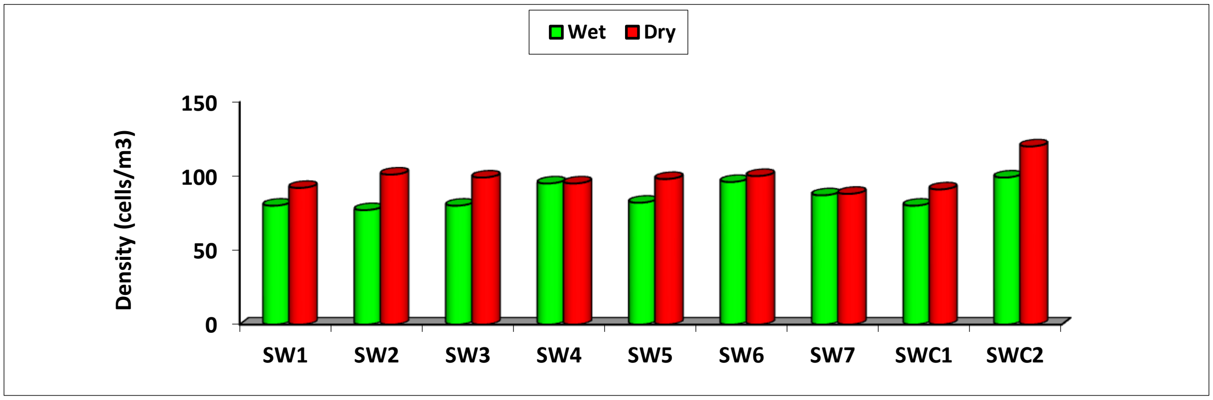

Fig. 4.2i: Spatial variation in the total density of Benthic macroinvertebrate fauna

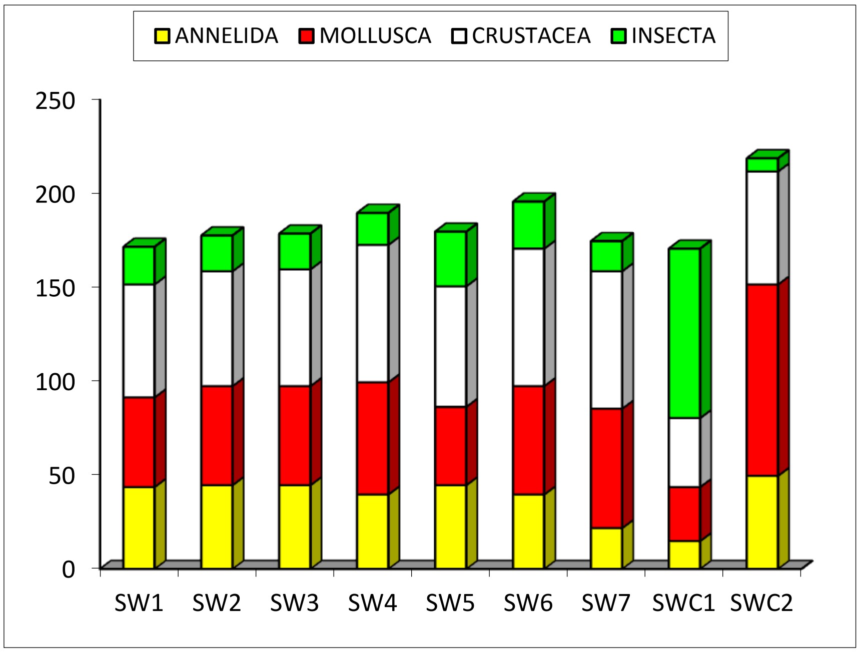

Fig. 4.2j: Spatial variation in the total density of Benthic macroinvertebrate fauna

4.11: Fish and Fisheries

Fishing is the major traditional occupation of the people in this area. This is carried out in the surrounding creeks, the Escravos River and a few nautical miles into the Atlantic Ocean close to the communities. Fishing gears used include gill nets (set and drift), cast nets, long lines, fish stakes and traps (Plate 4.3a). Fin fishes caught by the fishermen are mainly brackish species. Shell fish in this area include the shrimps *Panaeus* sp and *Macrobrachium* spp.

A total of eighteen (18) species comprising 12 fin fish and 6 shell fish species were recorded (Table 4.8). The dominant species were *Pseudotolithus senegalensis, Ethmalosa fimbriata, Chrysicththys* spp. The health status of the fish were satisfactory and the specimens were of medium size and showed no evidence of pathological deformities. The shell fish component was dominated by *Macrobrachium vollenhovenii*, and the periwinkles, *Tympanotonus fuscatus* and *Pachymelania aurita.*A list of the fin and shell fish from this area is presented in **Table 4.8.**

Table 4.8: List of Some Fin and Shell Fish from the study area

Family	**Scientific**	**Common Name**
	Fin Fishes	
Cichlidae	*Tilapia zilli*	Tilapia
Clupeidae	*Ethmalosa fimbriata*	Bonga
Mugilidae	*Liza falcipinnis*	Mullets
Sciaenidae	*Pseudotolithus senegalensis*	Croaker
Lutjanidae	*Lutjanus dentatus*	Snapper
Polynemidae	*Galeodes decadactylus*	Shiny nose
Trichiuridae	*Trichiurus lepturus*	cutlass fish
Sphyraenidae	*Sphyraena barracuda*	Barracuda
Pomadasyidae	*Pristipoma jubeleni*	Grunts
Eleotridae	*Bostrycgus africanus*	Goby/sleeper fish
Bagridae	*Chrysicththys* sp	Catfish
Ariidae	*Arius* sp	Sea catfish
	Shell Fishes	
Potamididae	*Tympanotonus fuscatus*	Periwinkle
Thiaridae	*Pachymelania aurita*	
Portunidae	*Callinectes amnicola*	
Palaemonidae	*Macrobrachium vollenhovenii*	
Penaeidae	*Panaeus* sp	
Gecarcinidae	*Cardiosoma armatum*	Amphibious land crab

Plate 4.3a: Local fish traps

Plate 4.3b: Smoked shrimps caught by local fishermen

4.12: Vegetation

The Saghara Field transverses two barrier islands: the Saghara/Otumara, and the Escravos barrier islands respectively. From the satellite imagery, overall picture of the terrain is established and approximate measurements herein made, for comparative purposes only, while qualitative observations are very specific.

Plate 4.4a: Satellite view of the various vegetation ecotypes in the study area
Source: Google Earth

The major sites in Saghara are within 0.160 - 2.9 km (max. 4.5) from the coastline. Saghara Field is on an average elevation of between 10 – 20 ft above sea level.

Cover Characteristics

The vegetation cover of Saghara Field falls within the sensitive tropical wetland vegetation ecosystem including four basic categories: the Salt Marsh, Mangrove Swamp, Phoenix swamp, and Fresh water swamp forest. Terminologies used are as defined in the Coastal and Marine Ecological Classification (CMEC) Standard (2012) unless otherwise stated; it is based on the "various life histories and taxonomic characteristics of the dominant life forms". It also recognizes the different plant associations and communities within the ecosystem as well as the diagnostic species occurrence, habitat conditions and physiognomy.

A. Salt Marsh

This describes the Emergent wetland vegetation found in a low-wave-energy tidal marsh environment of estuaries (CMECS, 2012). It is a sensitive wetland with low elevation, close proximity to the sea, and a history of inundation by sea water. Communities here are made up of emergent, halophytic, and herbaceous vegetation which are well suited for this unique difficult environment (woody shrubs are only occasional). These species can endure high salinity, partial inundation, muddy and anaerobic soil conditions. This environment is transitional, in depositional land formation, as well as in vegetation. It is at the early stage of succession from mud flats (downstream) to terrestrial / fresh water swamp habitat (upstream); and from aquatic (or semi aquatic) to terrestrial plants. This process could take centuries and low tides may expose bare mud or salt flats which can still be seen interspersing the vegetation landscape in many places. Two subclasses of this wetland ecosystem were observed: (a) Low, and Intertidal Salt Marsh; and (b) High Salt Marsh. Both forms of the Coastal Salt Marsh are predominant in the Saghara area accounting for over 75% of the land cover.

(i) Low and Intertidal Salt Marsh.

This refers to the Tidal Brackish Marsh (Ramsar 1996), which is regularly inundated with quiet waters nearly perennially flooded with depths of up to 1 (one) metre. Water movement in this terrain is largely tidal, and is related to the discharge of river flow through the more or less ‘vegetated lake’, and the regular egress and ingress of tidal waters through the inlets from the sea (Britannica online Encyclopedia, 2012). It was observed that the daily water level in the tidal creeks that supply this terrain falls by up to 1 metre thereby exposing highly silted margins and making navigation difficult. Generally the low marsh vegetation cover is in near pristine condition. This vegetation is typical of VG 11 area with an *Acrostichum aureum* thicket and vegetation cover of 85-90% while at VG 1, vegetation cover is less than 60% with 2500 – 3000 plants per ha. Average height of vegetation is 2 metres. Sighted here also are a few stands of black mangrove reaching up to 6metres in height.

The sampled areas were dominated by semi aquatic herbaceous halophytic shrubs and a few more or less clustered trees. The characteristic low drainage and water stagnancy in this ecosystem limits fresh water influx and sustains species dominance pattern. The vegetation community consists mainly of *Acrostichum aureum* (Golden leather / Mangrove fern) interspersed with groves of *Avicennia germinans;* while *Dalbergia ecastaphyllum* and *Rhizophora racemosa* occur as fringe vegetation around VG3. Generally, *Alchornea laxiflora* dominates the slot margins colonizing the dredge dump lining. However, it was observed that the dumping of dredge spoil had altered the ecology of the margins of this habitat in a few areas like at sampling location VG10 where a plantain plantation is facilitated by dredge spoils in an area where this vegetation intergrades with the terrestrial upland swamp vegetation.

(ii) High Salt Marsh/*Paspalum* Marsh.

The vegetation community is described by the dominant 'seashore *Paspalum* grass' (*Paspalum vaginatum*). This is a typical salt marsh with zonation from the totally submerged to the higher/Upper more terrestrial marsh zones. Much of Saghara area falls within the latter category, the Upper marsh zone. This occurs between the lower salt marsh and intergrades with the terrestrial swamp habitat at higher elevations in the landward direction.

There is no sign of any inundation from the tidal slots, creeks or rivers due to artificial vegetation and landforms lining them. The terrain is muddy especially during the rains due to the more or less clayey soil and high water table. The heavy precipitation characteristic of the region, results in puddles across the area. During short dry spells, the soil is mostly compacted and cracked with little moisture. However, the occurrence of groves of *Avicennia germinans* indicates that this is originally an Oligo-Mesohaline environment at an advanced stage of succession.

The ecology of the *Paspalum* Marsh within the study area can best be described as a vegetated upper supralittoral flat characteristic of certain non-sandy and non-rocky coasterlies and lower reaches of estuaries. It is critical to the leveling of marine delta plains: a climax stage of depositional land formation. Structurally, the vegetation can be stratified into the grass layer (*Paspalum vaginatum*), shrub layer (*Acrostichum aureum*) up 1.3 metres, and the tree layer (*Avicennia germinans*). In the low, tidal marsh subtype described earlier, the grass layer is entirely absent.

This vegetation sub-type is extensive in Saghara area. The predominance of the mangrove grass *Paspalum vaginatum* (up to 70% of total veg. cover) and the presence of *Avicennia germinans* (20% or more) as well as clusters of *Acrostichum aureum* indicate the high salinity prevailing in the soil as is characteristic of salt flats. Around VG 3 and 5 the population of black mangrove, occurs with tree density of about 35 – 50 trees per ha. In this vegetation cover type, few other mangrove associates where sighted including, *Rhynchospora corymbosa,* and small thickets of *Dalbergia ecastaphyllum, Machaerium lunatum* and, *Phyllanthus muellerianus.* Oppurtunistic species include *Alchornea laxiflora, Ludwigia abyssinica,* and *Cassia alata.*

B. Mangrove Swamp

The mangrove swamp vegetation is a very important community of halophytic tree species. Usually forming dense closed canopies, the mangrove swamp is among the most productive ecosystems, they play a huge role in stabilizing the delicate coast lines and estuarine wetlands. They help to prevent coastal erosion and mitigate tropical coastal storms; acting as windbreaks. This vegetation system was encountered as riverine fringe along the natural creeks between Otumara and Saghara. It is dominated by the red mangrove species. Three types of red mangrove vegetation were observed.

(i) Tall Mangrove

This vegetation is seen at VG 5 (Plate 4.4b). It is suited to the intertidal environment and is found mostly along tidal rivers and creeks in estuaries; elsewhere as fringing the open sea. The possession of stilt roots greatly aids it to withstand the regular changes in water level and the muddy intertidal landscape; it also plays a great role in shoreline protection, and hydrobiological food chain. The vegetation is homogenous and in near pristine condition with typically tall *Rhizophora racemosa.* Mature trees here are timber sized with girth of 2-2.5 meters gbh and height of up to 20 meters. However, at VG 5 it was obvious that the *Rhizophora racemosa* had been thinned down by the chain saw of timber merchants thus reducing the forest into a bush with low vegetation and open canopy; only a few mature trees are left on the water fringe. The once thick vegetation is now mainly twigs and saplings with a density of up to 1000 trees per ha and mean tree girth of just 14 inches and height of 7 metres.

(ii) Short Mangrove Forest

This short mangrove forest (Plate 4.4c) seen at VG 10 is different from the dwarf mangrove forest; the dominant species here is the *Rhizophora harrisonii* which is suspected to be the putative hybrid between *R. racemosa* and *R. mangle* **(**Norman and Allen, 2006). This species of red mangrove grows to between 6 and 9 metres in height compared to *R. mangle* which rarely exceeds 5 metres in the Niger delta. The roots also form high tangles and the tree density exceeds that in dwarf mangrove communities. The short mangrove rarely competes with the *R. racemosa* for the tidal river fringes and is mostly seen immediately behind the tall mangrove belt and before the dwarf mangrove which is further inland in basin forest. However, this vegetation was found to be present along the river course at VG 10, and inland at VG 11; both are in the Saghara influence area. It’s a climax community with an average height of 9 metres and a GBH of 30 – 35 cm. Tree density is over 4500 plants per ha.

Plate 4.4b: VG 5 tall Mangrove (above); and VG 10 short mangroves (below)

(iii) Dwarf Mangrove Swamp forest.

The dwarf mangrove forest was encountered at VG 7 Saghara. The vegetation is dominated by *Rhizophora mangle.* Near pristine conditions occur at Saghara, while in some areas, the vegetation is currently being ravaged by the indigenes for fuel wood (Plate 4.4c).

Plate 4.4c: The dwarf mangrove vegetation at Saghara and a pile of twigs harvested from it for fuel wood.

Average height of vegetation is 2.7 metres and reaches 4 metres. A few mangrove associates spotted include *Dalbergia ecastaphyllum, Phoenix reclinata, Endodesmia calophylloides,* and *Acrostichum aureum.* On the margins, *Rhynchospora corymbosa* was the only opportunistic species found.

C. Fresh Water Swamp Vegetation

The fresh water swamp forest as the name implies is a wooded forest land that experiences perennial flooding such that only species adapted to such conditions grow here. The species here unlike in the mangrove/brackish swamps are non salt tolerant. Inundation is usually from the ground water table which in such areas is close to the earth surface. However, these swamps are found in heavy rainfall areas and where there are streams or inland water bodies supplying the terrain with water; keeping the soil inundated with slowly moving or standing water for most of the year. Two ecotones of this swamp vegetation system were found in the study area:

(i) Transition Fresh Water Swamp Vegetation

This type occurs in the transition vegetation zone where the estuarine swamp vegetation intergrades with the terrestrial vegetation: thus it is transition vegetation. It is found in Otumara area on the land ward margins of the Salt Marsh Vegetation. This area coincides with the most disturbed area as the soil here is most arable, especially where it is stabilized by dredge dump. It is also close to the Saghara community and contains several economic tree species. Vegetation cover is over 60%. Typical swamp tree species present here are *Fleroya ledermanii* (1,000 trees pa ha), *Alstonia boonei* (148 trees pa ha), *Ceiba pentandra* (50 trees pa ha) and *Anthocleista djalonensis* (80 trees pa ha). These species make up over 80% of the tree population. Average height of vegetation is 13 meters with *Fleroya* spp and *Alstonia spp* reaching 15-17 metres. The dominant shrub is *Alchornea laxiflora.*

(ii) Fresh Water Swamp Vegetation

The drier type is dominated by *Elaeis guineensis* (247 trees pa ha) (Plate 4.4d). The wetter ecotone bears similar physiognomy with the transition swamp vegetation. Dominant tree species here include *Elaeis guineensis* (441 trees per ha), *Spondianthus preusii* (150 trees per ha), *Uapaca guineensis* (180 trees per ha), *Staudtia stipitata* (70 trees per ha), *Pycnanthus angolense* (30 trees per ha), *Fleroya ledermanii*, *Tricoscypha arborea*, *Ceiba pentandra* (10 trees per ha), and *Alstonia boonei* (15 trees per ha). Other species include *Pycnanthus angolensis, Anthocleista djalonensis*. Species emerging above the canopy here include *Uapaca guineensis*, *Lophira alata* (10 trees per ha), *Spondianthus preusii*, *Staudtia* stipitata, and *Cyclodiscus gabonensis*.

A number of woody and herbaceous climbers are also found. They include *Calamus deeratus, Laccosperma secundiflorum* growing in the typical gregarious manner scrambling over the canopy. Others include *Paulinia pinnata*, *merremia aegyptia*, and *Tetracera alnifolia.* The shrub layer is not rich as a result of inundation as is usual with swamp forests. Areas with more or less permanent flooding as well as Riparian systems contain similar floating aquatic macrophytes which include *Nymphaea lotus, Lemna paucicostata,* and *Wolffia arrhiza*. Rooted aquatic macrophytes are very common especially *Cyrtosperma senegalense*, *Sagittaria sagittifolia,* and *Pteridium aquilinum.* In drier areas, the shrub layer is dominated by tree saplings and shrubs like *Alchornea cordifolia, Alchornea laxiflora, Tabernaemontana pachysiphon, Coffea canephora* and *Costus afer* especially on the edges and where there is some high ground. *Heterotis rotundifolia* commonly forms a dense mat. *Rhynchospora corymbosa, Sacciolepis africana, Cyclosorus striatus* and *Sacciolepis africana* form pure populations near water logged places especially along right of ways.

Plate 4.4d: Showing a section of the fresh water swamp forest.

At Saghara the average height of this vegetation is about 17 meters (Plate 4.4e). A few stands of *Fleroya ledermannii, Pycnanthus angolense, Ceiba pentandra,* and *Alstonia boonei,* and *Ficus mucoso* can be seen with the last three species emerging from above the canopy to heights of 20 - 25 metres at intervals. At the canopy layer *Musanga cecropiodes* (Umbrella tree) is gregarious. *Anthocleista djalonensis* is common here. Because of the dense canopy, the forest floor is almost bare with a few weeds, shrubs and tree saplings. *Glyphaea brevis*, *Alchornea laxiflora, Chromolaena odorata* are common in disturbed areas *Coffea canephora, Tabernaemontana pachysiphon, Urena lobata, Costus afer*, *Vernonia conferta. Erismadelphus exsul* var. platyphyllus was sighted while *Elaeis guineensis and Allophylus africanus* are common; climbers include *Paulinia pinnata,* and *Mucuna flagellipes*.

Plate 4.4e: Showing a disturbed patch of the Palm dominated swamp vegetation at Saghara; *Tabanaemontana pachysiphon.*

D. Phoenix Swamp Forest

This vegetation type occurs on a flat muddy terrain (Plate 4.4f). This woodland vegetation is dominated by an uneven distribution of *Avicennia germinans,* and *Phoenix reclinata*: the latter often forming dense bushy clumps. Height of vegetation is about 6 metres while species density is an average of 3800 trees per ha. Black mangrove trees (120 trees per ha), and a few oil palm trees, emerge above this *Phoenix* canopy reaching heights of 8-12 metres. The *Acrostichum aureum* shrub layer is only sparsely vegetated in most areas. Total vegetation cover here is over 60 – 70%. Light thickets of *Dalbergia ecastaphyllum, Phyllanthus muellerianus, Hibiscus tiliaceous*, and *Endodesmia calophylloides* are present. This unique vegetation provides a habitat for the red-river hogs during the rainy season while the ripe fruits provide food for birds and monkeys. A checklist of plant species at Saghara field is presented in Table 4.9a.

Plate 4.4f: Showing a *Phoenix reclinata* swamp with *Avicennia germinans,* Oil palm and *Acrostichum aureum* associations

Table 4.9a: Checklist of plant species present at Saghara Field

S/N	Plant Species Present	Growth Form	Economic Importance	Common Name
1	*Acrostichum aureum*	H	Used for trapping crayfish	Golden leather fern
2	*Aframomum melegueta*	H	Medicinal	Aligator Pepper
3	*Alchornea cordifolia*	S	Medicinal	Xmas tree
4	*Alchornea laxiflora*	S	Medicinal	Low veld bead string
5	*Alstonia boonei*	T	Timber/Medicinal	Cheese wood
6	*Anthocleista* spp.	T	-	Forest fever tree
7	*Axonopus compressus*	G	-	Carpet grass
8	*Baphia nitida*	T	Chewing stick/Medicinal	Camwood
9	*Calamus spp*	CL	Basket weaving/Furniture	Sweet sedge
10	*Carapa procera*	T	Furniture	Carapa
11	*Celtis zenkeri*	T	Timber	Diana (Ohia)
12	*Chromolaena odorata*	H	Medicinal	Siam weed
13	*Phyllanthus amarus*	H	Medicinal	Carry me seed
14	*Emilia coccinea*	H	-	Flora's Paint brush
15	*Solanum torvun*	S	-	Devil's fig
16	*Setaria sp*	G	-	Bristle Grass
17	*Cocos nucifera*	T	Food	Dwarf Yellow Coconut

S/N	Plant Species Present	Growth Form	Economic Importance	Common Name
18	*Costus afer*	H	-	Ginger Lily
19	*Cyperus articulatum*	H	-	Guinea Rush
20	*Cyperus ligularis*	H	-	Mbew
21	*Dalbergia dendo*	T	-	East Indian Rosewood
22	*Dalbergia ecastaphyllum*	S	-	Coinvine
23	*Disppyros dendo*	T	-	Blackwood
24	*Machaerium lunatus*	S	Medicinal	Manatee bush
25	*Elaeis guineensis*	T	Food/wine	African Oil Palm
26	*Funtumia elastica*	T	Rubber	Silk Rubber
27	*Glyphaea brevis*	S	-	Bola Pane
28	*Ipomoea involucrata*	H	-	Close to the ground
29	*Irvingia gabonensis*	T	Food	African Mango
30	*Lophira alata*	T	Timber	Ekki (Azobe)
31	*Mariscus ligarus*	G	-	Not Documented
32	*Memecylon afzelii*	S	-	Not Documented
33	*Musanga cecropioides*	T	-	African Apple
34	*Rottboellia cochinchinensis*	G	-	Alligator weed
35	*Trema occidentalis*	S	-	Pigeon wood
36	*Ageratum conyzoides*	H	-	Goat weed
37	*Ceiba pentandra*	T	Timber	Silk cotton tree
38	*Mitragyna stipulosa*	T	Timber	Abura
39	*Myrianthus arborea*	T	Vegetable/Food	Not documented
40	*Nauclea diderrichii*	T	Timber	Opepe
41	*Palisota birsuta*	H	-	Sheeps Knee
42	*Panicum maximum*	G	-	Guinea Grass
43	*Paspalum orbiculare*	G	-	Rice Grass
44	*Paspalum vaginatum*	G	-	Biscuit Grass
45	*Pennisetum purpureum*	G	-	Elephant Grass
46	*Pentaclethra macrophylla*	T	Food	Old Oil bean tree
47	*Pycnanthus angolensis*	T	Timber	Akomu
48	*Raphia hookeri*	T	Wine	Wine Palm
49	*Rauvofia vomitoria*	S	Medicinal	Poisons Devils Pepper
50	*Sporobulus pyramidalis*	G	-	Giant Rat's Tail Grass
51	*Terminalia superba*	T	Timber	Afara
52	*Vernonia amagydalina*	S	Food	Bitter leaf
53	*Vitex rivularis*	T	-	Antelopes Garden Egg
54	*Ficus trichopoda*	T	-	Swamp fig
55	*Lygodium* sp	CL	-	Climbing fern
56	*Chrysophyllum gigantium*	T	Timber	Abure
57	*Psydrax subcordata*	T	-	Not documented
58	*Zanthoxylum gilletii(Fagara)*	T	Timber/Medicinal	African satin wood
59	*Musa sapientum*	T	Food	Dwarf Banana
60	*Musa paradisiaca*	T	Food	Plantain
61	*Xanthosoma* sp	H	Food	Cocoyam
62	*Manihot esculenta*	S	Food	Cassava
63	*Capsicum annum*	H	Food	Hot pepper
64	*Terminalia catapa*	T	Ornamental	Indian Almond

S/N	Plant Species Present	Growth Form	Economic Importance	Common Name
				(Ebelebo)
65	*Erythrophleum suavolens*	T	Timber	Red water tree
66	*Spondias mombin*	T	Food	Tropical plum
67	*Mormodica charanthia*	CL	Medicinal	Bitter melon
68	*Ormocarpus verrucosum*	S	-	Raphia Palm
69	*Ipomoea pes-capre*	CL	-	Railroad vine
70	*Antiaris Africana*	T	Timber	False Iroko
71	*Assystasia gigantean*	H	-	Burny vine
72	*Elaeocharis* sp	G	Mat weaving	Lawn Sedge

NB: T = tree; S = shrub; H = herb; G = grass/sedge and CL = climbers/lianas

4.12.1: Land Use and Agriculture

Land Use refers to the various uses to which the land in Saghara project area is put into. This was ascertained by observing directly in the field the various land use patterns. The major land use types in Saghara area include mangrove forest, dwelling places, cultivated agricultural lands, fallow lands, oil/gas exploration and production facilities, and communication facilities. A checklist of the various land uses in the area is presented in **Table 4.9b.**

Table 4.9b: Various Land Uses in Saghara Project Area

Order	Group	Percentage (%)
Agriculture and Fisheries	Agriculture and Fisheries	10
Forestry	swamp forest, mangrove swamp forest, Otumara River	30
Transport	Roads, track ways, foot paths,	5
Utilities/Infrastructure	Telecommunications,	3
Residential	Settlements/Dwellings,	5
Community Services	Places of worship, schools, health centres, community hall	
Retail Services	Shops, Restaurants and bars	2
Industry and Business	Well heads and associated oil exploration and production facilities.	5
Unused Land	Fallow Land, Unused land	40

4.12.2: Phytochemistry

Table 4.9c shows the results of the phytochemical screening carried out on the leaf tissue samples obtained during the field survey, to ascertain any chemical contamination. Elements screened for included heavy metal mainly associated with oil and gas activities. The toxic non essential Heavy metals screened for Include Cu, Cd, Pb, Hg, Va, Ni, Zn, and Cr. Only copper occurred in all the samples. Although there were elevated levels of copper in few samples from Saghara area, those levels were just around the lower limit (5.0 mg/kg) of the normal range of concentration in plants. Generally concentrations in leaves sampled, were below normal levels.
Other stations had concentrations of cadmium mostly below detectable levels while few samples where within the normal range. Leaves of plants sampled from nine points in Saghara (VG1, 2, 3, 4, 5, 6, 7, 10, 11) had non-detectable levels of cadmium.

Generally lead (Pb) concentrations in leaves sampled were very normal (1.0 – 10.5 mg/kg) when compared with the normal concentration range for Pb in angiosperm leaves which is 2.0 – 20mg/kg. In the study area, concentrations of Pb were at non-detectable levels; the leaf sampled from *Alchornea laxiflora* had the highest concentration (10.5 mg/kg) found within the study area, while samples from the other areas had concentrations of lead in the range of 2.5 – 7.5 mg/kg with mean concentration of 5.6 mg/kg.

Some of the samples from the study area had Nickel concentrations below detectable levels. In Saghara, concentrations range between 4.5 and 11.5 mg/kg. Mean concentration is 7.6 mg/kg. Thus Nickel concentration in plants from Saghara was far above the normal range of 0.02 – 5 mg/kg.Leaves sampled from Saghara had 4.0 – 9.5 mg/kg of Vanadium and mean concentration of 6.67 ± 2.4 mg/kg. Elevated levels were observed in leaves of *Rhizophora racemosa* from VG 5, 6, and 7 which are not close to the flow station but within the influence Zone of third party oil and Gas facility. The Chromium levels were below detectable levels. In Samples from Saghara, there were non detectable levels in samples VG 1,2,3,4 and 9. The mean concentration from the 7 other points was 10.9(±2.8) mg/kg.

Among the micro nutrient elements, there were critical levels of Fe in the samples, with concentration ranging between 540 – 730 mg/kg. With the exclusion of these points, average concentration was 304 mg/kg; well within the normal concentration range of Fe in leaves.

Table 4.9c: Showing the Results of Phytochemical Screening

Parameter / Code	Fe	Cu	Mn	Zn	Cd	Cr	Pb	Ni	V
	mg/kg								
VEG 8	230	4.65	5.15	25.5	4.0	6.5	ND	6.5	5.1
VEG 9	130	1.80	4.90	25.5	2.5	ND	4.0	5.0	4.2
VEG 12	275	3.40	4.65	29.0	ND	7.5	5.0	ND	ND
VEG 13	255	3.00	4.25	30.0	ND	6.5	ND	ND	ND
VEG 14	290	3.70	3.50	30.5	ND	7.5	10.5	ND	ND
VEG 15	605	5.80	4.55	25.5	ND	10.5	7.5	4.5	3.2
VEG 16	450	2.55	3.80	25.5	4.5	5.5	2.5	ND	ND
VEG 17	435	1.65	4.80	33.0	6.5	2.5	2.5	16.0	12.0
VEG 18	140	2.55	4.95	30.0	5.0	2.5	ND	8.5	7.1
VEG 19	280	1.85	3.30	38.0	10.5	6.5	ND	15.0	13.4
VEG 20	290	3.65	4.65	29.2	ND	8.0	7.5	ND	ND
VEG 21	275	3.58	4.44	29.0	ND	7.5	5.5	ND	ND
VEG C3	730	.80	3.30	30.0	ND	2.0	6.5	6.5	5.6

4.12.3: Pathology

Generally, the vegetation is devoid of diseased conditions. The plants were not appearing stressed except for salt stressed species (especially Oil palm) occurring in the phoenix swamp area.

4.13: Wildlife

Wildlife Composition

Saghara Field is in a protected area (Fig. 4.3). The wildlife diversity and distribution pattern observed in the Saghara Field reflects the uniqueness of this area in terms of terrain and vegetation cover. Generally it is not possible to provide specific numbers for the population size of the different wildlife categories, due to the time and scope constraints of this study; as random sighting especially of the amphibians and primates decreases with the increase in human activities within the area at any particular moment. However sighting was possible through chance encounters that proved the presence of the listed species.

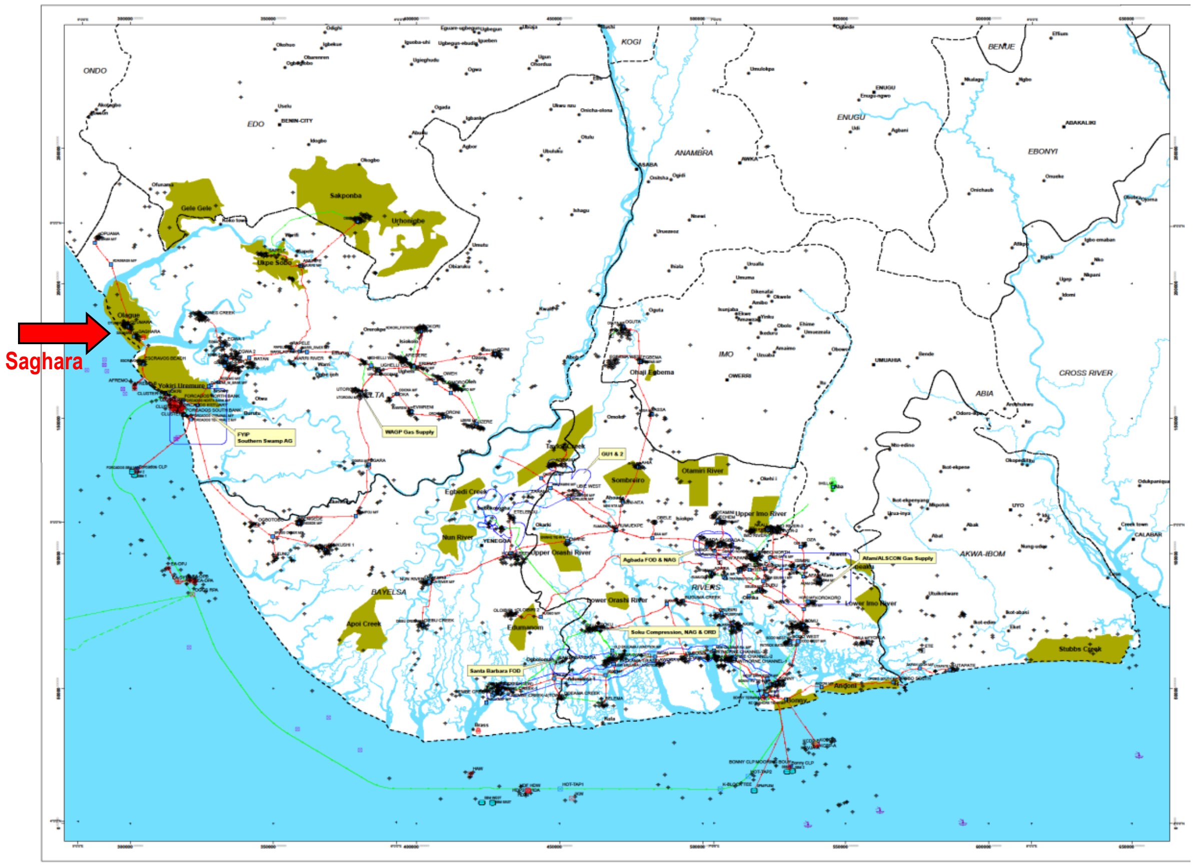

Fig. 4.3: Map of Niger Delta showing Protected Areas (Olague Forest Reserve which harbours the Saghara Field is proposed but yet to be gazetted)

The wildlife composition and species diversity in the Saghara area is low as has been previously observed in the Saghara Beach EIA report of 1998. This is traceable to the predominance of the High and low salt marsh in the Otumara axis which does not support land animals; hence the predominance of amphibians generally. Amongst the reptiles, the slender snouted crocodile, the African dwarf Crocodile and python species were common across the entire area. Due to the prominence of high vegetation at the Saghara end of the Otumara/Saghara Island, Primates sighted was mostly around the flare site area and the mangrove between Sahara and Otumara; the Mona monkey occurs in the Saghara Field.A check list of the wildlife spectrum in the four major categories of Mammalia, Aves, Reptilia, and Amphibia is presented in Table 4.10a, Table 4.10b and Table 4.10c.

Table 4.10a: Checklist of Mammals found in the project site

S/N	MAMMALS		STATUS		
	ORDER PRIMATES		Local	IUCN	Dcr 11
	Family Cercopithecidae (monkeys)				
1	*Mona* Monkey	*Cercopithecus mona*	Abundant	LC EWA	2
	ORDER PHOLIDOTA				
	Family Manidae (scaley anteaters)				
2	Black-bellied pangolin	*Manis tetradactyla*	Common	LC	1
	ORDER CARNIVORA				
	Family Viverridae				
3	African Civet	*Civettictis civetta*	Common	LC	2
	Family Herpestidae				
4	Marsh Mongoose	*Atilax palidunosus*	Common	LC dcrn	2
	ORDER ARTIODACTYLA				
	Family Suidae				
5	Red River Hog (Bush Pigs)	*Potamochoerus porcus*	Abundant	LC	-
	Family Bovidae Subfamily Bovinae				
6	Marsh Buck	*Tragelaphus spekii*	Abundant	LC	1

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

Table 4.10b: Checklist of Birds (Aves) found in the project site

S/N	BIRDS / AVES		STATUS		
	ORDER PELICANIFORMES		Local	IUCN	Dcr 11
	Family Phalacrocoracidae				
1	White-breasted Cormorant	*Phalacrocorax lucidus*	Abundant		2
2.	Great White Egret	*Ardea alba*	Common		
	ORDER CICONIIFORMES (Wading Birds)				
	Family Scopidae				
2	Hammerkop	*Scopus umbretta*	Common		2
	ORDER FALCONIFORMES				
	Family Accipitridae				
3	Yellow-billed Kite	*Milvus aegyptius*	Abundant		1

S/N	BIRDS / AVES		STATUS		
		parasites			
	ORDER PASSERIFORMES				
	Family Corvidae				
4	Pied crow	*Corvus albus*	Common		
	Family Ploceidae/Passeridae				
5	Orange weaver	*Ploceus aurantius*	Spotted		
6	Red-vented Malimbe	*Malimbus scutatus*	Spotted		
	Family Pycnonotidae				
7	Common bulbul	*Pycnonotus barbatus*	Common		
	ORDER PSITTACIFORMES				
	Family Psittacidae				
8	Congo African Grey Parrot	*Psittacus erithacus*	Abundant	**Vulnerable**	1
	ORDER CHARADRIIFORMES				
	Family Scolopacidae				
9	Common Sand piper	*Actitis hypoleucos*	Common		
10	Slender-billed Curlew	*Numenius tenuirostris*	Uncertain	**Rare C.E**	-
	ORDER COLUMBIFORMES				
	Family Columbidae				
11	Laughing dove	*Stigmatopelia senegalensis*	Spotted	LC stable	-
	ORDER CORACIIFORMES				
	Family Alcedinidae				
12	Blue breasted King fisher	*Halcyon malimbica*	Common		

Key: C.E = Critically Endangered; LC = Least Concern

Table 4.10c: Checklist of Reptiles found in the project site

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

S/N	REPTILES		STATUS		
			Local	**IUCN**	**Dcr 11**
5	Jameson's mamba	*Dendroaspis jamesoni*	Common		
	Family Crocodylidae				
6	Nile Crocodile	*Crocodylus niloticus*	Common		1
7	African Dwarf Crocodile	*Osteolaemus tetraspis*	Common	**Vulnerable**	1
	Family Pelomedusidae				
8	W.Afr. Black Forest Turtle	*Pelusios niger*	Common		
	Family Testudinidae				
9	Home's Hinge-back tortoise	*Kinixys homeana*	Common		

It was observed that the parrots migrate to the Saghara axis in the morning and return to the Escravos area at night. Several other migratory birds were observed including the White breasted cormorant, Slender billed curlew, and the Great white Egret. It was observed that wrong use of English names has also been borrowed into wide life studies such as the Saghara Beach-A EIA (1998) which reported the presence of Alligators in Saghara area. This appears to be corrected in the Saghara AGS Project EIA (2008) report that omits Alligators and reports the African dwarf Crocodile instead. The correct English name for the 'Alibaba' (local name) referred to in the latter study is Hamerkop and not the slightly similar Giant King Fisher. It is also possible that the White breasted cormorant is also mistaking for a hornbill or kingfisher, as it is not mentioned at all in previous reports from nearby areas. The Cattle egret mentioned in the same report is erroneous for Great white egret which migrates to the southern hemisphere including west African wetlands for breeding; feeding on fish, frogs, small reptiles etc

4.14: Geology and Hydrogeology

4.14.1 Geology and Geomorphology

The study area (Saghara) and the adjoining fields (Saghara and Escravos) are part of the geologic sequence of the Quartenary and Tertiary formations of the Niger Delta, consisting of three main geological formations – the Benin formation (the topmost unit), the Agbada and the Basal Unit, the Akata formations. Lithological units of the study area are generally composed of sands, silty sands and clays (Short and Stauble 1967). The land surface of the study area is characterized by low lying plains typical of the modern Niger Delta. These plains have swamps that are commonly flooded during the peak of the rainy season. The area slopes imperceptibly in the South direction towards the Atlantic Ocean and is drained by a network of Escravos River and the adjoining creeks, mangrove swamps, marshes and dredge slots.

4.14.2 Hydrogeology

The main aquifer system in the Niger Delta region comprises two Stratigraphic units. These are:

i. **The Alluvium:** The aquifer system within the alluvial deposits, especially the near surface beds close to the shore area, often saline bearing. However, the lateral extent of these shallow aquifers is very erratic, occurring as lenses of sands within the less permeable beds of silts and clay.

ii. **The Benin Formation:** For most of the Niger Delta Basin, this Chrono-Stratigraphic unit forms the main aquifer system, having a total thickness of 1892m (6000ft) around Warri. Its lithologic composition is mainly (90%) sands and sandstones. The remaining 10% is made up of clay and lignitic beds that are hardly continuous over any significant distance - largely occurring as lenses. Thus, the Benin Formation is one large aquifer system with enormous storage.

Recharge to this system is mainly from rainfall, while discharge sources include run-offs from the basin and abstraction through boreholes. Table 4.11 shows the aquifer prospectivity of the Niger Delta Basin.

Table 4.11: Stratigraphic sequence of the Niger Delta Basin with aquifer prospectivity
(Source: Olobaniyi *et al*., 2006)

	Stratigraphic Units	Lithologic Description	Aquifer Prospect
QUAT ERNARY	ALLUVIUM	Gravely sands, sands, silt and clays	Good
	MEANDER BELT DEPOSIT	Gravely sands, sands with thin clay units.	Good
	WOODED BACK SWAMPS & FRESH-WATER SWAMPS DEPOSITS	Mainly silt and silty clays with clayey intercalations	Poor
	MANGROVE SWAMPS DEPOSIT	Fine sands to silt and silty clays and clays with organic matter	Poor (Saline water)
	SOMBREIRO-DELTAIC PLAIN SEDIMENTS	Coarse to fine grained sands, silts and clays	Medium
MIOCENE TO RECENT	BENIN FORMATION	Mainly coarse-medium grained sands, lenticular with clay and shaly lens	Prolific Aquifer

4.14.3: Aquifer Characteristics

The lithostratigraphy of the Saghara axis where the three monitoring boreholes were drilled is made up of dark brownish humic loam material at the surface with black and white mica (muscovite and biotile). The clay content of the lithology increases from about one meter (1m) from the surface level down to a depth of four meters (4m). This clay material overlies a fine silty-sand material that is about four meters (4m) thick. Underlying this fine silty-sand material are sand materials that become coarser with increasing depth, and join the aquifer (water-bearing lithology) at about twelve meters (12m) depth (Fig 4.4a).

Saghara Area

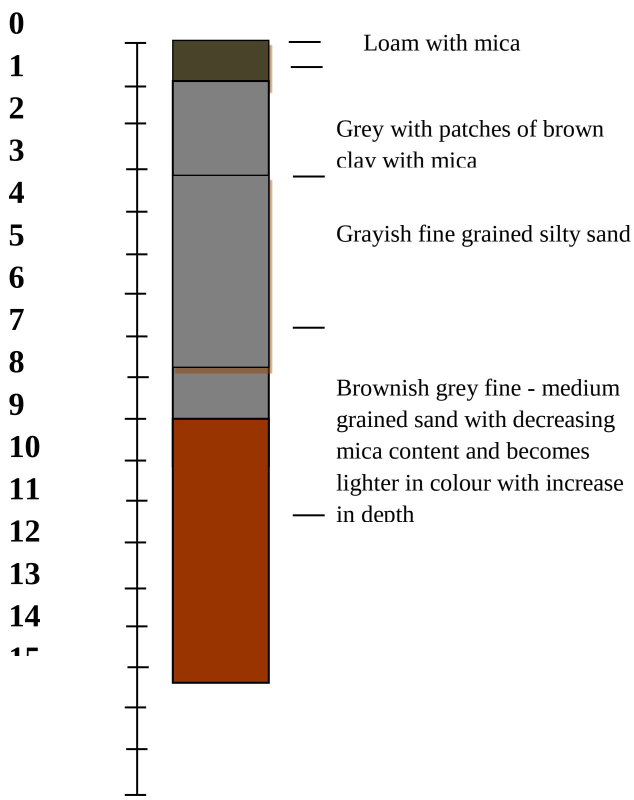

Fig. 4.4a: Average typical Litholog of the boreholes of the study areas

Water Level

The water level measured in the boreholes, ranges from 1.0m in borehole 5, to 1.2m in borehole 6, in Saghara axis

Groundwater Flow Direction

Groundwater flow direction in the area was determined using the data from the 3 boreholes. The data shows that the groundwater flow direction in the area is from Northeast to Southwest (Fig. 4.4b). This is in conformity with the regional groundwater flow direction in Niger Delta, which is from Northeast towards the coast in the South. Thus if there is any pollution of groundwater in the area, those South of the point of pollution are most likely to be affected.

The ground water recharge is via percolation from precipitation, and surface water bodies (Escravos river mainly and its tributaries). Consequently the base flow of the surface water bodies influences the ground water recharge rate especially during the dry season when the water table level drops.

Saghara

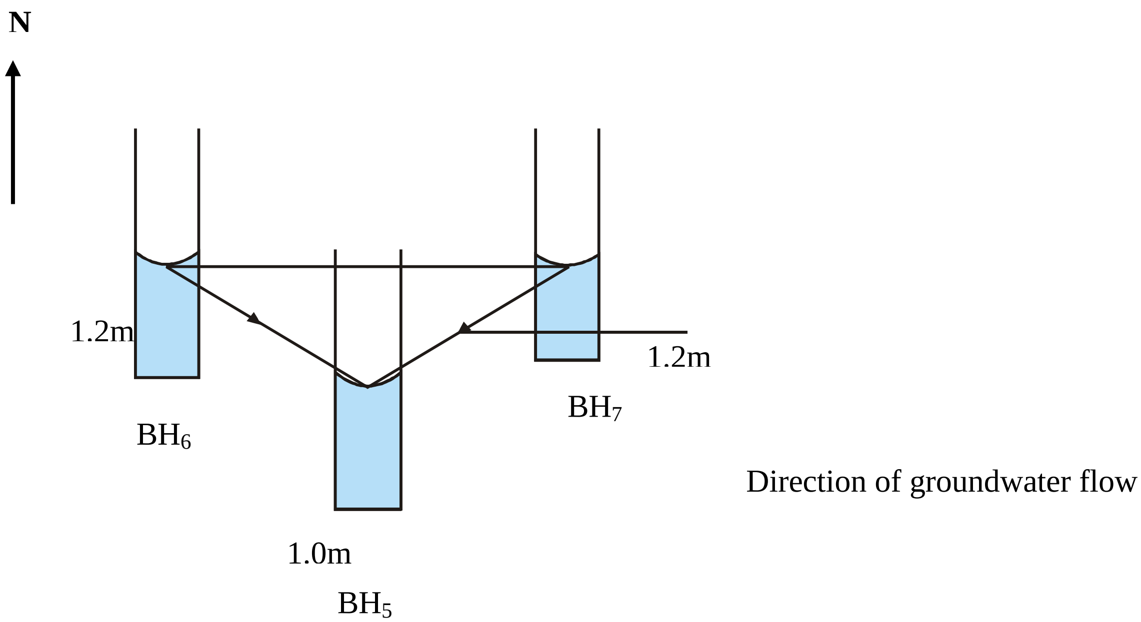

Fig 4.4b: Groundwater flow direction in the study area

4.14.4: Ground Water Quality

The quality of any water resources is its suitability for the intended use. Thus, this is a function of the physical, chemical and biological (bacteriological) characteristics of the water which in turn depend on the geology of the area and impacts of human activities. The wet and dry season results of laboratory analysis of the groundwater samples obtained from these boreholes are presented in Tables 4.12a and Table 4.12b for physico-chemical parameters, while Tables 4.12c gives the summary of minimum, maximum, mean values and the regulatory standards.

Table 4.12a: Physico-chemical qualities of Saghara Ground water Samples (WET SEASON 2012)

S/N	Parameters	Units	SAG GW4	SAG GW5	SAG GW6	SAG GW7
1	Ph		7.3	4.3	7.3	7.3
2	Temp	^{0}C	26.5	26.7	28.5	27.4
3	EC	µS/cm	11710	19620	11980	1730
4	Salinity	g/l	5.30	8.87	5.42	0.78
5	Col.	Pt.Co	10.9	11.4	15.9	14.2
6	Turbidity	NTU	7.3	8.1	11.3	10.2
7	TSS	mg/l	8.6	7.5	10.1	9.3
8	TDS	"	4810	5990	5870	620
9	DO	"	6.5	5.3	5.9	4.7

S/N	Parameters	Units	SAG GW4	SAG GW5	SAG GW6	SAG GW7
10	BOD_5	"	3.0	3.2	2.7	1.9
11	COD	"	194.4	162.4	146.4	180.8
12	HCO_3	"	109.8	207.4	152.5	146.4
13	Na	"	122.5	138.8	139.1	120.4
14	K		54.1	56.4	149.4	98.1
15	Ca	"	29.3	30.0	55.4	61.4
16	Mg	"	33.2	37.4	56.5	55.8
17	Cl^-	"	9790	8890	10800	1620
18	PO_4	"	1.91	1.82	1.11	1.55
19	NH_4N	"	1.77	2.43	1.84	1.98
20	NO_2^-N	"	1.31	2.04	1.21	1.29
21	NO_3^-N	"	3.10	3.61	3.44	3.58
22	SO_4	"	56.7	55.4	56.6	55.9
23	THC	"	0.10	0.10	0.13	0.34
24	TPH	"	0.003	0.001	0.002	0.001
25	PAH	µg/l	0.001	0.001	0.001	0.002
26	Benzene	"	ND	ND	ND	ND
27	Toluene	"	ND	ND	ND	ND
28	Ethylbenzene	"	ND	ND	ND	ND
29	Xylene	"	ND	ND	ND	ND
30	Phenol	"	0.002	0.001	0.002	0.002
	Heavy metals					
1	Fe	mg/l	0.10	0.10	0.12	0.19
2	Cu	"	0.025	0.019	0.030	0.028
3	Mn	"	0.004	0.004	0.006	0.009
4	Zn	"	0.035	0.025	0.007	0.010
5	Cd	"	0.022	0.022	0.009	0.007
6	Cr	"	0.001	0.001	0.004	0.011
7	Pb	"	0.145	0.145	0.008	0.026
8	Ni	"	0.081	0.081	0.025	0.030
9	V	"	0.074	0.073	0.020	0.021
10	Hg	"	ND	ND	ND	ND
11	Ba	"	0.002	0.001	0.001	0.002

Table 4.12b: Physico-chemical qualities of Saghara Ground water Samples (DRY SEASON 2013)

S/N	Parameters	Units	SAG GW4	SAG GW5	SAG GW6	SAG GW7
1	**pH**		7.24	7.36	7.10	7.21
2	**Temp**	**^{0}C**	32.1	32.6	32.5	32.1
3	**EC**	**µS/cm**	10580	10060	24700	3400
4	**Salinity**	**g/l**	4.78	4.55	11.2	2.56
5	**Col.**	**Pt.Co**	14.7	18.3	19.3	12.1
6	**Turbidity**	**NTU**	10.2	13.1	16.1	10.2
7	**TSS**	**mg/l**	14.3	16.3	12.4	9.9
8	**TDS**	"	5607	5332	13091	1701
9	**DO**	"	3.5	4.6	4.4	4.7
10	**BOD_5**	"	1.4	1.2	4.1	1.9
11	**COD**	"	64.0	61.6	60.0	180.8
12	**HCO_3**	"	160	166	120	146.4
13	**Na**	"	145.8	130.8	152.1	120.4
14	**K**	"	148.8	61.6	131.2	98.1
15	**Ca**	"	66.1	39.5	59.0	61.4
16	**Mg**	"	57.0	38.6	55.8	55.8
17	**Cl^-**	"	6040	4470	6470	1620
18	**PO_4**	"	0.21	0.18	0.81	1.55
19	**NH_4N**	"	0.23	0.09	0.14	1.98
20	**NO_2^-N**	"	0.54	0.51	0.37	1.29
21	**NO_3^-N**	"	0.61	0.69	0.46	3.58
22	**SO_4**	"	60.7	66.8	76.3	55.9
23	**THC**	**mg/l**	0.46	0.18	0.25	0.34
24	**TPH**	"	0.003	0.003	0.004	0.001
25	**PAH**	**µg/l**	0.002	0.001	0.002	0.002
26	**Benzene**	"	ND	ND	ND	ND
27	**Toluene**	"	ND	ND	ND	*ND*
28	**Ethylbenzene**	"	ND	ND	ND	ND
29	**Xylene**	"	ND	ND	ND	ND
30	**Phenol**	"	0.001	0.002	0.002	0.002
	Heavy metals					
1	**Fe**	**mg/L**	0.863	0.054	0.064	0.19
2	**Cu**	"	0.043	0.023	0.053	0.028
3	**Mn**	"	0.101	0.103	ND	0.009
4	**Zn**	"	0.135	0316	0.130	0.010
5	**Cd**	"	0.013	0.005	0.002	0.007
6	**Cr**	"	0.003	ND	ND	0.011
7	**Pb**	"	0.339	0.009	0.155	0.026
8	**Ni**	"	0.132	0.010	0.032	0.030
9	**V**	"	0.112	0.006	0.027	0.021
10	**Hg**	"	ND	ND	ND	ND
11	**Ba**	"	ND	ND	ND	0.002

Table 4.12c: Summary of Physico-chemical qualities of Saghara Ground water Samples

			WET SEASON			DRY SEASON			DPR/ *FMEnv
S/N	**Parameters**	**Units**	**MIN**	**MAX**	**MEAN**	**Min**	**Max**	**MEAN**	
1	pH		4.3	7.3	6.55	7.1	7.36	7.23	6.5-9.2/ 6.5-8.5*
2	Temp	^{0}C	26.5	28.5	27.3	32.1	32.6	32.33	30
3	EC	µS/cm	1730	19620	11260	3400	24700	12185.00	
4	Salinity	‰	0.78	8.87	5.09	2.56	11.2	5.77	
5	Colour	Pt.Co	10.9	15.9	13.1	12.1	19.3	16.10	
6	Turbidity	NTU	7.3	11.3	9.23	10.2	16.1	12.40	1.0*
7	TSS	mg/l	7.5	10.1	8.9	9.9	16.3	13.23	<10*
8	TDS	"	620	5990	4323	1701	13091	6432.75	1500/ 500*
9	DO	"	4.7	6.5	5.6	3.5	4.7	4.30	7.5*
10	BOD_5	"	1.9	3.2	2.7	1.2	4.1	2.15	0*
11	COD	"	146.4	194.4	171.0	60	180.8	91.60	
12	HCO_3	"	109.8	207.4	154.0	120	166	148.10	
13	Na	"	120.4	139.1	130.2	120.4	152.1	137.28	
14	K		54.1	149.4	89.5	61.6	148.8	109.93	
15	Ca	"	29.3	61.4	44.0	39.5	66.1	56.50	200
16	Mg	"	33.2	56.5	45.7	38.6	57	51.80	150
17	Cl^-	"	1620	10800	7775	1620	6470	4650.00	600/ 250*
18	PO_4	"	1.11	1.91	1.60	0.18	1.55	0.69	<5*
19	NH_4N	"	1.77	2.43	2.01	0.09	1.98	0.61	
20	NO_2^-N	"	1.21	2.04	1.46	0.37	1.29	0.68	
21	NO_3^-N	"	3.10	3.58	3.43	0.46	3.58	1.34	10*
22	SO_4	"	55.4	56.7	56.2	55.9	76.3	64.93	
23	THC	"	0.10	0.34	0.168	0.18	0.46	0.31	
24	TPH	"	0.001	0.003	0.002	0.001	0.004	0.00	0.3
25	PAH	µg/l	0.001	0.002	0.001	0.001	0.002	0.00	
26	Benzene	"	ND	ND	ND	0	0	0	
27	Toluene	"	ND	ND	ND	0	0	0	
28	Ethylbenzene	"	ND	ND	ND	0	0	0	
29	Xylene	"	ND	ND	ND	0	0	0	
30	Phenol	"	0.001	0.002	0.002	0.001	0.002	0.00175	
Heavy metals									
1	Fe	mg/l	0.10	0.19	0.13	0.054	0.863	0.293	1/1*
2	Cu	"	0.019	0.030	0.026	0.023	0.053	0.037	1.5/0.1*
3	Mn	"	0.004	0.009	0.006	0.009	0.103	0.071	0.5-5/ 0.05-0.5*
4	Zn	"	0.007	0.035	0.019	0.01	316	79.069	15/5.0*
5	Cd	"	0.009	0.022	0.015	0.002	0.013	0.007	0.01*
6	Cr	"	0.001	0.011	0.004	0.003	0.011	0.007	0.05*
7	Pb	"	0.008	0.145	0.081	0.009	0.339	0.132	0.05*
8	Ni	"	0.025	0.081	0.054	0.01	0.132	0.051	0.05*
9	V	"	0.020	0.074	0.047	0.006	0.112	0.042	0.01*
10	Hg	"	ND	ND	ND	0	0	0	0.001*
11	Ba	"	0.001	0.002	0.002	0.002	0.002	0.002	1.0*

** Limits for potable water sources (FMEnv)*

The groundwater is slightly acidic to slightly basic with mean pH values ranging from 6.5 to 7.23 in the wet and dry seasons respectively (Table 4.12c). These values fall within the regulatory requirement of 6.5 to 8.5 for groundwater. The pH is influenced by the brackish nature of the environment, with salinities varying from 5.09 to 5.77 ‰ and conductivity from 11260 in the wet season to 12185 µS/cm in the dry season.

The groundwater colour (13.1 – 16.1 Pt.co.), total suspended solids (TSS) and dissolved solids (TDS)) are high for both wet and dry seasons, exceeding the regulatory limits of 1.0 NTU, <10 mg/l and 500 mg/l for turbidity, TSS and TDS respectively for potable water. These high values are typical of areas experiencing salt water intrusion. The TDS values are a general indicator of the suitability of groundwater for various uses (Mazor, 1991): *Potable water:* up to 500 mg/L; *Slightly saline water,* adequate for irrigation: 501 to 1,000 mg/L *Medium saline water:* may be used for some crops and Aquaculture: 1,000 to 2,500 mg/L: *Saline water:* adequate for aquaculture and industrial use: 2,500 to 5,000 mg/L: *Brackish water:* 5,000 to 35,000 mg/L (the salinity of seawater); *Brine:* TDS greater than 35,000 mg/L. The mean concentration of Chloride was high, ranging from 4650 – 7775 mg/l in the dry and wet seasons respectively. The entire study area has values of Cl that exceed permissible limits. There are no health-related standards for chloride. FMEnv and WHO have set a regulatory limit of 250 mg/L for domestic water. Chloride content of 40mg/l and above is indicative of salt water intrusion.

The cations include metals present in non trace quantities such as calcium, magnesium, potassium and sodium. Many of these ions are major contributors to the overall salinity of groundwater. Extremely high concentrations of these species make water unfit for human consumption and for many industrial uses. The health related problems are not as those caused by the other contaminant groups. However, high concentrations of even relatively non toxic salts, for example, sodium, can disrupt cell or blood chemistry with serious consequences. The cations were dominated by sodium (Na), followed by K, Ca and Mg. This order of dominance is characteristic of groundwater in the brackish environment with high chloride content.

The mean nitrate-nitrogen level (1.34 – 3.43 mg/l) was low and fell within the regulatory limit of 10 mg/l for potable water. Higher concentrations can lead to Methaemoglobinemia (Blue Baby Syndrome) in infants, where the oxygen-carrying ability of the child's blood is severely reduced. The concentration of sulphate ranged from 56.2 – 64.93 mg/l. There are no health-related standards for sulphate. The WHO have set a limit 40mg/L for sulphate because water containing more than this amount has an unpleasant taste that makes it unsuitable for domestic use.

The volatile organic compounds (VOC's) benzene, ethylbenzene, toluene, and xylenes can have serious health effects if they are consumed in drinking water. Natural sources such as crude oil seeps are rare. Any detected amounts of these refined volatile organic chemicals most likely indicate groundwater contamination. VOC occurrences are not primarily controlled by bedrock geology, physiography, or major river watershed. Volatile organic compounds may be present in groundwater at very low concentrations. The laboratory results for the organic contaminants in the groundwater samples (i.e. Benzene, Ethylbenzene, Toluene, and Xylenes) were all below detectable limits of 0.001 mg/l. The concentration of petroleum hydrocarbons did not show any evidence of oil contamination. All the heavy metals were very low in concentration and in some cases were not detectable; they all fell within the national regulatory limits. This further affirms the non-hydrocarbon contamination status of the groundwaters of the Saghara Field.

Ground water Microbiology

Microbiological properties measured in the groundwater include heterotrophic and hydrocarbon utilizing bacteria, total fungi, hydrocarbon utilizing fungi, total and faecal coliforms. The population of microbes in the groundwater is presented in Tables 4.12d and Table 4.12e for the dry and wet seasons respectively. The total coliform ranged from 12 – 20 MPN/100ml in the dry season and 14 – 20 MPN/100ml in the wet season. However, faecal coliforms were not detected in any of the groundwater samples. By national regulatory standards, faecal coliform should not be present in drinking water sources.

Heterotrophic bacterial population in the groundwater ranged from 3.2 – 6.8 x 10^4 cfu/ml in the dry season and 4.5 – 6.8 x 10^4 cfu/ml in the wet season, whereas hydrocarbon utilizing bacteria ranged from 0.5 – 1.1 x 10^2 cfu/ml in the dry season and 0.4 – 1.1 x 10^2 cfu/ml in the wet season. Hence, hydrocarbon utilizing bacteria accounted for about 1% of the heterotrophic population in both seasons. The predominant genera of bacteria in the study area were *Bacillus*, *Pseudomonas*, *Enterobacter*, *Alcaligenes* and *Staphylococcus*. The total fungi in the groundwater ranged 3.2 – 6.8 x 10^4 cfu/ml in the dry season and 4.5 – 6.8 x 10^4 cfu/ml in the wet season. Hydrocarbon utilizing fungi in both seasons were not significant. The results suggest that the groundwater is not contaminated with hydrocarbons. *Aspergillus* and *Penicillium* were the most frequently isolated fungi in the study area.

Table 4.12d: Groundwater microbial population in the Dry season

Code	THB	THUB	Predominant Bacterial Isolates	Total Coli form Count	Faecal coliform	TF	HUF	Predominant Fungal Isolates
	10^4 cfu/ml	10^2 cfu/ml		MPN/100ml	MPN/100ml	10^3 cfu/ml	10 cfu/ ml	
SAG GW4	5.4	0.7	*Bacillus sp, Enterobacter aerogenes, Pseudomonas sp*	20	0.0	4.6	1.2	*Aspergillus sp, Penicillium sp*
SAG GW5	6.8	1.1	*Bacillus sp., Enterbacter sp*	12	0.0	1.4	1.0	*Aspergillus sp, Penicillium sp,*
SAG GW6	3.2	0.5	*Bacillus sp, Enterobacter sp,*	17	0.0	1.0	1.5	*Penicillium sp,*
GW7	4.3	0.9	*Bacillus sp, Enterobacter sp,*	15	0.0	2.3	1.8	*Aspergillus sp, Penicillium sp,*

Table 4.12e: Groundwater microbial population in the wet season

Code	THB	THUB	Most Predominant Bacterial Isolate	Total Coli form Count	Faecal coliform	THF	THUF	Most Predominant Fungal Isolate
	10^4 cfu/ml	10^2 cfu/ml		MPN/100ml	MPN/100ml	10^4 cfu/ml	10^2 cfu/ml	
SAG GW 4	6.3	1.1	*Alcaligene sp, Bacillus sp., Staphylococcus sp ,*	16	0.0	3.2	0.0	*Penicillium sp, Aspergillus niger, Aspergillus clavatus,*
SAG GW 5	5.4	0.7	*Bacillus sp., Staphylococcus sp, Alcaligene sp*	20	0.0	0.8	0.0	*Aspergillus niger, Aspergillus clavatus,Penicillium sp*
SAG GW 6	4.5	0.6	*Staphylococcus sp, Bacillus sp, Pseudomonas sp.,*	15	0.0	1.2	0.0	*Penicillium sp, Aspergillus niger,*
SAG GW 7	6.8	0.4	*Staphylococcus sp , Bacillus sp,*	14	0.0	0.9	0.0	*Aspergillus clavatus*

4.15: Social Environment

4.15.1: Communities in the Study Area

The project area has three major communities Ugborodo, Ugboegungun and Deghele. The Ugborodo community stretches along the coast while the Ugboegungun community is located further inland. Ugboegungun community is referred to as Saghara in National Population Census conducted in 1991. Both communities are in Warri Southwest Local Government Area of Delta State. Ugborodo is the name used for a group of settlements that include: Udeaja (Ugborodo), Ogidigben, Madagho, Ajudayibo, Ijaghala. Other steelements are Costain, Aruton, Otumara, Okitimekpo, Saghara and Ubaoke. The headquarters of Ugborodo group of communities is Udeaja near Aruton. These villages are united in kingship bonds and identify themselves as Ugborodo people. There are also range camps around, which are largely involved in fishing activities and these satellites camps are located within Deghele community which could be considered also a receptive community with respect to the potential impacts that are associated with the proposed project. With the exception of a few migrants of Yoruba, Ilaje, Urhobo, and Ijaw origin living along dotted settlements in the area, the Itsekiris are the landowners and major ethnic group in the region.

4.15.2: Cultural Properties and Values

The high humidity of the climate does not allow for preservation of archaeological artefacts in the area. Moreover, termites and other insects would not permit preservation of wooden artefacts. Stone objects are rare in the area because rocky formations are not part of the geological heritage. Sacred sites are routinely out of bound to strangers and some indigenous elements alike. Sacred groves are located far away from the SPDC acquired land and none are likely to be defiled during the project execution phase of Saghara AG Solution project. Emotional and religious attachments forbid open discussions about some deities, their activities and abodes. Sacred groves where spirits and deities are said to reside are indicated in Table 4.13a.

Table 4.13a: Sacred Groves Shrines and Taboos

Settlement	Sacred Grove	Shrines	Totem/Taboos
Deghele	Agbokhoma, Ugboosakporo-Obi	Osakpore	Crocodile
Ugborodo	Orubu, Ogonokwo		Cocoyam
Ugbeogugun	Okpokushoren	Omiresan	Snails

In Deghele, the guardian deity Osankporo stays in the Ugboosakporo forest, thus making it a sacred place. The deity celebrated during certain annual festival has Komama as the chief priest of the deity. According to Dube, the chief priest of Ise deity in Ugborodo, the popular Ise festival is celebrated every three years. The deity protects the settlement against evil, a claim which, seem to have been negated by the success of the Izon in an attack against the settlement. For Ugbeogungun, the shrine of Omiresan is quite visible from the jetty. The guardian deity is celebrated during the annual Omiresan festival. Osaogun sacred forest in Otumara is the home of Osaogun, the god of war. The grove is strictly out of bounds to women. If a female were to urinate in the forest, such a person will forever lose the ability to pass urine. Although there was no practical evidence of this, the people strongly believe in the potency of the deity.

4.15.3: Demographic Characteristics

Population Size

The 1991 census revealed that Delta State had a population of 2,590,491, made up of 1,271,932 males and 1,318,559 females, distributed into about 573,042 households. Encompassing a landmass or area of over 16,600 km^2, this translates to an average density of 156 persons per km^2. When the population was projected forward at the recommended annual growth rate of 2.83%, the State's population was expected to be 3,158,066 in 1998, distributed among the now expanded 25 LGAs (NPC 1991, 1994, 1998; Delta State Statistical Year Book, 1999).

The Warri South-West LGA in which the Saghara AGS project communities are located is now a densely inhabited area in Delta State. There were a total of 116,538 persons in the LGA in 2006, up from just 33,374 in 1991 (a 71.4% growth in 15 years or an annual growth rate of 4.8%). With the reconstitution of the LGAs and without any documented Government publication, it is difficult to say how many villages and towns actually make up the present Warri South-West LGA. The Warri South West LGA with a landmass of 2036 square kilometre (sq.km.) had a population density of 116 persons per km^2. Much of the landmass by providence is actually made up of more water than land and hence available land for habitation in the area remains a challenge. Table 4.13b shows the population size of each of the communities in the project area.

Table 4.13b: Population of the Communities in the study area

Communities	1991		1996		2006		2012*		2016*	
	Male	Female	Male	Female	Mal e	Female	Male	Female	Male	Female
Main communities										
Ugborodo	3795	2720	5054	3513	5719	5606	8308	5774	9519	6615
Ugbeogugun	714	863	1060	737	1453	1010	1755	1219	1990	1383
Deghele	191	335	354	246	485	337	585	407	664	462
Satellite communities/fishing camps										
Agogboro	706	617	889	619	1218	848	1427	991	1670	1160
Otumara camps	207	213	295	205	312	275	401	312	490	376
Aruton	256	316	368	257	411	290	596	319	754	996
Agokutu	148	164	210	146	287	201	336	234	394	273
Ugbogbelene ji	7	4	10	4	11	7	12	8	14	9
Okitimekpe (Ogborodo)	362	315	455	317	624	434	754	523	855	594
Abe Ugborodo	318	440	509	355	698	486	843	586	956	665
Ugborodo Camp	227	244	316	221	434	302	524	364	594	413
Ubagboro	144	184	221	153	302	211	365	253	414	287
Total	7075	6415	9741	6773	11954	10007	15911	10994	18319	13237

*Projections at 3.2% annual exponential growth rate and base year is 2006
Source: National Population Census 1991, 2006/Projection for 2012 and 2016

Saghara project communities are mostly creeks and are therefore characterized by inadequate land for habitation. Specifically, Ugborodo, Ugboegungun and Agogboro had the largest number of persons while quite few persons inhabited Ugbogbeleneji community. The Nigeria 2006 Census puts the population of the communities at 21,961 with males constituting 54% (11,954) and females 46% (10,007) but with a population growth rate of 3.2% the population figure is estimated to be about 26,905 comprising 56% (15,911) males and 44% (10,994) females as at 2012 (Table.4.10.1). As usual in the Niger Delta region it is noted that there are slightly more males than females. Sex ratio is the ratio of males to females in a given population, usually expressed as the number of males for every 100 females (Haupt and Kane, 2004). Sex distribution of the population in the study environment reveals a male dominant structure in the ratio of approximately about 2:1. According to the 2006 population census, the males are more than the females, constituting 52.4 percent of the Warri South West LGA's population as opposed to the females' 47.6 percent. The sex structure of the LGA is also slightly higher than that of the state; the male-female ratio is almost equal at 50.6% males to 49.4% females, giving a sex ratio of 102.5, slightly lower than the Nigeria average of 105 (FGN Official Gazette, 2007). For every 100 females therefore, there are to be found only 103 males, i.e. 3 more males in Delta State. Surveys carried out in the course of the Niger Delta Master Plan Development process show that there are actually more males (54%) than females (46%) in the Region.

Age Distribution of Household members

The distribution of households in the Saghara communities by age is shown in Fig. 4.5a. About 38.0% fell within the age bracket 0-20 years, while 34.0% were aged 21-40 years. A total of 24.0% were between 41-60 years old. Those above the age of 60 years were 4.0%. The communities therefore, have a high dependency ratio typical of the Delta State relatively high dependency pattern. Child dependency ratio (age group of 0-14 years) was found to be 31.23%, disaggregated into 16.37% (males) and 14.86% (females). The same source reported old age dependency (60 years and above) for both sex at 5.06% (Delta State Household Survey, 2006).

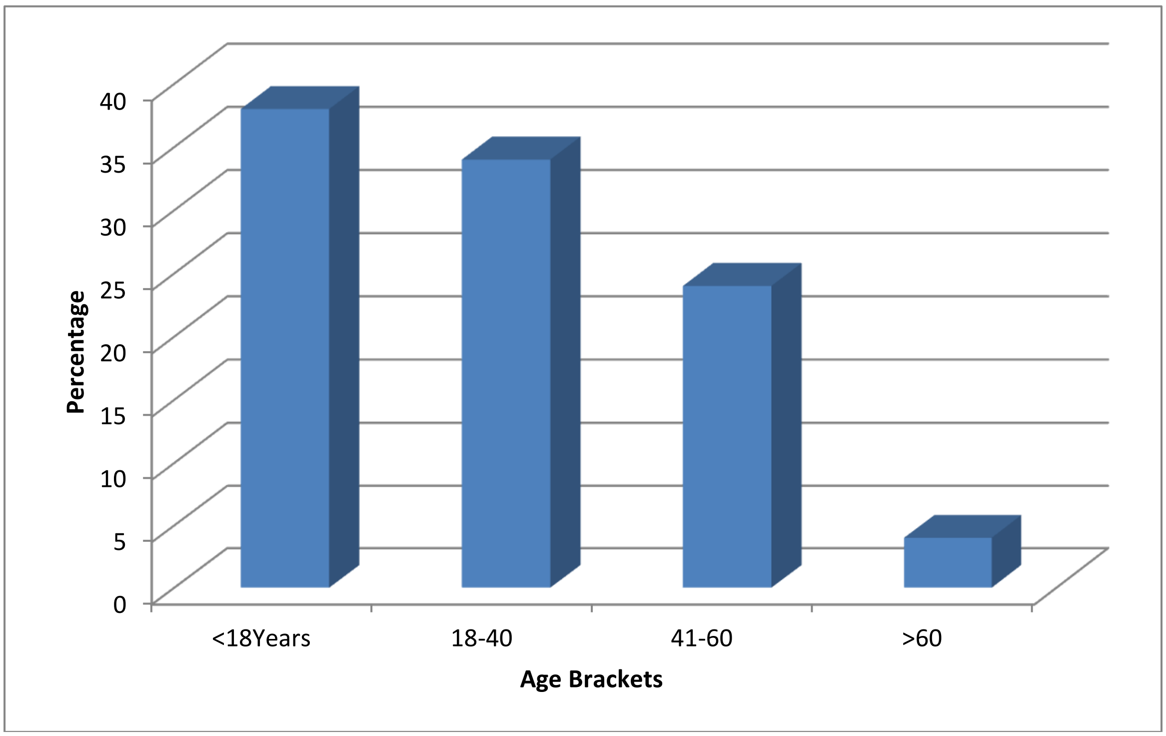

Fig.4.5a: Age Distribution of Respondents

Marital Status

Data in respect of marital status are presented in Fig. 4.5b. About 21.6% of the respondents are single, 65.2% are married/remarried, 6.8% are widowed, while 6.4% are separated/divorced. The low level of divorced household heads in the area is an indication that the indigenes valued marriage. Polygamy is preponderant in the area accounting for 71.4% while monogamy accounted for 28.6%. On the types of marriage contracted, majority of the marriage contracted was through native law and custom (75.7%) while 24.3% were contracted through church and court.

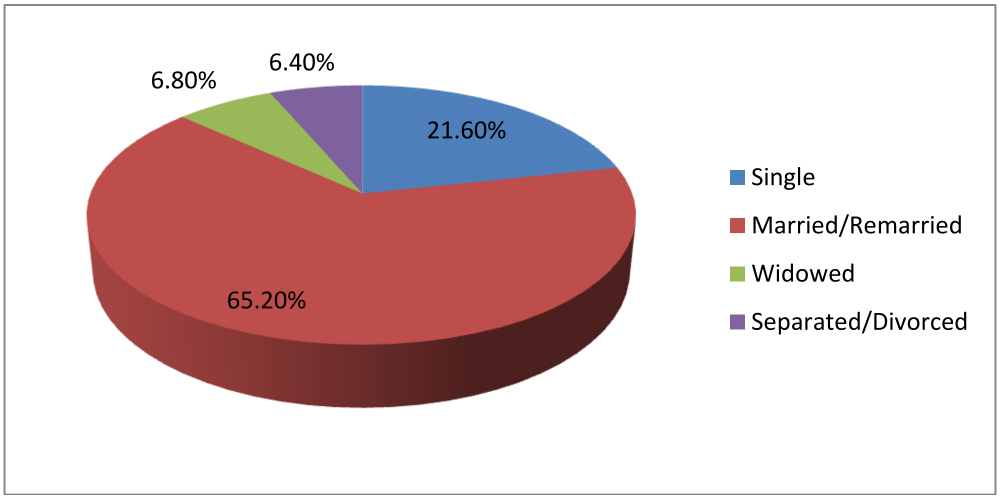

Fig.4.5b: Marital Status of Respondents

Educational Attainment/literacy level

Results showed that the rate of literacy in the project area seemed quite low as the model educational attainment was primary school level. About 67 percent of the sampled population has the post primary education and one-tenth (10%) has some forms of tertiary education. The low level of those with tertiary/post secondary education may be because of limited job opportunity in the past, coupled with limited access to the creeks due to water transportation challenges and predominantly fishing occupation of the indigenes. But about 5.0% reported having No Formal Education (NFE) and this is particular with the aged members of the communities and mostly those living in the fishing settlements. (Fig.4.5c). This is commendable considering that educational facilities are relatively absent and not within easy reach of those desirous of this necessary service.

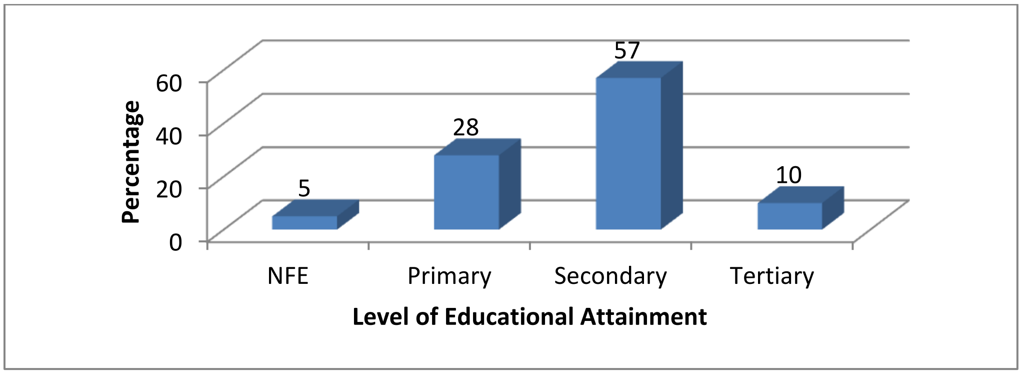

Fig.4.5c: Educational Attainment of Respondents

With respect to school enrolment, attendance and completion, educational statistics of Delta State according to 2006 Household Survey carried out by the Ministry of Economic Planning revealed 37.5% males and 26.7% females school enrolment and 83% of school attendance at primary school level; secondary school level enrolment and attendance levels of 88%; and the tertiary level enrolment and attendance level of 24% and 26% respectively in Warri South West LGA, which is the host LGA of the project communities.

Household size

The size of families differ from community to community, influenced in large measure by the cultural attitude of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. Field survey shows an average of 8 persons per dwelling unit with about 37% households having between 7 and 10 persons in a family. (Figure 4.5d). This result corroborates the NDDC, 2006 result got from enumeration of 3,919,364 households during the preparation of the Niger Delta Regional Master Plan Development which recorded an average household size of 7.46, but with more than 70% of them having an average of 8 occupants. This means that large households were found more prevalent in the rural areas (NDDC 2006)

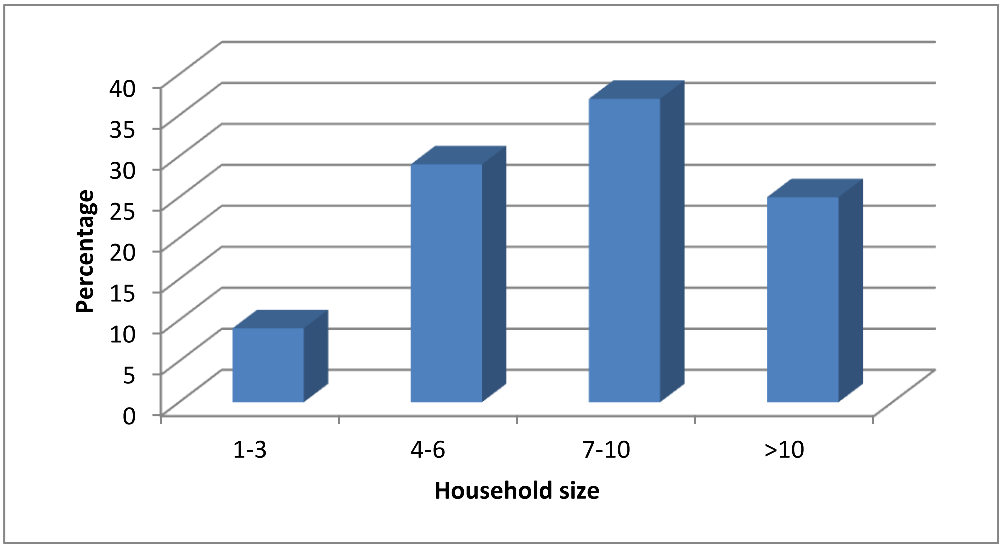

Fig. 4.5d: Family size in surveyed Saghara community

4.13.4: Micro-Economy and Livelihood structure in Project Area

Occupation

Fishing, apart from being the major occupation (58%) of the people in the area is considered as a way of life of the people. There is virtually no single person in the communities who is not knowledgeable in the art of fishing; even the children of primary school ages have considerable experiences in fisheries activities. It is conducted along the surrounding creeks, Escravos River, slots/canals and deep into the Atlantic Ocean. Fish catch is seasonal and depends on tides. The major species caught include tilapia, scale fish, shrimps, crayfish, oysters. Crabs and periwinkles abound in the area, although these are not given much attention. Fishing implements are artisanal, yet quantities caught more than meet domestic requirements, hence there is a large scale trade in fish. It is widely claimed that implements are expensive.

Apart from fishing, the people in the area are also engaged in a number of economic activities. These include hunting (5%), farming (15%), petty trading (10%), civil service/paid employment (2%) and artisanal (1%). Some of the crops grown include coconut, oil palm, raffia palm, mango, tomato, pawpaw, cassava and plantain, some of which are grown in commercial quantity. The general occupational distribution of the people in the area is presented in Fig 4.5c. Unemployment is about 9% in the area; apparently due to non-availability of vocational skill development and poverty-reduction programmes such as micro-credit schemes in the region.

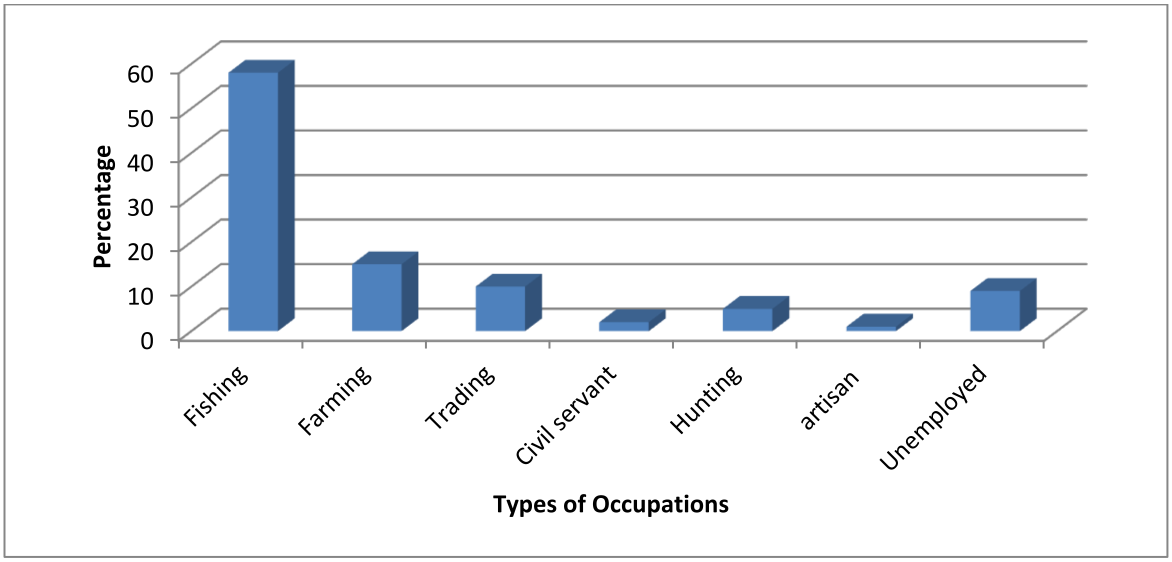

Fig.4.5c: General Occupational Distribution According to Communities

Income

The only basis on which inferences could be drawn in terms of derived income from economic activities by respondents was information volunteered individually during interviews. Data obtained in respect of income from fishing, farming and other sources are presented in Table 4.13c.

Table: 4.13c: Distribution of Household Income

Source	Income (₦)	Percentage
Fishing	Weekly	
	Below 5,000	59.6
	5,001-10,000	35.6
	10,001-15,000	4.5
	Above 15,000	0.3
	TOTAL	100.0
Farming	Weekly	
	Below 3,000	65.0
	3,001-6,000	21.0
	6,001-10,000	13.0
	Above 10,000	1.0
	TOTAL	100.0
Other Sources	Weekly	
	Below 5,000	38.0
	5,001-7,000	25.0
	7,001-10,000	26.0
	Above 10,000	11.0
	TOTAL	100.0

As noted earlier, fishing is the main source of income for the inhabitants; however, farming has started to assume a significant role especially since the introduction of improved variety of plantain suckers by SPDC. Some of the non-fishing vocations include palm-wine tapping, canoe-carving and gin-brewing. Therefore on the average, weekly income to fishers, farmers and other income earners is estimated to be about N3,560.00, N2,310.00 and N2,450.00 respectively. The low income levels in the study area were predicated on the stagnant rural economies, wherein natives depend mainly on low-technology-driven exploitation of natural resources at subsistence levels and with unsustainable practices.

Household Expenditure Pattern and Savings

Quantitative information obtained on household expenditures and consumption profile of the resident population as expressed by heads of household revealed that 22% of the households spend between N2,500 -N3,000 on their families on a weekly basis. Some 16% of the households spend between N1000 and N1,500 as weekly family expenses, while about 4% and 9% spend less than N500.00 and greater than N3,500.00 respectively weekly (Fig. 4.5d). The expenditure pattern observed was consistent with what have been found as household spending priorities in other rural areas of the Niger Delta. Feeding was listed as the most important spending item (51%), while medicare was considered the least important item of expenditure of the households. Interestingly, the proportion of household income spent on communication and transport is over 20%; this may not be unconnected to the increasingly use and popularity of mobile telecommunication among the people coupled with the high cost of transport fare associated with marine transport reported variously in the riverine communities of Niger Delta.(Table 4.13d).

Table 4.13d: Expenditure Profile of households in the area

s/n	Expenditure Profile	Percentage
1	Feeding	51
2	Clothings	5.4
3	Medicare	4.3
4	Education	11.1
5	Social/transfer	8.1
6	Communication/Transport	20.1
Total		100

Even though there are no banking facilities in the area, the residents of the area have engaged in some forms of saving using local institutions. Specifically about 34.6% of the respondents reported to have been saving portions of their income with local thrift institutions and cooperative societies where they are members. The average annual savings is reported to be between N10,000 -N20,000 in a year (Fig. 4.5e). There are a few number of unregistered social groups, trade associations and cooperative societies in the surveyed communities.

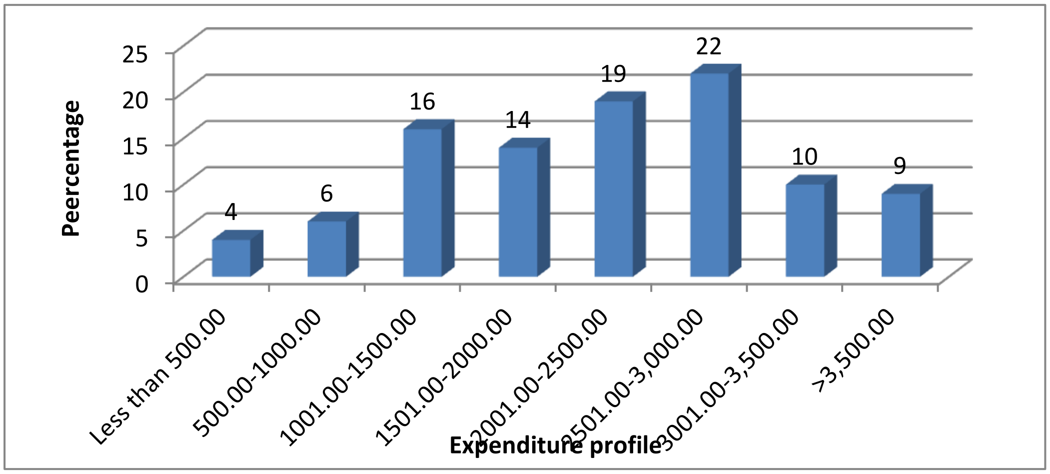

Fig. 4.5d: Weekly expenditure profile of families in Saghara community

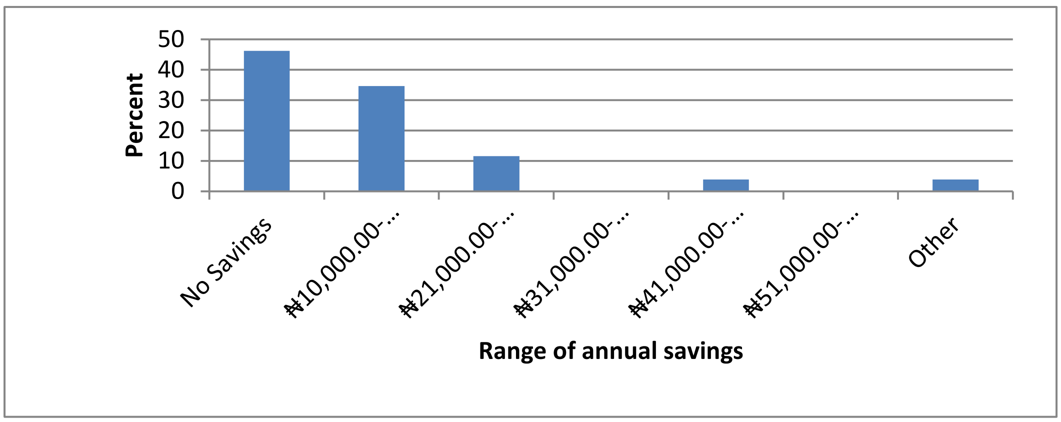

Fig. 4.5e: Annual savings of respondents

4.13.5: Social Infrastructure

Educational Facilities

Very few educational institutions exist in the entire area. There are primary schools in Ugborodo (primary and secondary schools gutted by fire during communal crises between the Itsekiri and the Ijaws) in 1999. Deghele and Ugbeogugun have one primary school each. No secondary school has been built in any other settlement. This has created problems for children of secondary school age who are now have to travel to towns and cities such as Warri, Yenagoa and Port Harcourt to achieve secondary education.

Health Care Facilities

The residents in all the Saghara AGS Project communities have limited access to functional primary health care services as there are only three primary health care (PHC) facilities located at Ugborodo and Deghele to render primary health care services to the population. A PHC built by CNL at Madangho but which was destroyed in 1999 during the inter-ethnic clashes between the Ijaws and Itsekiris has been renovated and opened for public use. There also exist PHC at Ajudaibo and Secondary Health Center- Cottage hospital at Ogidigben that serve the communities. The PHCs are located within the prescribed 5km or 30-60 minutes travel times. The limited numbers of health care facility compels the population to travel long distances to upland areas like Warri, Sapele and Koko to seek for medical treatment when the need arises. Some also resort to self medication, buying un-prescribed drugs from itinerant drug peddlers. Some seek the services of traditional medicine healers and deliveries of babies are undertaken by untrained traditional birth attendants (TBAs). Complicated cases are however, referred to Warri, sometimes too late resulting in the deaths of pregnant mothers.

Water Supply facilities

Potable water is available in Ugborodo, Ugbeogungu and Ubegbelemeji only. The first two communities are connected to the reticulation water facilities of Chevron Nigeria Limited (CNL) from the tank-farm. The population at the Saghara settlement sources water from SPDC's water facility, with points located by the facility's fence, close to the military sentry. Noticeable irregularity in supply was also observed as many receptacles/containers were left behind by households at the tap unfilled. Also, rain water harvesting appears to be common, indicating reliance on this water source (Plate 4.5a). In fact, an overwhelming majority (96%) acknowledged this as source of water supply. Inhabitants in other settlements and communities in the area are forced to drink water fetched from the rivers and other sources that are not entirely potable. Settlers often besiege oil installations to fetch drinking water, while most indigenes have sunk wells from where they obtain drinking water.

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

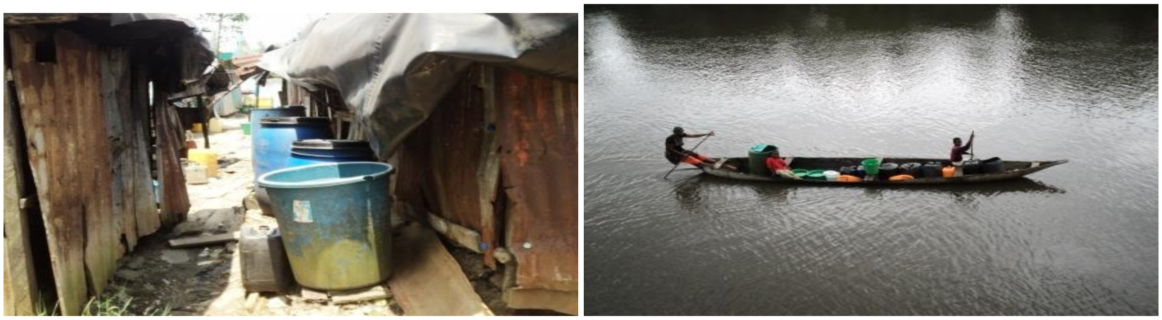

Plate 4.5a: Rain water Harvest and residents at fishing/farming settlements travel some distance to oil installations to fetch water in jerrycans.

Electricity Supply

Ugborodo in the Saghara AGS Project area is the only community that has access to regular electricity supply from the Chevron's tank-farm facilities in addition to a standby giant generator that provides energy to the population (Plate 4.5b). Ugbeogungun community has limited access to energy supply via two giant Generators provided by the SPDC and DESOPADEC respectively. As at the time of study however, one of the generators was no longer functional (that of the SPDC-sponsored) but both fuelling and maintenance cost of the functional generator are borne by the SPDC.

Plate 4.5b: Two giant generators supply electricity to the project communties

Electricity comes up only in the night, 6 pm to 7 am. The remaining settlements/ communities in the study environment have no access to electricity, a situation highly resented by the people. In the absence of this basic amenity, community members who can afford it purchase private generators for personal use and for business (to power electrical appliances, e.g. fridges and refrigerators for cooling of drinks). The local hurricane lanterns remain the old-time means for illumination of homes in the studied communities. Firewood (fuel-wood) energy is also utilised for cooking of foods and processing of fish (smoking).

Markets

The Gbogbodu market in Deghele has been burnt down. A 4-stall market built by Chevron exists in Ugbeogungun.

Transportation and Communication

Surrounded by water, the project area is only accessible through water; transportation is through hand-dug canoes (by residents in the villages/fishing camps particularly and for inter/intra community movement) and the popular fibre or outboard engine boats usually fitted with various grade of HP engines. Transportation of agricultural products, including processed fisheries, and other bulky items are undertaken by the cargo boats which travel on lower speeds and also charge lower fares (Plate 4.5c). The project area can be accessed from Warri, Sapele and Koko. Marine transport to the project area communities and other proximate villages can therefore be cumbersome, risky and costly; travel time varies from about an hour to more than 1 ½ hours depending on the location of the community within the area.

A few commercial transport boats ply the creeks at regular intervals; meanwhile, transportation fares were reported to be very exorbitant. For example, from Ugborodo and Ugbeogungun communities to Warri, transport fares vary from N1,500 to N2,000 per trip. This may be responsible for the high cost of items and hence living in the area, since traders have to incorporate this high transport fares into the goods for them to make a profit.

Only Ugbeogungun community has a concrete jetty (Plate 4.5c) while wooden jetties are commonly used in the other settlements and communities in the area.

The new mode of telephony, the GSM common to most Nigerian communities was found to be less effective in the study area. Depending on one’s location, connectivity is limited to one of the three networks of MTN, Airtell and Globacom. The resident population therefore, has limited access to telecommunication.

Plate 4.5c: Popular transportation means and available concrete jetties at Ugbeogungun community

Civic Gathering Places, Recreational Facilities and Security and Safety

The Saghara AGS project communities are much organised, social and hospital people. There are therefore, available in the permanent communities' places for community meetings and social events. Ugbeogungun and Ugborodo were found to have town halls built by the SPDC and CNL respectively (Plate 4.5d). Most of the fishing settlements and communities in the area use improvised structures and places to receive visitors. Communal activities such as football, dancing, masquerade displays, etc. are organized for recreation during festive periods in the studied communities. Common recreational activities among youngsters include football and playing of snooker games, found common at the Saghara settlement. Several drinking parlours and local restaurants also abound in the communities.

The study area was acclaimed to be generally very peaceful until the inter-communal crisis of the late 90s which devastated the communities. During that crisis, the few social and infrastructural facilities available were damaged. Lives and property were lost and the result was destitution. Presently, the communities have managed to resettle and resume their normal activities. Occasional fears are still being entertained because of the sporadic nature of attack in the Niger Delta generally. The reported social vice in the area include: piracy, pipeline vandalisation, petty stealing and prostitution.

Plate 4.5d: Modern Town Halls for Ugbeogungun and Ugborodo communities

Housing Types and Ownership

Housing structures in the Saghara settlements in the area are mainly built with ephemeral forest materials, e.g. raffia palm fronds, bamboos and plank/wood, with modal roofing materials been of thatched materials and a few roofed with zinc. Over a third (38.5%) of surveyed respondents own and live in houses constructed of wood wall and has zinc roofing. Some 23.1% prefer to describe their housing as ''other'' while equal percentages of the respondents own and live in houses made of mud with thatch roofing (wattle and daub type) and those of block with zinc roofing respectively (Fig. 4.5f).

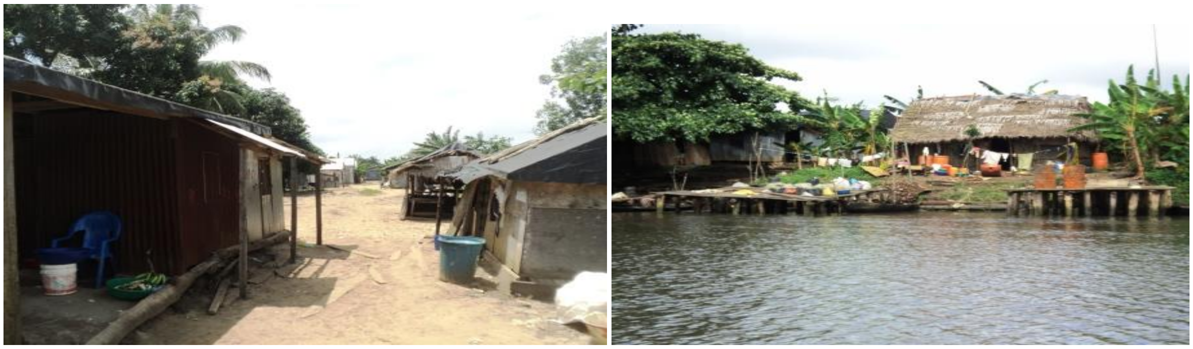

Plate 4.5e: Typical housing structures in the project area constructed of wood, zinc and thatch

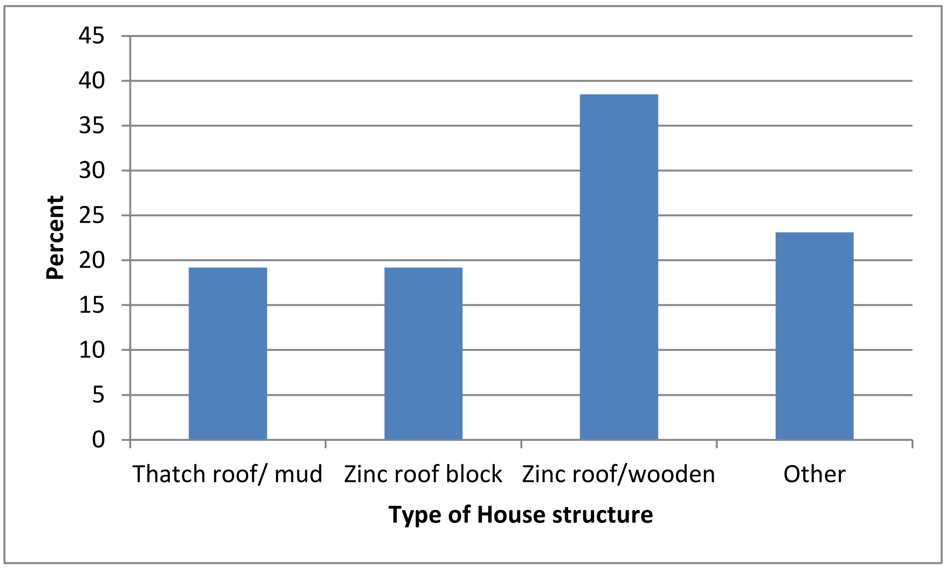

Fig. 4.5f: Housing ownership and type in Saghara community

4.13.6: Natural Resources and Land Use

A number of plant species encountered are of economic importance. They produce edible fruits, food crops, palm oil, palm wine, medicine and materials for thatch-building. Of particular interest is the extensive mangrove forest between Otumara and Saghara. These economic trees produce resins and dyes that can be useful in textile manufacture for both local and international markets. Canoe building, which is extensively carried out in the region thrives on the basis of these trees found in that forest. Plantain cultivation is produced on dredge dumps. As a result of its extensive cultivation, it has become a major source of income and food for the inhabitants. Equality of note is the numerous species of mammals such as monkeys and grass cutters on land and fish, shell-fish, periwinkles in the waters. They provide sources of food and revenue for the people in the area. Despite the fact that nature reserve is abundant in the area, lumbering and indiscriminate felling of trees for fuel purposes is depleting the forest.

4.13.7: Social Structure and Organisation

At the apex of the social organization is the Olu, who is resident in Warri to whom all Itsekiris owe allegiance. Each settlement in the study area is headed by the most elderly person (gerontocracy). He is assisted in the administration of the community by an Executive Committee (EC). This organ performs a number of functions. Some of them being:

- Day-to-day administration of the community
- Dispute resolution and peace-making among members of the communities.
- Nominate community members who work with companies or contractors, when projects are being executed in the communities.
- Fix daily remuneration for workers engaged by companies during project execution
- Liaise between the community and external bodies and
- Determine the type of community projects to implement when necessary

Next in the hierarchy is the Youth Council. Specifically, it assists the communities Exco in their day-to-day administration of the communities. It also actively participates in communities' development programmes, mobilise members for vigilante activities and help to maintain peace and orderliness in the area. We also have women as part of the social structure, though they are not often consulted in matters relating to the administration of the communities. Nevertheless, women play significant roles particularly in the areas of child-birth, income generation from fishing and allied activities. They also perform ceremonial roles during marriage ceremonies and burial rites. The social-political organization described above is presented in Fig. 4.5g.

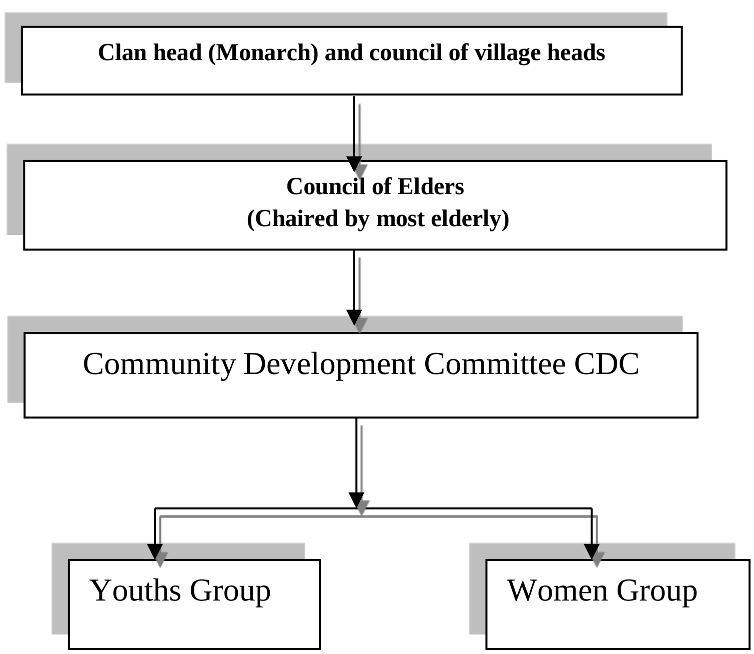

Fig.4.5g: Socio-Political Organization of the Communities in the Project Area

4.13.8: Security and Safety

The study area was acclaimed to be generally very peaceful until the inter-communal crisis of the late 90s which devastated the communities. During that crisis, the few social and infrastructural facilities available were damaged. Lives and property were lost and the result was destitution. Presently, the communities have managed to resettle and resume their normal activities. Occasional fears are still being entertained because of the sporadic nature of attack in the Niger Delta generally. The reported social vice in the area include: piracy, pipeline vandalization, petty stealing and prostitution.

4.13.9: Perceptions of impacts of SPDC's existing Saghara Flowstation on human environment

Interaction with the population in the Saghara Field project environment during Focus Group Discussions (FGDs) revealed a mix of perceptions on how the operations of the SPDC have impacted the human and physical environments since coming on stream in the area over 40 years ago. On the negative side, the people perceived that the following have occurred since oil and gas development activities intensified in the area:

- Environmental pollution and hazards particularly oil spills and effects on fisheries;
- Effect on agricultural production leading to reduction in farm harvests;
- Effect on inhabitants' living environment, specifically from emissions and gas flaring activities which has caused a deterioration in rain water quality (acid rain phenomenon) and thus makes rain water undrinkable;
- Harassment of inhabitants by the military when population sources water from water points placed near the sentry;
- Health impacts- noise pollution resulting from flowstation, flare and constant chopper flights and excessive heat caused by constant gas flaring activities;
- The general lack of basic amenities particularly in nearby farming and fishing settlements and resentment from deprivation
- Low number of employment opportunities for indigenes of the area.

4.13.10: Perceptions, concerns and social needs/expectations of the population

The general population in the Saghara AGS project area has a mixed outlook on the proposed project. While many perceived the potential impacts of the project in the negative light, a few were hopeful and full of expectations as per the benefits that are likely to be derived in form of increased local economy and social infrastructural provision from the project.

Majority of the population (85%) in the project area feared that the proposed project activities shall impact on the livelihood system in more ways than one. These shall include damage to their agricultural land (31%), pollution of fishing grounds (28%) and loss of residential homes (26%). About one-tenth (14%) also fear that noise nuisance shall increase during project implementation and further impact on their health. With respect to positive benefits, the expressed needs/expectations of the people from each of the host communities are as shown in Table 4.13e.

Table 4.13e: Needs assessment of the studied communities

Deghele	Ugborodo	Ugboegugun
Water Supply project	Ugborodo-Arunton Road repair	Civic Centre
Women Programme	Women Programme	Women Programme
Completion of electricity project and a health centre	Civic centre, shore protection and completion of electricity project estimated	Walk ways and pedestrians bridge
Rehabilitation of civic centre	Business Development	Agricultural Assistance
Agricultural Assistance		Health Centre
Business Development		Business Development

4.14: Health Studies

This section reviews the relevant baseline information concerning health issues in the Saghara AGS Project Area. It evaluates the demographic, social, biological, economic and environmental determinants of health with particular reference to the project area. Although it relied more on pieces of information collected on health and other relevant issues during the baseline survey, it nevertheless took cognisance of other relevant pertinent pieces of information from literature and other sources to provide a comprehensive picture. The roles of social, biological, economic and environmental factors as determinants of health have been described in the literature and many are well known (Harris, Harris-Roxas, Harris & Kemp). However, the concerns expressed by the respondents during baseline survey naturally received more prominence in highlighting the baseline health situation.

4.14.1: Determinants of Health in the Project Area

The major factors that were reported to contribute to poor health status in the project communities were similar to those observed in other rural communities in Nigeria. Infectious or communicable diseases, poverty, inadequate access to potable water and acceptable sanitation facilities, poor health infrastructure, poor personal hygiene and unsanitary environmental conditions were noted by the respondents to account for the poor health status in the communities. Respondents in the project area observed that the commonest ailments were malaria, diarrhoeal diseases, respiratory tract infections and measles; all which are communicable diseases. Respondents also reported a rising prevalence of non-communicable diseases such as cancers, hypertension and diabetes mellitus which they associated with oil and gas exploration. Community conflict was reported to be responsible for most deaths that occurred among the youths. Interventions to reduce poverty, increase access to potable water and basic sanitation, improve health infrastructure and access, and reduce communal conflicts would improve health status in the communities. The potential of the proposed project to contribute to all of these is evident and will be discussed in appropriate sections.

4.14.2: Demography

Saghara and its satellite villages are rural and inhabited mainly by the Itsekiris. The population structure of the communities is consistent with those of similar communities in the Niger Delta *(UNDP, 2006)*. Permanent residents in the communities were mostly the elderly, fisher-folks and traders; several of younger members, particularly males in the 20 – 39 year age range reside in Warri. The implications of this for commercial sex work and its consequences for transmission of sexually transmitted diseases (STI) and HIV as well as other social vices such as smoking, drug and alcohol abuse, and violence must be considered.

4.14.3: Environmental Health

Most members of the project communities were able to meet the daily per capita water requirement of 20 – 40 litres albeit from a variety of potentially contaminated sources. The sources of drinking water in the various communities are as shown in Fig. 4.6a. Tanker water (supplied by SPDC) and sachet water were the most common sources of drinking water in the bigger communities – Ugborodo and Ugboegungun. About 15% of households spent more than 30 minutes to complete a round trip to fetch potable water from their preferred source. This proportion is better than the average rate of 28.5% reported in the 2008 National Demographic and Health Survey for rural areas in Nigeria and compares well with the average proportion reported for urban areas (Fig 4.6b). The proportion of the project community households with adequate access to potable water was better than the average reported for South-South Nigeria in the 2008 National Demographic and Health Survey (*NDHS 2008)*.

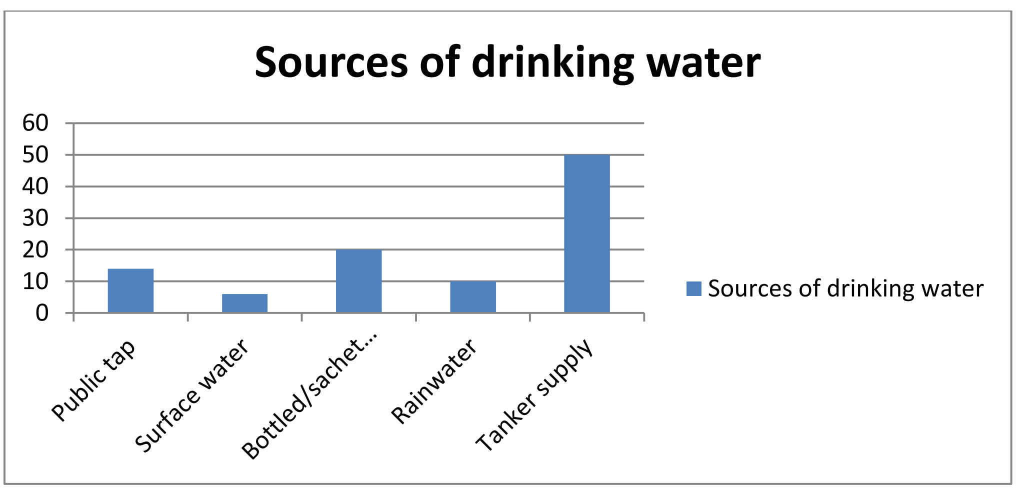

Fig. 4.6a: Sources of drinking water

Water for other purposes was obtained from contaminated surface and ground water sources. Results of laboratory analysis of surface and ground water samples collected during field studies showed low total coliform counts. The Total Coliform counts of the ground water sample ranged from 12 to 20 MPN/100ml for dry season and 14 to 20MPN/100ml for the wet season. No faecal coliforms were observed in the ground water. Surface water samples contained even higher levels of between 11 MPN/100ml and 35 MPN/100ml in the dry season and 12-40MPN/100ml the wet season. The Total Coliforms count was much higher than the limit specified by WHO for potable water (0.0 MPN/100ml). These findings are not surprising considering the widespread use of the over-hung (jetty-type) toilet in the communities (Ordinioha 2011). The use of water contaminated with coliforms is capable of causing diarrhoea, but can be made potable by the addition of chlorine tablets, especially those that also have coagulants and flocculants, like the “water guard” marketed by the Society for Family Health. (Clasen *et al*., 2005). Respondents also complained that water from some of the boreholes in the communities was salty and as a result these boreholes were abandoned. High salinity of ground water is not uncommon and is a reflection of salt water intrusion which is an established phenomenon in the Niger Delta Costal communities.

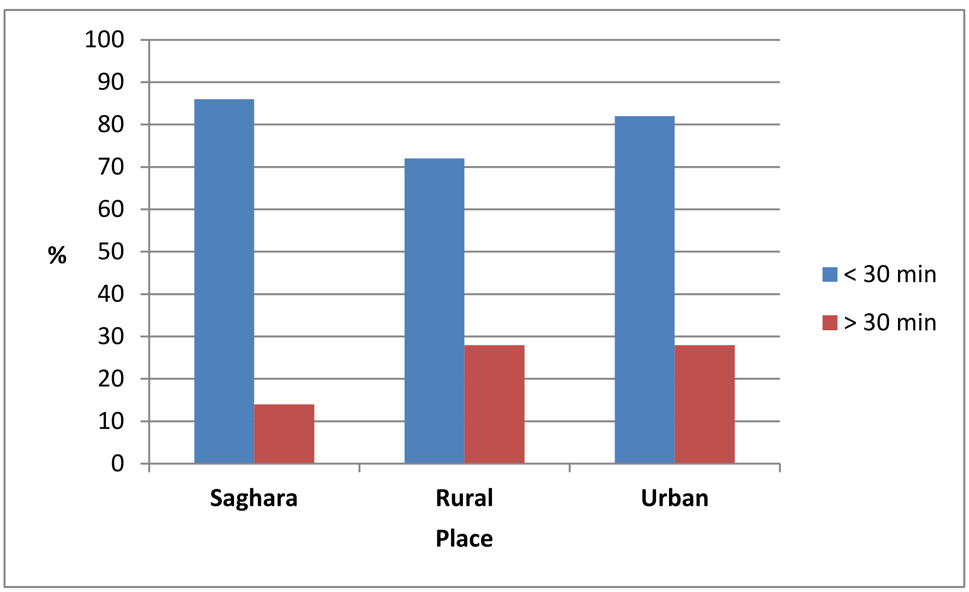

Fig. 4.6b: Time spent to fetch water in the Saghara communities

Natural and artificial surface water bodies abound in the project communities. Such water bodies provide favourable breeding grounds for vectors of diseases (eg. mosquitoes) that transmit Malaria, Filariasis and Schistosomiasis hence it is not surprising that Malaria and other arthropod-borne diseases were reported to be prevalent in the communities.

Plate 4.6: (a) Water installation (b) Artificial pond in the project community

Plate 4.6c: Water Storage in poject community (a) Surface tanks (b) Rain water Harvesting

Apart from high salinity and high coliform count, ground water samples did not contain any detectable concentrations of Benzene, Toluene and Xylene components of the Total Hydrocarbon Content that are said to be potentially carcinogenic (ATSDR, 1999). While iron content was high, other heavy metals - Cadmium, Lead, Manganese and Vanadium were not in detectable concentrations in the water. These later heavy metals have been shown to have some effects on human health (WHO/FAO/IAEA, 1996).

It was observed during the field study that members of the communities often used discarded drums of drilling chemicals as water storage containers. The health implications of the use of the drums are however not known to members of the communities. There is therefore a need for proper health education, especially as the oil companies operating in the communities can easily be blamed for any health effects that arise from the use of the drums.

Plate 4.6d: Water storage with drilling chemicals drums

Access to Sanitary Faecal Disposal Facility

Sanitary disposal of faeces is another important determinant of health. Sanitary disposal of faeces reduces the risk of faeco-orally transmitted infections like cholera and other diarrhoeal diseases, typhoid, intestinal helminthiasis, etc. Access to sanitary faecal disposal/sanitation facility is another Millennium Development Goal. During field study, a faecal disposal facility/latrine was considered to be sanitary if it was either a toilet or a latrine with a septic tank that effectively prevents contamination of surface or ground water with fresh human faeces. Overhung toilets or flush toilets that channeled effluents directly into the river were considered insanitary. A household had access to sanitary faecal disposal facility if it had a private facility or shares one with not more than five other households in a building or compound (Billig *et al*, 1999). Most latrines in the project communities were the jetty or over-hung toilets that discharge faeces directly to surface water and therefore insanitary. Few sanitary toilets were however seen in the bigger communities.

Plate 4.6e. The jetty-type toilet is the commonest toilet in the host communities Housing and vector/pest control

Twenty (20) houses located at the centre of the two major communities, Ogidigben and Ugborodo, were studied during the community survey. Several of the houses were modern, built with cement blocks and had zinc/aluminium roof. Most had mosquito screens installed but the nets were mostly torn and rarely replaced, except as part of the general renovation of the house. The houses in the smaller communities, especially the fishing settlements had walls that were made up of metal sheet overlaid with plywood. These houses were mostly built in the popular traditional architecture and often with very small windows. The rooms were poorly ventilated and the house generally offered little protection against disease vectors and pests, especially as the communities are at the river bank or close to the forest. Mosquito, Tse-tse fly, Chrysops and Sandfly were the most important insect vectors identified during the field study.

Plate 4.6f: Several houses in the host communities were raised to avoid the seasonal flood

Plate 4.6g: Modern dwelling at Ogidigben

Air Quality

Poor indoor air quality or air pollution is associated with acute respiratory diseases particularly among children who are less than 5 years old. The use of firewood and other bio-mass fuel as domestic fuel is a major cause of air pollution, with wide-ranging health implications (WHO, 2003). Firewood was the commonest source of fuel for domestic use in the host communities. It was also the main fuel used for fish drying, the predominant method of fish preservation in the communities. The level of use of firewood in the communities is however consistent with the findings in other Niger Delta communities where an average of 73% of the households in the communities was observed to use firewood as their primary energy source (UNDP, 2006).

The concentrations of suspended particulate matter (SPM) in the ambient air of the study communities varied from 0.62ug/m^3 to 2.66ug/m^3. These concentrations are significantly lower than the Nigerian Federal Ministry of Environment limit of 250ug/m^3, and even the WHO's annual limit of 20ug/m^3 that is said to be the threshold for significant adverse health effects (WHO, 2006*)*. This is remarkable, considering that SPM is not only produced by gas flaring, but also by the combustion of bio-mass fuel, such as firewood that is commonly used in the communities. Saghara AGS project should therefore contribute to improvement of air quality in the project communities.

Plate 4.6h: Firewood is the commonest source of fuel for domestic use

Waste Management

The wastes generated in the communities were mainly garbage and other domestic wastes. These wastes were often dumped close to residential accommodation or at the bank of the river, where they sometimes served for land reclamation and/or shoreline protection. Leachates from the wastes can however become a source of contamination of the water body.

Plate. 4.6i: Refuse dump site

4.14.4: Behavioural Factors

Behavioural factors play important role in the epidemiology of both communicable and non-communicable diseases. Cigarette smoking, substance (drugs) and alcohol use are well-established risk factors for coronary heart diseases, cancers and several psychosocial health-related issues like prostitution, armed robbery, domestic and gender-related violence. Risky sexual behaviour is associated with transmission of sexually transmitted infections including HIV. Influx of younger males and females into the project communities to search for employment can influence change in sexual behaviour within the project communities. Fortunately however, by virtue of its scope, the Saghara AGS should not result in such influx.

4.14.5: Alcohol and Tobacco use

Alcohol and Tobacco were commonly used in the host communities like most communities in South-South Nigeria. Alcoholic beverages, including the locally distilled gin called K*ai*-kai or O*gogoro,* were freely available and at all time in the communities. Alcoholic beverages were used during social functions and even in ancestral worship. Alcohol is also a ubiquitous solvent for several traditional medicines. The number of drinking bars and well stocked provision stores that sell alcoholic beverages in communities like Saghara and Ugborodo were higher than that expected for communities of their size. However, cases of alcoholism were said to be low, in spite of the large number of persons that take alcohol in the communities. Binge drinking was however said to be high in the communities, especially during festive periods and burial ceremonies when indigenes converge from all works of life.

4.14.6: Sexual Behaviour

The sexual behaviour of members of the project communities posed significant risk for the transmission of sexually transmitted infections including HIV/AIDS. Polygamy was common among the married adult males while single girls reported that they had multiple sexual partners. Culturally in the communities, fidelity in marriage is prescribed for women while men could engage in extra-marital affairs. While more detailed information on the sexual behaviour of members of the communities could not be obtained because of the sensitive nature of the topic, discussants were nevertheless unanimous on the fact that sexual behaviour is no different from that of the other communities of the South-south region of Nigeria. According to 2003 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2004).

- The age at first sexual intercourse in the Niger Delta region was about the lowest in the country at 16.7 years; lower than the national average of 16.9 years.
- 20.9% of women in the region had sex with a non-marital partner in the 12 months before the study, which was much higher than the national average of 9%.
- 15.3% of women aged 15 – 29 years in the region had sex in exchange for gift or favour, compared to 2.8% in the North East zone, and 8.3% in the South East zone. The national average was 6.9%
- 5.9% of women aged 15 – 29 years in the region had sex with multiple partners in the 12 months before the study, compared to 1.1% in the North West zone and 2.0% in the South West zone. The national average was 2.7%
- 18.2% of women aged 15 – 29 years in the region had at least one non-marital partner, while 2.6% had more than one partner, compared to 1.3% and 0.5% in the North West, and 8.9% and 2.5% in the South-East. The national averages were 7.6% and 1.3% respectively.

4.14.7: Knowledge of HIV/AIDS

Human Immunodeficiency Virus in adult Nigerians is mainly transmitted through the heterosexual route and this explains why the "ABC" method forms the basis for HIV control in Nigeria. The "ABC" method is an acronym that stands for sexual abstinence, being faithful in monogamous relationship between HIV-negative partners, and condom use for people not practicing abstinence. Focus group discussants had heard of HIV/AIDS and demonstrated good knowledge of the "ABC" methods of HIV prevention. They attributed their knowledge to the health enlightenment campaigns conducted by the health workers and NGOs with the generous support of SPDC. Shell Petroleum Development Company has championed health education about HIV in the Niger Delta region perhaps because oil and gas projects have been reported to increase the transmission of HIV in the Niger Delta (Nwauche and Akani 2006).

4.14.8: Household Food Security and Feeding

Most members of the communities regularly eat the local staples of cassava, yam and plantain. These are starchy staples that were however complemented with fish and shell foods, which are the major agricultural produce of the people. Several respondents pointed to a worsening household food security situation in the communities due to the communal crisis that engulfed the area.

The prevalence of malnutrition among the under-five children is one of the indicators for Millennium Development Goal One. The nutritional status of under-fives in the project communities was assessed during the field survey using anthropometry. Two hundred and thirty-nine under-five children were assessed; of these, 46 (19.25%) were found to be under-weight. Fig 4.6c compares the prevalence of malnutrition in the project communities with the national and South-South geopolitical zone averages. Although the prevalence was lower than the national averages, it was nevertheless higher than that of the South-south zone. It should however be borne in mind that malnutrition in children is not only a reflection of the diet and socio-economic status of the household but is also influenced by frequency of infections and other environmental conditions (Ruel and Menon 2003).

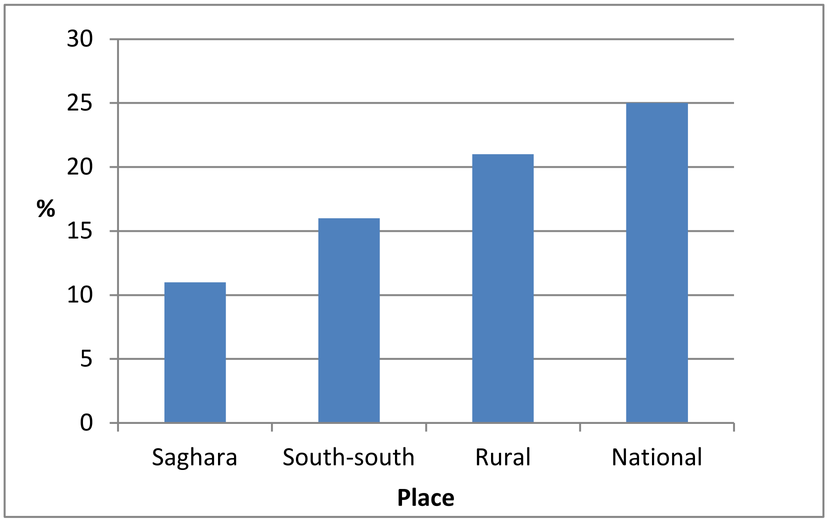

Fig. 4.6c: A comparison of the prevalence of childhood malnutrition

4.14.9: Mortality Pattern

Focus group discussants felt that mortality rates, especially among under-fives and pregnant women, were falling in their communities; they also felt that the rates were similar to those of the neighbouring communities. Maternal deaths (women dying during pregnancy or childbirth) were reported to be very infrequent, occurring about once in every five years. Compared to the past, the discussants felt that the remarkable decrease was due to early recognition of signs of severe illness during pregnancy or childbirth and the rapid movement of the patient to Warri, Oghara or Benin for appropriate treatment. The causes of the maternal deaths recorded in the communities in the last five years, according to verbal autopsy, were prolonged labour, post-partum haemorrhage, abortion and eclampsia. These causes are also consistent with the findings in most other communities in Nigeria (NDHS, 2008).

On the average, about 62 child deaths were reported to occur in the communities every year. The common causes of these deaths were: malaria and its complications, especially anaemia and febrile convulsion, gastro-enteritis (diarrhoea and vomiting), acute lower respiratory tract infection; and vaccine preventable diseases, especially measles. These causes are also common in most other communities in South-south Nigeria (NDHS, 2008) and are associated with poor environmental conditions, poor health seeking behaviour and poor standard of health care delivery in the communities.

4.14.10: The Health System

Primary Health Centres

Most of the host communities, including the smaller communities, had a health facility located within the prescribed 5 kilometre distance or 30-60 minutes travel time. The Primary Health Care facilities were either sited in the communities, or had the host communities as part of their catchment area. In addition, most of the facilities in had received assistance from the SPDC through the supply of medical equipment, consumables and training of staff. Notwithstanding the availability of the physical facilities, utilisation of facilities has been less than optimal because of dearth of health staff. The focus discussants reported that health workers left the communities at the wake of the communal crisis of the late 1990s and early 2000s. During the field studies, renovated and yet-to-be commissioned health facilities were seen in Ajudiabo.

Plate. 4.6j: PHC Ajudaibo

Secondary Health Care Facilities

The host communities are served by the Cottage Hospital in Ogidigben, located within a maximum of 60 minutes travel time from the farthest project community including the fishing settlements. This hospital has two doctors and five nurses and the facilities expected of a secondary health care facility. The hospital was also being sand-filled by the Delta State Government, as at the time of the field study. The hospital currently has the capacity to attend to accident and emergency cases and provide in-patient and general outpatient services. Again, despite the availability of this service, utilization was poor because of the sparse population in the catchment communities. Referral from the facility is to the Delta State University Teaching Hospital, Oghara, Central Hospital Benin or University of Benin Teaching Hospital, Benin. All centres are adequately equipped to handle severe cases in all medical specialities.

Fig. 4.6k: Cottage hospital in Ogidigben being renovated

Medical Emergency Evacuation System

There was no official medical emergency evacuation system in all the host communities. Members of the communities made their own private arrangement to convey sick persons to the referral hospitals for treatment. The average boat fare from the communities to Warri was N2,000.00, while it might cost up to N40,000.00 to charter a speed boat during an emergency.

4.15: Consultation and Stakeholders Engagements

Consultation is a major requirement in all SPDC projects designed to interact at various levels of project activities with communities and secure their cooperation and support in order to achieve harmony in carrying out projects. Consultation is generally seen as the whole process of seeking information from relevant stakeholders, including communities, academia, NGOs, government and industry on the environmental and socio-economic implications of all facets of the project.

Scoping as a phase in an EIA process is designed to serve as a consultation forum with stakeholders and also to obtain information on significant socio-economic, health and ecological issues on the proposed project. The scoping workshop for the proposed Saghara Field Associated Gas Solution Project was held on Tuesday 25th October 2005 at Conference Hall of Hotel Excel, Effurun. Stakeholders such as regulator, communities, NGOs and specialist in various fields also attended. In all, 41 participants attended the scooping workshop. Presentations were made, plenary and syndicate sessions were held with the participation of all stakeholders' in attendance. This report represents the summary of the activities and outcome of the workshop.

Objectives of Consultation

The main objectives for carrying out consultation for the Saghara Field AG Solution Project include:

- Sustaining consultation with stakeholders via people's parliament with explanation on key issues associated with the project and their effects on the people.
- Maintaining effective communication between SPDC and the host communities.
- Assuring full commitment to implement mutually accepted sustainable community development Projects.
- Facilitating communication and understanding between the various stakeholders and SPDC (the project proponent).
- Gaining support and buy-in from all relevant stakeholders.
- Comply with mandatory statutory requirements.
- Identifying issues relevant to the project which are likely to cause impact.
- Avoiding conflict with the primary stakeholders by addressing issues promptly.
- Ensuring that any apprehension and disenchantment about the project with respect to environmental impacts are given the required attention by sensitizing, and mobilizing the host communities to express their concerns vis-a-vis the potential impacts of the project.

- Providing a link between the communities and SPDC in order to obtain early notification of any changes in the environment as a result of the project.
- Being aware of stakeholders' views of the project with respect to the present environmental conditions in the area and any changes thereof in the future.
- Considering effective participation of the host communities in maintaining and sustaining the beneficial impact of the project.
- Maintaining continuous interaction with the host communities to obtain early warning information on the physical, chemical, biological, health, and social components of the environment to tackle detrimental consequences during the construction and operational phases of the project.

Relevant Stakeholders

Stakeholders are those affected to varying degrees by the impact of the proposed project. There are two classes of impact stakeholders- Primary and Secondary. The primary impact stakeholders include those camps dotted along the creeks and the two major Ugborodo and Ugbeogungun.

The secondary impact stakeholders are the Local Governments responsible for the welfare of the affected communities, the ecologists, conservationists, academia and researchers and environmental NGOs both within and outside the country. There are also institutional stakeholders from the government sector including primary regulatory authorities – Federal Ministry of Environment and DPR, and the secondary regulatory authorities - the Delta State Environmental Protection Agency, Delta Ministry of Environment and the Warri Southwest Local Government Area.

Stakeholder Consultation

The scoping workshop, conducted on Tuesday 25th October 2005 serves as the first contact with the communities on the project. Regulatory agencies represented by the Federal Ministry of Environment have been contacted through the project proposal while DPR were contacted through letter of notification. During the scoping workshop exercise the project activities were explained to all stakeholders in attendance. Besides these activities, consultation with the communities will be on a continuous basis, at every stage of the EIA and project execution. There will be community engagement during field data gathering. Also, there will be feedback to the communities on the outcome of the EIA, the mitigation measures and the Environmental Management Plan (EMP).

The one-day Scoping Workshop for the EIA of Saghara Field was well attended with a total of 41 persons. Representatives of the three host communities, Nigeria Environmental Society, Delta State Ministry of Environment, NGOs, SIA, HIA and Natural Environment consultants, Federal Ministry of Environment and other stakeholders were in attendance. Information on the technical aspect, biophysical, health, and social environment of the project area were presented by SPDC representatives.

Identification of Potential Impacts

The following question format was used as a guide to identify potential impacts and mitigative measures:

A: What is the issue/impact?

B: What aspect of the project will cause the impact and when /where is it likely to occur?

C: What are the sensitive or vulnerable resources/ receptors that could be impacted?

D Who are those impacts likely to affect?

E: What information do you need to predict the magnitude of (b) on (c)?

F: Is the potential impact significant (both positive and negative impact)?

G. What potential measures would you propose to enhance or eliminate or reduce the impact?

The resulting (Table 4.14a, Table 4.14b and Table 4.14c) is the summary of the consultation and expert opinion of the detailed assessment requirement for executing the EIA.

Future Consultations

Shell Petroleum Development Company (SPDC) will continue to consult with all the relevant parties concerned with or likely to be affected by the project at all stages of the project development.

Table 4.14a: Impact Themes and Significance Matrix/assessment during stakeholders' engagement (Group A)

A What is the issue/impact?	**B** What aspect of the project will cause the impact and when is it likely to occur?	**C** What are the sensitive or vulnerable receptors that could be impacted?	**D** Who are these impacts likely to affect?	**E** What information (project data/ENV. data) do you need to predict the magnitude of the impact	**F** Is the potential impact significant? (both positive or negative impact).	**G** What potential mitigation measures would you propose to enhance or eliminate or reduce the impact?
Employment	Negotiation/consultation	Work force, community	Entire community	Demographic Data Baseline	Yes, could lead to dispute	Proper MOU
Pollution and traffic	Marine transport of material	Fishermen, aquatic life	Community	Hydrographic Information, Baseline	Yes Could affect economic life	Compliant of Marine vessels
Social vice	During project execution	Youth workforce	Community	Baseline Data	Yes insecurity, Poor health	Health education social mobilisation
Accidents	All aspects	Workers, community	Community	Risk Assessment	Yes Life and dealth involved	HSE Compliance
Change in living standards	During demobilisation	Community	Community	Rate of Commercial Activities	Yes	Micro credits, employment, proper project implemntation

Table 4.14b: Impact Themes and Significance Matrix (Group B)

A **What is the issue/impact?**	**B** **What aspect of the project will cause the impact and when is it likely to occur?**	**C** **What are the sensitive or vulnerable receptors that could be impacted?**	**D** **Who are these impacts likely to affect?**	**E** **What information (project data/ENV. data) do you need to predict the magnitude of the impact**	**F** **Is the potential impact significant? (both positive or negative impact).**	**G** **What potential mitigation measures would you propose to enhance or eliminate or reduce the impact?**
Boat traffic	Mobilisation	Water, river banks, aquatic life	The host community	Turbidity, TD	Highly significant	Provide drinking water
Erosion	Clearing and Excavation	Water, river banks, aquatic life	The host communities	Turbidity	Highly significant	Resist cutting back filling
Employment	Construction throughout the project	Communities	The host communities	Population	Highly significant	Positive
Pollution of air and water	Construction	Aquatic life and air	The host communities, aquatic life, vegetation etc.	NOx, H2S	Low	Monitor the oil, Size adequate equipment
Land acquisition	Acquisition of ROW	The farms, animals, wildlife	Communities	Land use	Highly significant	Don’t acquire more than what is require
Noise	Mobilisation and construction	Wildlife, Human and fish	Communities	Noise value	Highly significant	

Table 4.14c: Impact Themes and Significance Matrix (Group C)

A What is the issue/impact?	B What aspect of the project will cause the impact and when is it likely to occur?	C What are the sensitive or vulnerable receptors that could be impacted?	D Who are these impacts likely to affect?	E What information (project data/ENV. data) do you need to predict the magnitude of the impact	F Is the potential impact significant? (both positive or negative impact).	G What potential mitigation measures would you propose to enhance or eliminate or reduce the impact?
Trenching: smaller part of excavation, it increase the workforce, it also increase employment and social economic activities	They are interrelated	Aquatic life, mangrove and aquaculture	Community people Farmers, fishermen, Migrant workers, Company workers, Contract personnel	Scale of digging in terms of numbers, location extent	Yes. Because for the few period the company will be there income will be improved There will be loss of herbal resources	Adequate compensation for land loss and land degradation
It divert labour and skills from the former traditional way of living				The skills of excavation		Minimise or avoid ecologically rich and sensitive area where herbal resources are abound
Farmland losses and wildlife				Extent of forest management		Provide health facilities

A **What is the issue/impact?**	B **What aspect of the project will cause the impact and when is it likely to occur?**	C **What are the sensitive or vulnerable receptors that could be impacted?**	D **Who are these impacts likely to affect?**	E **What information (project data/ENV. data) do you need to predict the magnitude of the impact**	F **Is the potential impact significant? (both positive or negative impact).**	G **What potential mitigation measures would you propose to enhance or eliminate or reduce the impact?**
Lose of secret forest and land and other cultural artifacts				Extent of forest management clearance		Provide public enlightenment and education on health hazard
It encourage consumption of alcohol and smoking or social vices				The rate of compensation-prices for land and resources		Provide forum for dialogue
Excavation Loss of herbal resources Pollution in general Erossion Noise pollution				Duration of activities		Empower community members with job opportunity and small scale economic activities so that they can sustain themselves beyond the project
Pilling of civil foundation Increase in income				Range of aquatic resources in the area		Public participation

A **What is the issue/impact?**	B **What aspect of the project will cause the impact and when is it likely to occur?**	C **What are the sensitive or vulnerable receptors that could be impacted?**	D **Who are these impacts likely to affect?**	E **What information (project data/ENV. data) do you need to predict the magnitude of the impact**	F **Is the potential impact significant? (both positive or negative impact).**	G **What potential mitigation measures would you propose to enhance or eliminate or reduce the impact?**
Possible accident Lots of noise/vibration						
Land degradation Land acquisition				Possible noise level		
Community conflict over land						
Land loss						
Increase income						

Plate 4.6l: Women and youths of Madangho community during FGD sessions

Plate 4.6m: Japhet Emami, 1st from left (top) Community Chairman Ajudaibo, receives study team on behalf of community, held discussions with SIA/HIA Team and showed team around

Plate 4.6n: At the home of Pa Thomas Mewe Pirah, the Olaraja (Eldest-man) of community, Messrs. Utienyin Maku (treasurer) and Ojogbo Johnbull (secretary of community, standing) and other EXCO Members present during team's visit to Ogidigben Community

CHAPTER FIVE
ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1: Introduction

A large variety of methods exist in different countries for environmental impact assessment. The method adopted in the preparation of this EIA consists of the following steps:

- Identification of effects
- Prediction of effects
- Evaluation and Interpretation of impacts
- Communication
- Inspection procedures

The following considerations were adopted in this impact assessment:

- Comprehensiveness - ability to handle all possible range of elements and combinations thereof;
- Selectivity - capability to identify early in the procedure those aspects that are important;
- Mutual exclusiveness - should be able to examine every component of an impact from different perspectives;
- Confidence limits - is the method able to ascertain and isolate uncertainties?
- Objectivity - should allow no bias either from the assessor or project initiator;
- Interactions - should be able to examine both sides of a coin and provide feedback.

Uncertainties

In our efforts to produce a credible EIA report, we are constantly assailed by the problem of uncertainties. Any Impact Assessment contains four kinds of uncertainties, due to:

(1) the natural variability of the environment, particularly the occurrence of rare events such as floods, unpredictable climate change and natural disasters;
(2) inadequate understanding of the behaviour of the environment;
(3) inadequate time-tested data for the area being assessed;
(4) socio-economic uncertainties (inadequate data for prediction of human response to economic crises). There is always uncertainty in predicting the way a community will respond after a major industrial project had been sited in their domain.
(5) Health uncertainties such as the problem of determining the direct causes and effects of diseases, and that of ascertaining the disease vectors that are brought into the project environment by itinerant applicants.

In this study, we have endeavoured to use available cost-effective techniques and review of published data to mitigate these uncertainties and where possible, predictions are subjected to statistical tests of confidence.

5.2: Basis for Screening

The Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) and FMEnv Sectoral guidelines require that a screening process must precede an impact assessment. In assessing the impacts of the different phases of development of this project, on the receiving environment, which is essentially brown, the information required for assessing the likely impacts of the proposed project include:

(a) knowledge of the project activities, equipment types, and operational procedures,
(b) the results of baseline studies,
(c) findings of other EIA studies on similar projects and other literature findings on the primary project activities,
(d) comparison with FMEnv/DPR/UNEP/WHO guidelines and standards,
(e) environmental audit reports on similar existing projects,
(f) series of expert group discussions and seminars,

The criteria applied to the screening of various activities are:

(i) Magnitude - probable level of severity (High, Medium, Low).
(ii) Prevalence - likely extent of the impact (Local or Widespread).
(iii) Duration and frequency - likely duration - long-term, short-term or medium - (Use SPDC Risk Matrix).
(iv) Risks - probability of serious impacts (High, Medium, Low) - (Use SPDC Risk Matrix).
(v) Importance - value attached to the undisturbed project environment (High, Medium, Low).

Environmental Screening Process

Comprehensive checklists of developmental activities and possible environmental effects were produced (Appendix 6a - c), and based on the information from Section 5.1.2 above, these lists were tailored to this project's components and associated historical effects as shown in Table 5.1.

5.3: Scoping

Objective of Scoping

The objective of scoping is to determine the terms and boundaries (spatial and temporal) of the environmental impact assessment. It seeks to identify *ab initio*, those aspects of the proposed activity which, based on past experience, literature searches or intuitive perception, could have significant negative impacts on the environment. In particular, with respect to biological species, the scoping addressed the public concern about human health and safety, losses of important commercial species, places of major recreational or aesthetic value, rare and endangered species as well as habitat losses. Past experience has shown that time and funds are two limiting factors in the execution of EIAs, hence scoping has aided more meaningful data collection, and led to more efficient use of fieldwork time and funds. Based on the ToR for the project, Table 5.1 shows the identified phases of the project development and the activities involved therein.

Table 5.1: Identified Phases of Project Development and their Activities

S/N	Project Phases	Project Sub- Phases	Activities
1	Pre-Mobilization and Mobilization	Pre-Construction - Site Investigation/Preparation	Transportation of materials and personnel to site, Clearing of RoW.
	Construction	Pipeline/Manifold Construction	Trenching, Pipe stringing and Welding, Coating and Wrapping, Hydrostatic Testing, River crossing, Cathodic protection, back filling and Spoil disposal, Non-Destructive testing (NDT).
		Fibre Optics Cable Laying	Clearing the seabed of debris using de-trencher grapnel, High Pressure Water Jetting Burial of Cable, back filling of cable trenches
		Mothballing of Saghara Flowstation	Shutdown of plant, Engineering work for Preservation,
3	Commissioning / Operation and Maintenance	System Commissioning, Operation & Maintenance	, Corrosion control
4	Decommissioning and Abandonment	Decommissioning and Abandonment	Domestic and Industrial waste management. Cutting, Lifting, Welding, Draining, Cleaning, Water Traffic.

Past experience shows that the activities requiring detailed study are Sweeping & Dredging, Laying of pipes and Cable, Transportation, Construction, Installation and operation of the CPF and disposal of wastes. Based on the identified activities likely to cause significant impacts, we analyse the various environmental components shown in Table 5.2 with a view to estimating the level of data/information collection required.

5.4: Impacts Identification

The main effects of the activities are identified using the Screening Matrix in Table 5.5. The Screening Matrix has distinguished between positive and negative impacts, direct/indirect, local or widespread, short or long term impacts, as well as the level of importance attached to each impact.

These impacts in the form of residues and emissions include but are not limited to:

a) Discharges to water.

b) Emissions to air.
c) Noise and vibrations.
d) Heat, Light and Radiation.
e) Discharges to Land
f) Effects on Ecosystems.
g) Effects on Socio-economics
h) Effects People's Health

The ISO14001 requires identification, evaluation and registration of environmental aspects associated with SPDC's activities. SPDC's HSE MS is the tool for achieving ISO 14001 requirement, and this EIA report is a component of the HSE-MS. We identified impacts associated with activities of the project through many sources of documentation including:

- Regulator-approved Environmental Impact Assessment for similar projects, e.g. SPDC Southern Swamp Associate Gas Gathering Project, 2003;
- Results/reports from HAZID Workshops
- Procedure for Evaluation and Registration of Environmental Aspects, HSE P-04.
- Accompanying Guidelines for SPDC EIA Process, Report Review, SPDC 2004-0002713 Vol iv, 2004.

The impactable components of the environment and the checklist of the associated and potential impacts are shown in **Tables 5.2 (a and b).**

Table 5.2 (a): Impactable Environmental Components and Associated Impact Indicators for all phases of the project development

S/N	Components of Environment	Impact Indicators
1	Climate	Humidity, Temperature, Rainfall, Wind.
2	Air Quality	Particulate, NO_x, SO_x, CO_2, CO, VOCs, H_2S, CH_4 Heavy metals (Fe, Cd, Cr, Pb, Ni, V, Zn), BTEX
3	Water Quality	Colour, alkalinity, TDS, TSS, Turbidity, EC, THC, pH, DO, BOD_5, COD, Oil & Grease, PAH, TPH, BTEX, Anions/Cations, NH_4^+, NO_3^- , NO_2^-, PO_4^{3-}, SO_4^{2-} , SiO_2, Na^+, K^+, Ca^{2+}, Mn^{2+}, Mg^{2+} . Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Hg).
4	Groundwater	Solids, pH, Na, Cl, Cond, THC, TPH, Trace metals.
5	Soil/Land Use	Contamination with oil, Loss of farmland.
6	Hydrobiology	Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic Macrophytes, Macrophyte-associated macrofauna
7	Fisheries	Productivity, Diversity & Abundance,
8	Noise & Vibration	Ambient noise level dB(A)
9	Socio-economic Status	Population, Social Structure, Income, Settlement pattern, Employment, Education and Infrastructure.
10	Health Status	Incidence of diseases, change in health status, Safety and Security

Table 5.2 (b): Checklist of Associated and Potential Impacts

Development Phase	Project Activity	Potential/Associated Impacts
Premobilization and MobilizationSite Preparation	**PREMOBILIZATION AND MOBILIZATION SITE PREPARATION** RoW Clearance	• Surface erosion from removal of tree canopies, • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE • Loss of vegetation and habitats for wildlife. • Employment opportunities • Irreversible alteration of drainage pattern of the RoW. • Water related disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing
	Waste Disposal	• Suspended solids in water • Discharge of faecal waste into the water will contaminate surface water sources and increase water related diseases (cholera, etc.)
	Water Traffic	• Fishing/Water traffic disruption
Construction	**CONSTRUCTION** Pipeline/Manifold Construction, and Laying Fibre Optics Cable,'Trenching/Back filling	• In tidal swamps, this will increase surface water sediment loading and suspended solids, • Irreversible soil compaction and may alter the topography of the RoW. • Injuries and accidents from not following approved work procedures and non-use of Personal Protective Equipment PPE • Improper disposal of backfilling residue will alter the natural drainage pattern of the area. • Disaggrgation of Benthic habitats at river crossing.
		Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe at river crossing.
	Welding/Coating/Wrapping/NDT	• Exposure to radioactivity and release of chemicals from pipe weld non destructive testing • Welding will cause occupational impact from emission of toxic fumes • Employment opportunities • Improper disposal of laybarge deck drainage will contaminate surface water and sediment.
	Hydrostatic Testing	• Discharge of untreated test water into the receiving environment.

Development Phase	Project Activity	Potential/Associated Impacts
	River Crossing	• Disaggregation of benthic habitats and loss of benthic organisms. • Disturbance of seabed topography • Shoreline erosion • Disruption of fishing activities • Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment PPE
	Water traffic	• The size and number of barges conveying equipment, materials and personnel, and the associated waves will endanger small canoes/boats and limit fishing activities. • Increased income to local workers • Disruption of fishing activities • Water related diseases may increase due to poor sanitation practices when more pressure is put on already inadequate housing facilities • Increase in cases of sexually transmitted diseases (HID AIDS) and other disease strains, may result through immigrant workers.
	Power generation and supply to Communities	• Improvement of socioeconomic activities and quality of life of residents
	Waste Disposal	• Substantial quantities of packing materials will be generated on site and need to be managed properly to avoid littering the project area. • Contamination of water with paints and corrosion inhibitors. • Leaks and spills of diesel fuel and lubricants into water,
Commissioning, Operation and Maintenance	Waste Disposal	• Gas emissions from pipelines damage due to sabotage. • Contamination of water with paints and corrosion inhibitors.
Abandonment	Mothballing of Saghara Flowstation Engineering Work for Preservation	• Soil/Water pollution from removal of oil pumps, Surge vessel and Separators • Employment opportunities • Contamination of surface water from large volumes of flush water produced during shut down • Harmful X-rays from non-destructive testing (NDT)/ examination to ascertain the integrity of equipment and suitability for preservation.

Development Phase	Project Activity	Potential/Associated Impacts
	Cutting/Lifting	• Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works.
	Waste Disposal	• Poor aesthetic features from abandoned structures on site. • Solid waste generated during Engineering work for preservation • All solids and oily/chemical waste generated during shut down process.
	Restoration	• Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment.

Table 5.3: SPDC Risk Matrix

CONSEQUENCES					INCREASING LIKELIHOOD				
					A	B	C	D	E
Severity	People	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the Organisation or more than once per year in the industry	Has happened at the location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health	Slight damage	Slight effect	Slight impact		**Low**			
2	Minor Injury or health	Minor damage	Minor effect	Minor impact		**Risk**			
3	Major Injury or health	Moderate damage	Moderate effect	Moderate impact			**Medium**		
4	PTD or up to 3 fatalities	Major damage	Major effect	Major impact			**Risk**	**High**	
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact				**Risk**	

Table 5.4: ISO Criteria and Rating for Identification of Significant Environmental Impacts

Criteria and Rating for Identifying Significant Environmental Impacts of the proposed Saghara AGS project are:

1. Legal / Regulatory Requirements (L) – is there a legal/regulatory requirements or a permit required?
   0 = There is no legal/regulatory requirement
   3 = There is legal/regulatory requirement
   5 = There is a permit required

2. Risk (R) - What is risk/hazard rating based on RAM?
   1 = Low
   3 = Medium/intermediate risk
   5 = High risk

3. Environmental impact Frequency (F) – What is frequency rating of impact based on RAM?
   1 = Low frequency
   3 = Medium intermediate frequency
   5 = High frequency

4. Importance of Affected Environmental Component and Impact (I) – What is rating of importance based on consensus of opinions?
   1 = Low importance
   3 = Medium/intermediate importance
   5 = High importance

5. Public Perception (P) – What is rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?
   1 = Low perception and interest
   3 = medium/intermediate perception and interest
   5 = High perception and interest

5.5: Impact Quantification And Determination Of Significance

The identified associated and potential impacts of the proposed Saghara field project were quantified using the Risk Assessment Matrix (Table 5.3) and the ISO 14001 criteria for identified significant environmental aspect/impacts. The ISO criteria are shown in Table 5.5.

The significant potential impacts (High) of the proposed project (Table 5.5) were identified as those impacts in the checklist of Table 5.5 that satisfy the following criteria.

High Impact
$(L+R+F+I+P) \geq (15)$: Sum of weight of legal requirement, risk factor, frequency of occurrence, importance and public perception greater than or equal to the benchmark (15).

$(F + I) > 6$: Sum of weight of frequency of occurrence and importance of affected environmental component exceeds the benchmark (6).

$P = 5$: The weight of the public perception/interest in the potential impact equals the benchmark (5).

Medium Impact
$(L+ R + F + I + P) \geq 8 < 15$: Sum of weight of legal requirement, risk factor, frequency of occurrence, importance and public perception greater than or equal to (8) but less than the benchmark (15).

Table 5.5: Significant Impacts of the Proposed Project

Project Activity	Description of Impact	Impact Identification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
All Phases	Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost;		x	x		x		x		0	5	3	3	5	16	6	H
	Fatality, damage to assets due bad weather		x	x		x		x		5	1	1	5	5	17	6	H
	Deprivation of personal liberty, injury, fatality due to Kidnapping		x	x		x		x		3	3	5	3	5	19	8	H
PREMOBILIZATION AND MOBILIZATION SITE PREPARATION RoW Clearance	Increased erosion potential due to removal of vegetation canopies and road paving		x	x		x		x		3	1	1	1	1	7	2	L
	Loss of vegetation and habitats for wildlife.		x	x		x		x		3	1	1	1	1	7	2	L
	Irreversible alteration of drainage pattern of the RoW.		x	x			x		x	3	1	1	1	1	7	2	L
	Income to local workers that may be employed for the bush clearing activities	x		x		x		x		0	3	1	5	5	14	6	P
	Water related disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing.		x	x		x		x		3	5	5	3	5	21	8	H
	Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers.		x	x		x		x		0	5	5	3	5	18	8	H
	Injuries and accidents from not following approved work procedures and non-used of Personal Protective		x	x		x		x		0	3	3	5	5	16	8	H

Project Activity	Description of Impact	Impact Identification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Equipment PPE																
	Increased in suspended solids in water(Waste disposal)		x	x		x		x		3	5	3	5	3	19	8	H
	Discharge of feacal waste into the water will contaminate surface water sources and increase water related disease (cholera etc).		x	x		x		x		5	5	3	5	3	21	8	H
	Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed.		x	x		x		x		3	3	3	3	5	17	6	H
	Water traffic disruption with possible increase in marine accidents		x	x		x		x		3	3	3	3	5	17	6	H
	In tidal swamps, trenching and backfilling will increase surface water sediment loading and suspended solids.		x	x		x		x		5	3	5	5	3	21	8	H
CONSTRUCTION Trenching/ Backfilling	Irreversible soil compaction which may alter the topography and drainage pattern of the RoW.		x	x			x		x	5	1	1	1	1	9	2	M
	Improper disposal of backfilling residue will alter the natural drainage pattern of the area.		**x**	x			x	x		5	1	1	1	1	9	2	M
	Substantial quantities of packing materials will be generated on site and need to be managed properly to avoid littering the project area.		**x**	x		x		x		3	1	1	1	1	7	2	L
Optical Fibre Cable Laying	Improper disposal of backfilling residue will alter the natural drainage pattern of the area.		**x**	x			x	x		5	1	1	1	1	9	2	M
Welding / NDT	Exposure to radioactivity and release of chemicals from pipe weld non destructive testing		**x**	x		x		x		3	3	3	3	5	17	6	H
	Welding will cause occupational impacts from release of toxic fumes		x	x		x		x		3	1	3	3	3	13	6	M

Project Activity	**Description of Impact**	**Impact Identification**								**Impact Quantification**							
		Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
	Employment opportunities	x		x		x		x		0	3	1	5	5	14	6	H
Coating/Wrapping	Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities.		x	x		x		x		3	3	1	5	5	17	6	H
	Leaks and spills of diesel fuel and lubricants into water.		x	x		x		x		3	3	1	1	3	11	2	M
	Improper disposal of lay barge deck drainage will contaminate surface water and sediment.		x	x		x		x		5	1	1	1	1	9	2	M
	Contamination of water with paints and corrosion inhibitors.		x	x		x		x		3	3	1	3	1	11	4	M
Hydrostatic Testing	Discharge of untreated test water into the receiving environment.		x	x		x		x		5	1	1	1	1	9	2	M
River Crossing	Disturbance of riverbed topography.		x	x		x		x		3	3	1	1	1	9	2	M
	Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe at river crossing		x	x			x	x		3	3	1	3	5	15	4	H
	Disaggregation of benthic habitats and loss of benthic organisms.		x	x		x		x		5	1	1	3	1	11	4	M
	Shoreline erosion		x	x			x	x		3	3	3	3	1	13	6	M
	Injuries and accidents from not following approved work procedures and non-use of Personal Protective Equipment PPE		x	x		x		x		3	5	3	1	3	15	4	H
Water traffic	The size and number of barges conveying equipment, materials and personnel, and the associated waves will endanger small canoes/boats and limit fishing activities..		x	x		x		x		5	5	3	3	5	21	6	H

Project Activity	Description of Impact	Impact Identification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Increased income to local workers	x		x		x		x		0	3	1	5	5	14	6	P
	Disruption of fishing activities		x	x		x		x		3	3	3	3	5	17	6	H
	Water related disease may increase due to poor sanitation practices when more pressure is put on already inadequate state of housing facilities.		x	x		x		x		3	5	5	3	5	21	8	H
	Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through migrant workers.		x	x		x		x		0	5	5	3	5	18	8	H
Power generation and supply to Communities	Improvement of socioeconomic activities and quality of life of residents	x		x		x		x		0	3	3	5	5	16	8	P
Commissioning and Operation Pigging	Improper disposal of oily sludge from pigging will pollute surface water and sediments		x	x			x	x		3	3	1	3	3	13	4	M
Corrosion Control	Water pollution by corrosion inhibitors		x	x			x	x		3	3	1	3	3	13	4	M
	Gas emissions from pipelines damage due to sabotage.		x	x		x		x		3	5	3	3	5	19	6	H
DECOMMISSIONING AND ABANDONMENT Cutting/Lifting	Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works.		x	x		x		x		3	1	1	5	5	15	6	H
Restoration	Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment.		x	x		x		x		3	1	1	3	3	11	4	M
Engineering Work for Preservation	Reduction in adverse effect of flaring	x		x			x			3	1	1	3	3	11	4	P
	Contamination of surface water from large volumes of		x	x		x		x		3	3	1	3	1	11	4	M

Project Activity	Description of Impact	Impact Identification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	flush water produced during shut down																
	Harmful X-rays from non-destructive testing (NDT)/ examination to ascertain the integrity of equipment and suitability for preservation.		x	x		x		x		3	5	1	3	3	15	4	H
	Solid waste generated during Engineering work for preservation		x	x		x		x		3	1	1	3	3	11	4	M
	Mothballing of Saghara Flowstation will improve the air quality of the field.	x		x			x		x	3	1	1	5	5	15	6	P
	Poor aesthetic features from abandoned structures on site.		x	x		x		x		3	1	1	3	3	11	4	M
	Employment opportunities	x		x		x		x		0	3	1	5	5	14	6	P
	Pollution by all solids and oily/chemical waste generated during shut down process.		x	x		x		x		3	5	3	3	5	19	6	H

5.6: Discussion of Ranking

The rationale for the rating in Table 5.5 is given below for different environmental components. The sign +/- is placed before the total score to indicate positive impact (+) or negative impact (-).

Air Quality

Measured air quality parameters show that some emissions from existing facilities are significant, mainly from gas flaring. The aim of this project is to reduce gas flaring to at most 10% of production, thus further reducing emissions below existing levels, with resultant improved air quality. The proposed mothballing of Saghara Flowstation will obviate gas flaring in that field completely. This is positive impact (+15).

Water Quality

Bush clearing and destumping in swamp environment have been identified from past studies, Macgill, 1996 (Plate 5.1) as sources of negative impact on creeks in the construction area. The impacts are severe for TSS, TDS and toxicity. Trenching and back-filling in tidal swamps will create turbidity with high spatial extent, especially during the rainy season but these impacts will be of short duration. Cable laying, trenching and river crossing activities will have moderate impacts on macrobenthic organisms. The overall negative impact of these activities is significant (-19).

Plate 5.1: Bush cleared area prior to dredging in Opukushi field (Macgill, 1996). Observe the impact on water: Turbidity, Suspended solids

Hydrogeology

Groundwater contamination is rated significant (-15) for pipeline burial within Saghara field where burial depth is greater than 0.8 m. Also, hydraulic seepage will lead to salt water intrusion into the groundwater during pipeline/optic cable crossing from Saghara to Escravos.

Soil and Landuse

The project terrain is flat, low lying and flooded during the rainy season. Soil erosion is expected to be a medium impact resulting from bush clearing, excavation, spoil disposal and trenching. This score (-13) is borne out of experience of past projects of similar nature. The surface area to be exposed is a small fraction of the total land area in the project field.

Ecology

Loss of flora and habitats for fauna due to bush clearing is the expected impact on ecology. In this project, no new land acquisition is required. for pipelines. All pipeline activities will take place in the existing RoW which is routinely maintained. The impact on ecology is therefore minimal (-7). Cable laying (-9) and riverbed clearance (-9) have medium significant impacts on ecology respectively.

Fisheries and Commercial Transport

Fishing is one of the major occupations in the area. Project-related water transport will disrupt fishing activities (-17). Movement of many watercraft - Cable Laybarge, equipment movement barges and personnel carriers, will endanger commercial water transport activities. The impact is significant (-21).

Socioeconomics

It is to be expected that all phases of development activities will accrue economic benefits to all cadres of workers involved, both locally and nationally (+14, significant because P=5). Electrification of some of the communities will have multiplier effect on the quality of life (+16).

Health

With about 150 construction workers, half of them locals, human waste disposal and other toxic wastes could get into water and give rise to water related disease (-21). Other potential negative impacts judged to be significant are scored as: sexually transmitted disease (-18), accident to workers (-16). Toxic fumes could result from welding and cutting equipment as well from residual hydrocarbons in the process equipment, during abandonment activities (cutting of steel members, etc.), as well as falling objects during lifting operations. Exposure to radioactivity and release of chemicals from pipe weld non destructive testing (-17).

Injuries and accidents from not following approved work procedures and non-use of Personal Protective Equipment PPE (-15) is also significant.

Wild life and Forestry

The probable impact of bush clearing, noise, heat and light on wild life is of low impact and of short duration (-7). The potential impact on forestry is also of low significance (-7).

5.7: IMPACT PREDICTION AND ANALYSES

The activities scheduled for execution are as detailed in Chapter 3, Sections 3.0. We restate here for ease of reference, those activities likely to have impacts:

Facility Construction Scope:

- Fabrication & Installation of a new bulking manifold in Saghara Flowstation
- Tie-ins.
- Fabrication & installation of process piping, vent, drain lines and flush line along with supports.
- Fabrication & installation of process piping / valves from tie-in points along with pipe supports.
- Mothballing and in-situ preservation of existing Saghara flowstation and the 8” oil delivery line from Saghara to Trans-Forcados Pipeline (TFP).

Pipeline Construction Scope:

- Replacement / re-routing of Eleven (11) 4’’ flow lines from Seven Wells in Otumara currently flowing to Saghara manifolds, to Otumara flow station inlet manifold.
- Laying of new Test line (4” x 5km) from Saghara flowstation to Otumara flowstation
- Laying of new Bulk line (6” x 5km)from Saghara flowstation to Otumara flowstation
- Laying of 2” x 5km Corrosion Inhibition line from Saghara Manifold to Otumara CPF
- Installation and commissioning of manifolds, piging facilities at Saghara Otumara and NGC manifold at Escravos beach.
- Laying of 21 km Fibre optic cable from Saghara wells to Escravos Beach NGC Facility
- Cathodic protection systems, Hook-ups and Tie-ins.

All the potential impacts from the above activities will come mainly from site preparation and construction. Site preparation precedes all the above activities and their impacts will be discussed under the environmental components to be affected.

Emissions to Air

(i) Analysis Years

The analysis years for the prediction/estimation of ground level impacts are 2012-2015, covering the site preparation, construction and commissioning phases of the project (expected to operate by the year 2015). The purpose of analysing for these years is to account for the possible changes in meteorology, national air quality standards, pollutant sources and receptors, during the intervening years. If no changes in these parameters are anticipated between 2012 and 2015, the same values for these parameters will be used for 2012 and the year 2015. As at the present time, we do not anticipate significant changes in pollutant sources and receptors, nor in the national air quality standards. However, the effects of global atmospheric warming may lead to progressively increasing ground surface temperatures which may lead to slight increase in plume height of flared gas mass. For the purpose of this analysis, we may, as a first order approximation, ignore the possible contributions of increase in ground surface temperatures on plume height, and assume identical conditions between now and the year 2015.

(ii) Primary Pollutant Sources

The primary pollutant source within the Saghara field is the flowstation. The sources of pollution within the flowstation are the gas flares, crude oil pump engine drivers and fugitive emissions.

(iii) Secondary or Exogenous Sources

Escravos Beach Flowstation is South of Saghara Flowstation. Given the predominant Southwesterly wind direction in the area, Escravos Beach Flowstation could be an exogenous source of pollutants to the Saghara Flowstation.

(iv) Pollutant Receptors

All the host communities of interest are upwind of both Saghara and so are not sensitive receptors.

Impact Scenarios

The following impact scenarios are considered:

Emission Scenarios

(i) No Project Scenario

A no-project scenario implies continued gas flaring. Fig. 5.1 shows the gas flare record for Otumara and Saghara Flowstations from 2007 to 2013, (the data for 2013 represents one month flare- January). With planned decommissioning of Saghara Flowstation, gases currently flared there will be added to those flared in Otumara. Nitrogen dioxide (NO_2) and SO_2 are presently above regulatory limits albeit for short averaging times. A no-project scenario will mean continued violation of regulatory guidelines.

(ii) Emission from Existing sources

The existing pollutant sources are as indicated in section 5.5.1(ii). The existing air quality within the Saghara field is reported in Section 4.2 of this report, and found to be within the statutory guidelines of DPR/FMEnv for most parameters except NO_2 and SO_2 which exceeded the limits. The emissions from the proposed activities are viewed as distributed sources within the control volume and are assessed for the various stages of the development.

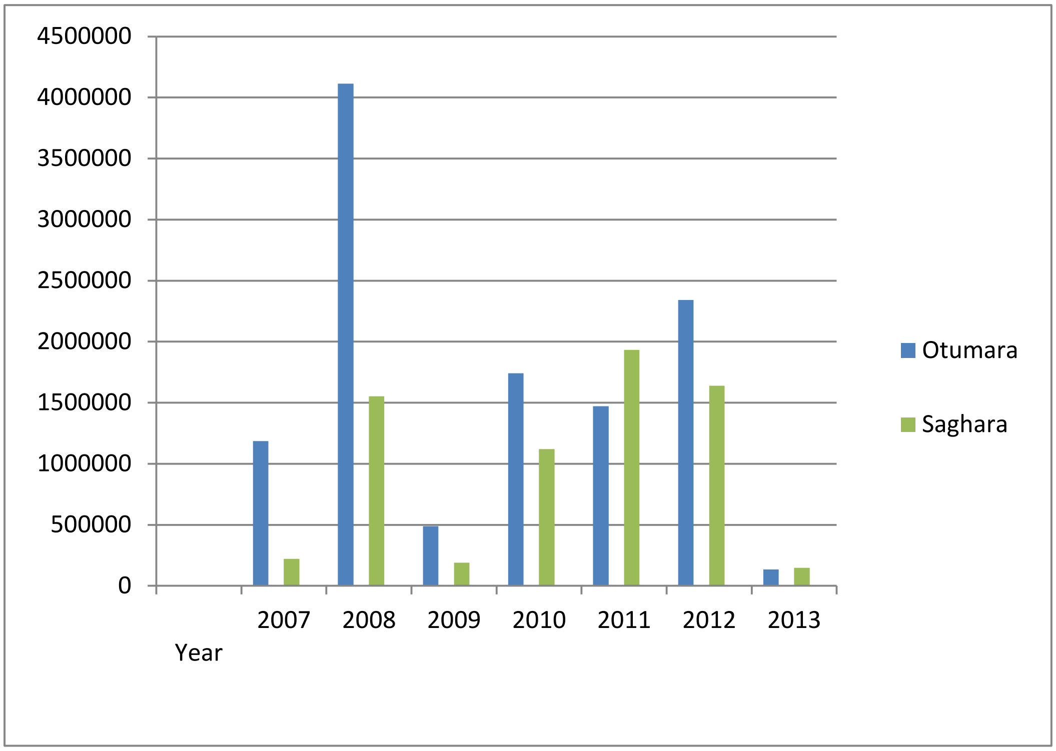

Fig. 5.1: Otumara and Saghara Gas Flare Records (scf/d)

(iii) Site Preparation and Construction

Aspects of climate and meteorological conditions that are likely to affect this phase of the project are rain and wind. In the project area, 95% of the rain falls during the months of April to October, accompanied by Southwesterlies. This will cause flooding of the field and exacerbate construction impacts. The dry season period for the area is November to March, and this is the period for which construction is recommended. Dry season construction is the worst case scenario for air quality. The principal air quality impacts during construction in the dry season are:

- dust from earth moving/excavation equipment,
- emissions from construction equipment.

Site preparation includes clearing the RoW, debris from seabed, while construction includes, among others, transportation, laying of optic fibre cables and pipelines. These activities will derive motive power from diesel powered engines. Given the volume rate of exhaust from diesel generators shown in Table 5.6, pollutant concentrations from such activities will be minimal. The ground surface in the area being normally wet, will not cause significant dust generation during the dry season construction. The particulates measured in all the flowstations and major communities within the project area showed particulate concentrations well below regulatory limits of 250 - 600 μg/m^3. Thus, given the nature of the ground surface in the area, it is not expected that the impact of construction and site preparation activities will increase particulate concentration above DPR/FMEnv limits.

Table 5.6: Operational gas flares and typical gaseous emission sources and quantities

SOURCE	QUANTITY 2012 (Existing)	QUANTITY 2015 (Forecast Operational case)	REMARKS
Saghara*	1,639,412 mmscfd	-Nil	Daily average
Exhaust gas from gas engine power generator	0.2 mmscfd		
Exhaust gas from diesel engine power generator	0.22 mmscfd		Unit normally on standby
Exhaust gas from gas engine oil pump driver	0.59 mmscfd (each)		
Instrument Gas	Minimal		Instrument Gas Vent

Note:

1. Data for Diesel/Gas Engines supplied by Caterpillar.
2. Gas production data taken from production and gas forecast records.
3. * Data from SPDC, Basis for Design

Typical exhaust gas analysis for specific pollutants has been provided by Caterpillar Company for the gas and diesel engines within the flowstation site. The exhaust gas analysis is expressed on mass flow basis (kg/hr) for the engine operating at maximum power and is shown in Table 5.7. The table shows that for power generators, 97% of the exhaust gas is carbon dioxide whereas with gas powered engine pump (lower combustion efficiency), carbon dioxide constitutes 67% of the exhaust, while nitrogen oxides account for 32%. The proposed project will eliminate these gas engines.

Table 5.7: Typical Exhaust Gas Compositions

Exhaust Gas Component (kg/hr)	Engine Type		
	Gas Engine Generator	Diesel Engine Generator	Gas Engine pumps
CO_2	42.86	40.55	10.6
CO	0.06	0.28	0.13
NOx	1.38	1.05	5.02
Hydrocarbon	0.02	0.09	0.07
SO_2	-	0.05	-

(iv) Operational

Apart from negligible fugitive emissions from pipeline joints, the only potential gas emission is through sabotage of oil/gas pipelines. Given the prevailing trend in the Niger Delta, the probability is high. The actual gas flared in 2012 in Saghara Flowstation amounted to 1,639,412 mmscfd.. Using the current Best Practice for Green House Gas (GHG) Emissions Estimation, this translates to the results shown in Table 5.8. Table 5.8 below shows the GHG emission scenario in 2012 and 2015. It shows that the proposed project will lead to complete elimination of flared gas, and consequently GHG emissions in Saghara Field.

Table 5.8: Green House Gas Emission Scenario (Saghara Field) between 2012 and 2015

GHG	**Tonnes/day**	
	2012	**2015**
CO_2	108,522.86	0
CH_4	2095.63	0
N_2O	1982.33	0

Impacts on Soil/Land Use and Groundwater
Soil/Landuse

Site Preparation
(a) Bush Clearing and Destumping
RoWs usually consist of shrubs and no de-stumpable trees. Since all the new pipelines are to use existing RoW, and the Maniflod is to be constructed within the Saghara Flowstation, no land take is expected for this project. The impact of this phase of the project on soil is that of compaction and erosion. Soil compaction will also alter the drainage pattern of the area. These impacts were rated low in significance and require no mitigation.

(b) Construction Activities

Pipelines

The stripping of topsoil, trenching and backfilling and reinstatement operation, coupled with the contact pressure of equipment within the working width, have potential impact on soil structure and drainage (assuming standard construction method). Three main processes cause the impacts: compaction, disaggregation and rearrangement, and loss of water. Compaction occurs in soils where the bearing strength of the soil, or a horizon within the soil, is exceeded by the weight of the plant machinery moving over it. The resulting changes in permeability could significantly affect the drainage characteristics of a soil and water logging could occur. This, in turn, could have secondary impacts upon vegetation species composition and hence, a tertiary impact on landscape quality. The soils most susceptible to this damage are those of high porosity, low-bearing strength and high water content, typical of the soils of the proposed project areas. The textural profile of the soils in the project areas soil compactionshows the soil to be sandy to loamy sand at both top and bottom levels. Generally, under the wettest condition, most soils are susceptible to structural damage from compaction and measures to avoid this problem will be outlined under mitigation. Soil compaction is an irreversible impact and is thus better avoided.
The impact of this phase of the project was assessed as medium for soil compaction and high for surface water pollution. Appropriate mitigation measures will be proffered in Chapter 6.

Saghara-Escravos Beach Fibre Optics Cable Route

It is expected that the Fibre Optics cable will run along the existing RoW from Saghara, across Escravos Estuary, to NGC Facility in Escravos Beach Field. The impact of this activity on Soil and Landuse is the alteration of the topography and the drainage pattern of the RoW. The impact significance was rated medium for mitigation measure will be proffered in Chapter 6.

Impacts on Groundwater

Site Preparation

Site preparation activity likely to have negative impacts on groundwater is removal of vegetation canopy. This will lead to evapotranspiration with consequent lowering of groundwater level. However, the proposed project is on wetland, and given the negligible quantity of canopy removal compared with the total canopy in the field, the impact is not considered significant.

Construction

The water table in Saghara ranged from 1.0 m to 1.2 m. The depth (above ground surface) to aquifer is about 12m.. From past experience of pipeline profiles, no pipeline lies more than 3 m below the ground level (pipeline burial depth in Saghara is 1.2m) It is recognised however that there is wide variability in aquifer cover in Northern Swamp area. Borehole lithologs indicate that the aquifer will not be contaminated by pipeline construction in this field. However, the probability of salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe) at river crossing, is significant, if appropriate mitigation is not adopted.

Operation and maintenance

Pipe bursts (gas), due to weakening by corrosion (if it occurs), will cause gas leakage into the soil. When gas leaks into the soil environment, the soil aggregates have been found to be broken down and frequently appear to be laminated or layered (Adams and Ellis, 1960). It kills the surrounding vegetation, blackens the soil and gives a peculiar acrid odour like that of a stagnant pond bottom. Gas saturated soils are impermeable to vertical water penetration from the top, although lateral ingress is possible. There is always a substantial increase in total Carbon, exchangeable manganese, at times up to 64 ppm which is very injurious to plants (Schollenberger, 1980). Gas saturated soils also show increase in pH, water retention and total porosity with a corresponding decrease in bulk density (Garner, 1971). On the average, the area affected by both lateral and vertical movement of the gas is so small that it is seldom an economic problem in agriculture.

Impacts of Pipeline Sabotage

The probable impact of corrosion leakage of underground gas pipe is given above. In the unlikely event of gas pipeline sabotage, wherein it will be assumed that the pipe is accessed after excavation to a depth of at least 1.2 m and sawed or drilled, the scenario is akin to that of a fluid bursting through an orifice (if drilled) under infinite pressure, to atmospheric conditions, or through a slit (if sawed). It is expedient to consider the orifice scenario. A gas explosion will result in a hyperbolic gas plume with increased temperature and pressure leading to catastrophic consequences for the perpetrators of the act and other life in the neighbourhood. The plume of the hyperboloid and the extent of its propagation can be determined using a mathematical model based on Computational Gasdynamics, but this is outside the scope of this EIA.

Because the pressure of the gas in the pipeline is infinite (theoretically), the size of the hyperboloid will continue to grow until the pipeline is depressurized. It is thus important that immediate action is taken to depressurize a sabotaged pipeline, preferably through the installation of auto-shut-off pressure sensors at spaced intervals along the pipeline. A gas pipeline sabotage could prove more disastrous than that of an oil pipeline because of the comparative ease of efflux of gas.

Toxicity of Gas

From the composition of a typical gas, the dominant gas is methane, with low concentrations of ethane, propane, *n*-butane and isobutene, etc. These gases are all regarded as **simple asphyxiants**. Apart from physical pressure from gas explosion, those in the immediate neighbourhood of an incident will be asphyxiated.

Effects on Ecosystem

The mangrove swamp forest is an area of highest ecological sensitivity, ranking 10 in a scale of 1 - 10 in increasing order of sensitivity (Gundlach & Hayes, 1978). Similarly, the primary forest is an ecological conservation area. Section 21 of the Petroleum Decree No. 51, 1969, protects both mangrove and primary forests.

Site Preparation

Generally, RoW and site clearing tend to remove the canopy over soil, leading to trans-evaporation, with consequent soil dryness. Fortunately, the soils of the project area have high moisture content, therefore canopy removal will have negligible impact on soil dryness. Aspects of site preparation activities which affect the ecology in different ways, include:

- bush clearing and de-stumping,
- river crossing;
- Water traffic

These aspects will be briefly described below.

The potential impacts of site preparation (Bush clearing, de-stumping) are summarised as follows:

(a) Bush Clearing and Destumping

It is proposed that gas pipelines from Saghara to Escravos Beach will follow existing ROWs, Thus, there is negligible impact of pipeline site preparation.

Construction

(a) Trenching and Backfilling

Because most of the areas are swampy and experience tidal influence, loose soil from trench would be carried by both surface runoff and tidal waves into the water bodies which criss-cross the area; this effect will be more pronounced during the rainy season when the volume of surface runoff is higher. The above activity has the following ecological consequences through silt deposition (Shell UK, 1989):

- affect survival of fish eggs in sand beds due to de-oxygenation;
- affect survival of bottom dwelling invertebrates due to smothering by silt;
- affect survival of young fish through gill damage from sediment particles,
- impede photosynthetic activity thereby limiting productivity.

(b) River crossing and Water traffic

Escravos River crossing will present the greatest ecological challenge among the whole project components (the River is about 2.011 km wide at the proposed crossing point). A ditch of about 2m width will be dredged across riverbed, with both banks sloped to the design profile of the pipeline. This may mean that the dredge depth at the riverbanks could be as deep as 5 to 6 meters depending on the river profile. Sufficient length (in excess of the width of the river) of the pipe will be strung, coated and lowered into a prepared trench, about 2 m wide and 2.5 m below the river bed. The trench will be backfilled after pipe burial. The anticipated impact is that of dislocation of habitat for benthic species and mortality of some due to deoxygenation, consequent upon exposure of anaerobic sediments.

Escravos River is a major waterway, hence water traffic and fishing activities will be curtailed during construction. There are instances of riverbank erosion at pipeline crossing points due to improper rehabilitation after dredging. Riverbed topography will be adversely affected by eroding seabed currents and therefore needs to be properly restored.

(c) Optical Fibre Cable Laying

It is expected that the Optic Fibre Cable will be laid along existing ROW, hence the impact is the same as that of laying pipelines.

Operation and Maintenance

(i) Pipelines

A potential operational impact is leakage of gaseous hydrocarbon from the pipeline facilities either due to corrosion or third party action. Pipeline damage by sabotage had been frequent in recent times and often resulted in damage to vegetation, and soil macrofaunal mortality occasioning reinstatement of soil and vegetation. As a result of the high flammability of the gas being transported, fires and explosions may likely result during sabotage. Thus, pipeline security is going to be one of the determinants of sustainable operation of the facilities. Pipeline maintenance would involve occasional pigging operations with the aim of:

- clearing the line to remove unwanted precipitates;
- checking pipe interior for damage or deformity;
- detecting areas of corrosion.

Slug catchers would be installed at appropriate locations at the ends of the pipelines, for removing sludge, which will be disposed -off in accordance with SPDC laid down procedures.

(ii) Power Generation

Past experience has shown that whenever production facilities are installed on piled platform over creeks, both plankton and benthic fauna population are always low in abundance in the vicinity of the facilities (Macgill, 1994. 1996, 2000). While power generation provides positive socioeconomic impact to the host communities, its operation and maintenance often constitute source of pollution of the water body under the Plant support, through spills and leaks of lubricants.

Impacts on Wildlife & Forestry
Impact of the Proposed Project on Forestry and Wildlife

Site Preparation and Construction

- Bush clearing and de-stumping will result in reduction of habitats for arboreal and infaunal species, respectively.
- Noise from the use of bulldozers will cause migration of wildlife from affected areas.
- Bush clearing will lead to the loss of economic trees and plants.

The site to be cleared is the existing RoW which does not provide significant habitat for wildlife, since it is regularly maintained. The impact is therefore not significant either spatially or temporally.

Operation

Operation of the Manifold in Saghara filed will have no impacts whatsoever on Forestry and Wildlife in the project environment.

Impacts on Water
Site Preparation

Saghara facilities are in Brown Fields where ROWs already exist and most pipeline works will take place along the ROWs. Bush clearing and de-stumping for pipeline route from saghara to NGC Manifold in Escravos, re-routing existing Saghara Wells to Otumara Flowstation, connecting Bulk lines and Test lines from Saghara Flowstation to Otumara Flowstation, are all activities that will involve trenching and backfilling. The impacts of these activities are inundation of the water bodies with suspended solids and increased turbidity (see Plate 5.1). These impacts will be wide spread as the debris are redistributed by tidal waves to adjoining water bodies, but of medium significance and short duration.

Construction/Installation
Optic Fibre Cable Laying

The impact of laying Optic Fibre Cable on swampy land is the same as that of laying pipeline because they follow the same procedure. However, laying Optic Fibre Cable across Escravos River, is low in magnitude and importance and short in duration, hence is not judged significant. Actually, we observed during cable laying in Southern Swamp AGG Project (Macgill 2002), that an observer in the Lay Barge did not notice visibly anything happening below the surface water. The only impact at River crossing, is on Benthic organisms, which is however is of medium significance.

Operation and Maintenance

Under normal operating conditions, operation and maintenance of the Manifold and the Pipelines have no negative impact on surface water. However, under abnormal conditions, such as pipe rupture due to corrosion, or damage by Sabotage, pollution to surface water may occur.

Noise and Vibration Impacts

Site Preparation and Construction

The ambient noise levels at most sites within the field were within regulatory limits. The highest noise level of 65.2 dBA was measured at uninhabited location in Saghara (AQ5). The activity equivalent continuous sound pressure levels, L_{Aeq} at a distance of 10 m for various site preparation and construction activities are shown in Table 5.9.

Table 5.9: Typical Noise Levels for relevant Construction Equipment*

Equipment Description	**dBA @ 10 m**	**ırks**
Piling, H-section Steel		ınne-metre energy, 65% on-time
Piling, sheet Steel		m energy, 70% on-time
Excavator		W, 100% on-time
Trenching		W, 100% on-time
Trench filling		W, 60% on-time
Dredging		ger 35 m long, 100% on-time
Clearing River Banks	79	80% on-time
Gas Turbine	140 @1m (85 @ 1 m)	20 MW capacity**

* Noise Control on Construction and Open Sites, BS 5228, Part 1, 1984.

** Noise in the Human Environment, Vol 2, Environment Council of Alberta, Canada, 1979.

Prediction of Construction Noise

In predicting construction noise, (using BS 5228, Part 1, 1984 methodology), the following significant factors are taken into consideration:

(a) the sound power outputs from the equipment,
(b) the periods of operation of the equipment,
(c) the distances of the noise sources to the sensitive receptors,
(d) the presence of screening barriers,
(e) the reflection of sound by surrounding surfaces, and
(f) wind speed and direction, as well as atmospheric and ground absorption

characteristics.

The major sources of construction noise are shown in Table 5.9, and the no communities likely to be affected are within 6 km of the site, hence no negative noise impact on communities is expected.

Impacts on Resource Utilization

The Niger-Delta region is rich in a variety of natural resources, in terms of oil and gas, fresh and brackish water bodies, wetlands and forest resources (mangroves and rain forest), fisheries and human resources. A major factor in the measurement of an organisation's environmental performance is its proactive stance on the use of available resources. In Saghara field, the potential impacts of the proposed project on natural resource utilization are presented below.

Oil and Gas

The extraction of oil and gas from Saghara field results in the depletion of existing resource, as they are non-renewable. However, extracting oil and gas for sale means that these energy sources are available for use and for foreign exchange income. Since the emphasis is to maximise exploitation and production of oil, and by implication, gas from the field through the integrated oil development programme. Responsible exploitation and utilisation of all forms of hydrocarbon, for the benefit of all stakeholders is the key to assuring the conservation of non-renewable resource as effective use is being made of what is available in the area.

Mothballing of Saghara Flowstation implies that there will be no gas flaring in that field.

Diesel Fuel

Diesel will be used extensively as fuel largely during construction phase, but will be used only sparingly during operation to power boats for periodic visits to well heads

Land Take

Land is an important element of natural resources because of its potential for agricultural use, habitation and nature conservation. The Saghara AGS field is an area of brackish and fresh water swamp with very little dry land and therefore unsuitable for large-scale agricultural use. There are community settlements within the area that exist on fishery and very little agriculture. Availability of land within saghara field is made possible through the reclamation of parts of the swamp forest for operational purposes. Parts of the land take also support the small community settlements and fish camps within the field. The extent of land use within the field is governed by operational requirements, that is, the size of the flowstations including the flaring areas and the size of the slots required to access the well heads. This project requires zero land take.

Forest products

No direct use is made of forest products through operational requirements within the field. However, the presence of access routes to Saghara Flowstation and associated facilities has contributed to greater exploitation of forest products by human settlers within the area. Forest products exploited by local people include timber for building homes, fish traps, canoes, house furniture, fuel energy for cooking, etc. Others include raffia palm for making native gin, fruits, nuts, berries etc, which are used for food and palm leaves used for their house roofing. These may not have any significant impacts on the swamp forests at the moment but further oil and gas exploitation could lead to more demographic movement to the area thereby increasing exploitation with major impacts on the fresh water forests. Fuel wood, the principal fuel for cooking in the area, will become plentiful. Those trading in fuel wood will not search far to fetch it. Mothballing of Saghara Flowstation is unlikely to abate the quest for exploitation of Saghara Field Forest Resources.

Fish

Fishing is a key activity among the local communities within the Saghara field. The swamps and the freshwater/brackish water creeks of the field are very important habitat and nursing grounds for fish. As well as its importance to the ecosystem, fish is equally important to the rural population housed in remote fishing villages and camps for food and commerce. Much of the fish is consumed locally with some sold to flowstation and facilities workers within the area. There are also instances when large catches are exported by water transport to Warri for sale. The project will have significant but short term negative impact on fish abundance arising from disruption of fishing activities during construction. Closure of Saghara Flowstation will certainly impact negatively on fish sales in the area.

Water

Water use and conservation is not an issue within field partly due to the high volume of seasonal rainfall within the area (annual average of 2480 mm), and because there is no infrastructure for storage and treatment of water for human consumption. The flowstation facilities rely on water imported from Warri with barges on a regular basis. The water is used on site for cooking, washing, bathing and conveniences. Drinking water for flowstation personnel is bottled and supplied during regular food runs. The local communities sometimes rely on drinking water available to the flowstation or collected in containers during rainfall. Coastal communities rely on hand-dug wells in the oasis (small patches of freshwater forests) for potable water. The project will have some negative impact on those nearby settlers who rely on water brought to the Flowstation for their needs.

Electricity

Presently electricity is generated *in-situ* within all the flowstations in the field. For normal flowstation operation, electricity is generated via gas driven engines and backed up by stand-by diesel generators. Presently, electricity is used only at the flowstations. The proposed project will add a 6.5MW (ISO) power plant to the Flowstation. This power will drive the CPF and the booster stations at the flowstations as well as supply electricity to the three major communities.

5.8: Risk Assessment

Risk assessment involves identifying all environmental, assets, reputational and health hazards attendant upon the execution of all phases of the proposed project. For each of the relevant hazards identified, potential sources of the hazard, typical consequences and remedial actions are addressed. The hazard identification process makes use of the SPDC Risk Matrix; see Table 5.3. Only those hazards, which have been assessed to lie in the Medium and High-risk areas, are addressed. We identify the hazards with the phases of the project development in which they have potential for occurrence as shown in Table 5.10.

Table 5.10: Hazid Identification (HAZID) Assessment

S/N	Development Phase	Activity/Event	Hazard	Effects	Remedial Action	Priority Rating
1	All Phases	Climate Extremes Kidnapping	• Heavy Rainfall • Lightning • Deprivation of personal liberty, injury, fatality	• flooding, soil erosion, creek siltation, personnel discomfort, • impairment of construction activities, • poor visibility leading to boat accidents. • Electrocution of people, damage to equipment • Trauma, loss of assets, fatality	• Incorporate effects into detailed design, • Schedule construction during dry season • Careful marine journey management • Install lightning arrestors on construction sites/flowstations. Adequately ground steel structures. • Adhere strictly to Project Security Plan	M H H M H
2	Site Preparation	Bush Clearing	• Wrong use of chain saws • Lack of concentration • Diesel fuel spill during equipment fuelling • Insensitivity to third party property • Disruption of Community socio-economic life	• Personnel injury from chain saws • Harm to people from falling trees • Soil/Water pollution • Damage to fish ponds, shrines, distilleries and farms • Community displeasure • Damage to fishing gears, loss of fishing. • Disrupts commercial water traffic • Shoreline erosion	• Exercise of care and diligence • Alertness and proactive action plan • Employ spill-proof fuelling system. • Relocate and pay compensation • Proactively sensitize the communities • Pay reasonable compensation. • Provide potable water to affected communities. • Early notice to NIWA and general public of work plan, with strategic moored guideposts. • Protect (shoreline/river bank) areas with serious erosion Problems. • Spread spoils evenly starting at least	H

S/N	Development Phase	Activity/Event	Hazard	Effects	Remedial Action	Priority Rating
		Seabed Clearance/Cable Laying		• Spoil disposal degrades aesthetic quality of the environment and impedes drainage. • Damage to aquatic ecosystem Damage to seabed topography	5m from the shoreline. • Minimize requirement for dredging by using low-draft vessels. Use silt curtains to cordon off dredge site to minimize spread of total solids. • Ensure adequate reinstatement of seabed topography. • Fluidize seabed to the minimum width required.	M
3	Construction		• Barge/Boat movement • Community disturbance • Impact on the environment • Loss of control.	• Risks to fishing /local commercial boats. • Damage to fishing gears • Shoreline erosion by waves • Damage to assets, delay in construction, hostage taking/harm to personnel, harm to company reputation • Land take and pollution of the environment • Project delays	• Prudent marine journey management • Proactive community engagement • Pay legitimate compensation • Prudent marine journey management • Proactive community engagement strategy. • Evolve and implement robust Environmental Management Plan (EMP).	H H H

S/N	Development Phase	Activity/Event	Hazard	Effects	Remedial Action	Priority Rating
					• Review dimensional tolerances in design, review roll-off roll-on offloading strategy and shipping configuration.	H
4	Operation	System/Pipeline failure . Pipeline sabotage.	• Discharges from facilities, emissions, fire/gas explosion, waste disposal. • Emergency gas flares	• Damage to the ecosystem, • Negative community reaction, • Damage to company reputation. • Risk to human health	• Evolve and implement robust Environmental Management and Security Plans (EMSP). • Effect rapid shutdown in the event of sabotage. • Introduce pre-flaring sound warning signal, and install vertical flare stack.	H
5	Abandonment	Dismantling and carting away of facilities.	• Impact on the environment • Accidents from falling objects	• Damage to the ecosystem, • Undesirable aesthetics. • Risk to human health	• Evolve and implement robust site restoration plan (SRP). • Evolve proactive risk management plan	M
		Mothballing of Flowstation	Contamination of surface water from large volumes of flush water produced during shut down	• Compromise of surface water quality • Harm to aquatic life	• Adhere to SPDC Waste Management Guidelines	M
			Harmful X-rays from non-destructive testing (NDT)/ examination to ascertain the integrity of equipment and suitability for preservation.	• Risk to human health	• Evolve proactive risk management plan	H
			Pollution by all solids and oily/chemical waste generated during shut down process.	• Soil/Water pollution • Damage to fish ponds, shrines	• Adhere to SPDC Waste Management Guidelines • Pay appropriate compensation	M

5.9: Social and Health Impacts

The expected impacts of the proposed gas gathering project on the physical, health and socio-economic environment are examined under the following sub-themes.

Demographic Impacts

The various phases of Saghara AGS development will most likely attract additional people to the host communities. Some of these will be people who have come from elsewhere to seek employment or to trade. Others may be employees of the project who may take up residence in any of the host communities. Other categories of people who may move into the communities to take advantage of Saghara AGS are contractors or itinerant youth who may want to perpetrate the vexatious habit of extorting money from Saghara AGS personnel and other operatives. New in-migrants will impact on the host communities in various ways. There will be pressure on existing facilities and social infrastructure, housing, sanitation and health services. Considering that the state of infrastructure and facilities is already very poor, the impact will be very negative. More substandard houses may be built in response. There may even be a rise in anti-social activities.The structure of the population will be further skewed in favour of the youth as immigrants are likely to be young adults looking for ways of eking out a living.

Socio-economic Impacts

The socio-economic impacts are both beneficial and harmful. First, we examine the beneficial effects of the proposed Saghara AGS project development.

Beneficial Effects

Employment is one area in which expectations are very high in the communities. Saghara AGS will employ different categories of personnel, skilled and unskilled. With particular reference to the communities, employment will be provided for mainly unskilled workers because of the rather low level of skill development in relation to project requirement. However, the project will invigorate the economies of the communities. Traders in food items and general consumer goods will witness a boom in demand as more people move into the communities. Increased demand for fish will encourage more people into fishing thus creating more employment. Boat operators will also benefit, as traffic will increase with the increase of in-migrants. If people acquire new skills from Saghara AGS, they may create employment for themselves and even employ others. In this sense, the project may be a source of development for the communities. By energising the local economy, creating direct and indirect employment, new sources of income will be created and old sources enhanced. Saghara AGS will therefore play a major role in poverty alleviation in the communities.

Saghara AGS will require the opening of waterways to facilitate the movement of materials and men. These waterways may not only open up the communities but will facilitate inter-community movements and communication. This project has a Project Global Memorandum of

Understanding (PGMoU) with the communities for sustainable development projects to be initiated and managed by the communities. The total value of the projects under the PGMOU is N350 million. Indeed, Saghara AGS portends to be a harbinger of modern growth in the host communities.

Harmful Effects

The mobilisation of personnel and equipment to site is required for the commencement of the various phases of the proposed project. This increased water traffic involving the movement of heavy equipment, and machinery along the major waterways in Saghara AGS will occasionally cause localised disturbances to local commuters in canoes. Waves generated from the movement could endanger the canoes both in the middle and banks of the waterways. Indeed, wave generated from the water traffic is capable of breaking fragile canoes tied along the banks in the communities. In any of the above cases, SPDC - community conflict is the likely result and demand for compensation by affected persons will be made.The movement of heavy equipment and supply boats along the waterways, as well as the dredging of some of the waterways, could also cause temporary disturbance to commercial and fishing activities. Part of the disturbance may result in the destruction of fishing nets and traps, which are common features of the riverine areas. Accidental destruction of fishing nets could provide grounds for SPDC - community conflicts and demands for compensation by the affected individuals.

Health and Safety Impact

The Saghara AGS project will encourage immigration of different categories of people including skilled and unskilled labour force and service providers. This will result in added pressure on the inadequate infrastructures (both in quality and quantity) and the attendant problems of overcrowding and contagious diseases. The likely diseases to be encountered in the Saghara AGS project area are classified into three categories:

- Communicable diseases – Malaria, Skin infections, Respiratory tract infections, sexually transmitted diseases, Diarrhea/Dysentery, and Hepatitis.
- Non-communicable diseases – High blood pressure, Asthma etc.
- Injuries – occupational accidents, boat accidents, fire accidents, sea piracy.

The sources of drinking water in the Saghara AGS project area did not meet the WHO requirement for drinking water. Analysis showed that the water sources contained high Total and faecal Coliform counts. The prevalence of other faecal pollution indicators suggested that the water was polluted with faeces. Further contamination of domestic water sources by spilled chemical agents such as lubricating oil and diesel may occur during the site preparation and construction phases. The potential for air related diseases as a result of the Saghara AGS project activities will increase due to elevated levels of suspended particulate matter, oxides of carbon, nitrogen and Sulphur, heat and exhaust emissions.

Increase in population will lead to more waste production, which will require greater attention in the form of refuse collection and disposal, sewage disposal and disease vector control. In addition, waste will be generated during some of the project activities such as site clearing, dredging and demolition/abandonment. Improper disposal of industrial and domestic wastes into the surrounding water bodies (especially human wastes from houseboats and other facilities) may increase the incidence of water borne diseases, which are prevalent in the communities.

The noise-level measurements in the communities of the project area ranged from 46.3 to 65 dBA. The expected increase in noise levels has the potential of causing disturbance and inconvenience to communities. Increased job opportunities and boat travels will enhance the chance for occupational accidents leading to injuries. Gas leakage in the operational phase of the project can result in serious fire outbreak and injuries and maybe even fatalities.

CHAPTER SIX
MITIGATION MEASURES

6.1: Introduction

In Chapter 5 of this report, a number of potential and associated environmental (biophysical), socio-economic and health impacts of the Saghara AGS project were identified and assessed (using ISO 14001 Impact Assessment tool and RAM) as either positive or negative. The negative impacts were further categorised as Low, Medium or High significance. In concert with SPDC HSE Policy, all impacts identified as being of Medium or High significance, require appropriate mitigation measures.

6.2: Mitigation Measures

Mitigation measures are actions taken to minimize negative impacts, while also enhancing positive ones. These measures typically aim to improve the environmental sustainability of a project. Depending on the nature of the impact they apply to, they can already be applied during the design, planning or implementation stage of the project. Mitigation measures are often implemented on a continuous basis through the project's life-cycle. Specific mitigation measures are aimed at reducing negative impacts to As Low As Reasonable Practicable (ALARP) and where possible enhance positive ones. At the preliminary Engineering Design level, some mitigation measures had been proffered based partly on past experiences and corporate HSE policy, and partly on regulatory requirements. As part of the feasibility study for the Saghara AGS project, strategies have been put in place for the management of potential impacts identified at that level. SPDC as a company determined to carry out Exploration and Production through sound principles of sustainable development is committed to the implementation of mitigation measures that will ensure sustainability.

Table 6.1 presents a summary of the mitigation measures recommended to ameliorate all the significant associated and potential impacts identified for the Saghara AGS project.

Table 6.1: Summary of Significant Impacts and Mitigation Measures for the Identified Potential and Associated Impacts

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**
All Phases	Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost;	H	SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March)	L
	Fatality, damage to assets due bad weather	H	SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March)	M
	Deprivation of personal liberty, injury, fatality due to Kidnapping	H	SPDC shall strictly implement its Project Security Plan	L
PREMOBILIZATION AND MOBILIZATION SITE PREPARATION RoW Clearance	Increased erosion potential due to removal of vegetation canopies and road paving	L	SPDC shall minimise bush clearing to what is required for construction activities SPDC shall avoid de-stumping as much as possible within the RoW	L
	Loss of habitats for wildlife.	L	SPDC shall minimise land-take as much as practicable SPDC shall pay adequate compensation for loss economic trees/plants	L
	Irreversible alteration of drainage pattern of the RoW.	L	SPDC shall deploy low pressure swamp Boggy	L
	Income to local workers that may be employed for the bush clearing activities	P	N/A (impact is beneficial)	
	Water related disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing.	H	Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on communicable diseases related to water and sexual behaviour. Step-up HIV/AIDS awareness programmes. Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if	M

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			identified.	
	Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers.	H	Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for workers and local hands that will be employed	M
	Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment (PPE)	H	SPDC shall ensure the provision and enforcement of the use of appropriate PPEs on site. SPDC shall provide adequate First Aid and functional medevac system on site. SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the controls and barriers are adhered to. SPDC shall ensure that daily tool box meetings are held	L
	Increased in suspended solids in water	H	Use of silt curtain to prevent migration of plant matter, debris	L
	Discharge of feacal waste into the water will contaminate surface water sources and increase water related disease (cholera etc).	H	Treat all waste water to DPR standards prior disposal Provision of mobile toilets for its work-force SPDC shall regularly monitor the quality of effluent to ensure that it meets regulatory standards SPDC shall adhere to its waste management procedure	M
	Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed.	H	SPDC shall ensure strict compliance with good marine journey management practice, including sensitisation of quarter masters / boat masters on how to pass fishing and commercial boat	L
	Water traffic disruption with possible increase in marine accidents	H	SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal	L

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**
			fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy.	
	Third Party agitation	H	Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU	M
CONSTRUCTION Trenching/ Backfilling	In tidal swamps, trenching and backfilling will increase surface water sediment loading and suspended solids.	H	SPDC shall deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	L
	Irreversible soil compaction which may alter the topography and drainage pattern of the RoW.	M	SPDC shall use low pressure tracked equipment for construction	L
	Improper disposal of backfilling residue will alter the natural drainage pattern of the area.	M	SPDC shall ensure that no soil mounds are left after back-filling	L
	Improper disposal of backfilling residue will alter the natural drainage pattern of the area.	M	SPDC shall ensure that no soil mounds are left after back-filling	L

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
Optical Fibre Cable Laying	Exposure to radioactivity and release of chemicals from pipe weld non destructive testing	H	SPDC shall provide radiation counter to workers for monitoring individual radiation levels. SPDC shall provide and enforce the use of protective aprons. SPDC shall ensure that the activity is carried out in accordance with standard procedures.	L
Welding / NDT	Welding will cause occupational impacts from release of toxic fumes	M	SPDC shall enforce the use of appropriate PPEs.	L
	Employment opportunities	P	Positive impact	
	Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities.	H	SPDC shall ensure the use of well trained personnel, and appropriate PPEs Implement its HSE policy on lifting and hoisting	L
Coating/Wrapping	Leaks and spills of diesel fuel and lubricants into water.	M	SPDC shall ensure best engineering of pipeline design, construction and installation. Design to incorporate auto leak detection for pipelines. SPDC shall establish effective gas leak monitoring programme for the pipelines	L
	Improper disposal of lay barge deck drainage will contaminate surface water and sediment.	M	SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge into the receiving environment	L
	Contamination of water with paints and corrosion inhibitors.	M	SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment.	L
	Discharge of untreated test water into the receiving environment.	M	SPDC shall ensure that appropriate containment (drip pans) and clean up procedures are adopted	L
Hydrostatic Testing	Disturbance of riverbed topography.	M	SPDC shall use the best available technology (fluidized bed) to minimize disturbance to riverbed topography	L
River Crossing	Salt water intrusion into ground water, through	H	SPDC shall ensure no hydraulic connection between the sea	L

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	ELPS (hydraulic seepage around the circumference of the pipe at river crossing		and the coastal forest by using cofferdams and sheet pilling for the shoreline approach, The use of shore protection techniques to achieve rapid stability of the excavated area for the shore approach area after the installation of offshore section of pipeline	
	Disaggregation of benthic habitats and loss of benthic organisms.	M	SPDC shall adopt due diligence (exercise care) to minimize adverse impacts on benthic organisms	L
	Shoreline erosion	M	SPDC shall carry-out shore protection in areas susceptible to shoreline erosion	L
	Injuries and accidents from not following approved work procedures and non-use of Personal Protective Equipment PPE	H	SPDC shall ensure the use of well trained personnel, and the use of appropriate PPEs	L
	The size and number of barges conveying equipment, materials and personnel, and the associated waves will endanger small canoes/boats and limit fishing activities.	H	SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy.	L
Water traffic	Increased income to local workers	P	Positive impact	
	Disruption of fishing activities	H	SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line	

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			with SPDC policy.	
	Water related disease may increase due to poor sanitation practices when more pressure is put on already inadequate state of housing facilities.	H	SPDC shall step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on communicable diseases related to water and sexual behaviour. Step-up HIV/AIDS awareness programmes. Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified.	M
	Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through migrant workers.	H	SPDC shall step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for workers and local hands that will be employed	M
	Improvement of socioeconomic activities and quality of life of residents	P	Positive impact	
Power generation and supply to Communities	Improper disposal of oily sludge from pigging will pollute surface water and sediments	M	SPDC shall ensure that effluents and solid wastes are collected for off-site disposal SPDC shall transfer all pigging sludges to the saver pit	L
	Third Party agitation	H	Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU	M

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
Commissioning and Operation of Pipelines and Manifold Pigging Corrosion Control	Water pollution by corrosion inhibitors	M	SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment	L
	Gas emissions from pipelines damage due to sabotage.	H	SPDC shall intensify its pipeline surveillance plan	L
	Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works.	H	SPDC shall provide adequate and relevant training to all staff especially local hands SPDC shall adopt safe operating procedures consistent with good statutory and SPDC HSE requirement SPDC shall its HSE Policy on Hoisting and Lifting	L
MOTHBALLING Engineering Work for Preservation	Contamination of surface water from large volumes of flush water produced during shut down	M	SPDC shall ensure the use of an environmental barge to contain large volumes of flush water	L
	Harmful X-rays from non-destructive testing (NDT)/ examination to ascertain the integrity of equipment and suitability for preservation.	H	SPDC shall provide radiation counter to workers for monitoring individual radiation levels. SPDC shall provide and enforce the use of protective aprons. SPDC shall ensure that the activity is carried out in accordance with standard procedures.	L
	Solid waste generated during Engineering work for preservation	M	All wastes emanating from engineering works for preservation shall be segregated and removed from the facility in accordance with SPDC Swamp Procedure for Waste Management	M
	Mothballing of Saghara Flowstation will improve the air quality of the field.	P	Positive impact	L
	Poor aesthetic features from abandoned structures on site.	M	All wastes emanating from engineering works for preservation shall be segregated and removed from the facility in accordance with SPDC Swamp Procedure for Waste Management	L

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**
	Employment opportunities	P	Positive impact	L
	Pollution by all solids and oily/chemical waste generated during shut down process.	H	SPDC shall ensure that any spilled oil or chemical must be immediately cleaned to bring the station to SPDC acceptable shutdown state. SPDC shall use appropriate SHOC cards when handling chemicals and paints and follow SPDC Swamp Procedures for waste management	L
	Third Party agitation	H	Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU	M

CHAPTER SEVEN
ENVIRONMENTAL MANAGEMENT PLAN

7.1: Introduction

Environmental management is concerned with a planned, integrated programme aimed at ensuring that unforeseen and unidentified impacts of a proposed project are contained and brought to an acceptable minimum. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from feasibility study to abandonment.

In keeping with SPDC policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design, up to the present stage of EIA and will continue throughout the project life cycle. This EIA report is part of the environmental management programme, and is intended to provide an environmental input into the planning and execution of the project.

This environmental management will be carried out in accordance with the provisions if ISO 14001, sections 4.3.2 - 4.3.4, which are reflected in SPDC HSE-MS Manual, sections 1.4 and 4.2 from which the project's HSE-MS is derived. The project's HSE-MS as detailed in doc no. SF3-12.01.HSE.010/011 addresses the overall approach adopted for management of HSE risks through the project development phases by the Saghara AGS project management team. The project HSE-MS document, provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practises etc, and to demonstrate how HEMP will be applied on the project such that HSE risks are As Low As Reasonably Practicable.

Good environmental management, which is part of SPDC's HSE-MS goals, has the following long term objectives:

- Ensure compliance with legislation and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified in this environmental impact assessment are implemented, a comprehensive EMP was developed (Table 7.1). The EMP will take cognisance of the technical implementation of the EIA findings in the design phase of project development, such that a plan of action for managing residual environmental risks can then be evolved.

7.2: SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislation but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be affected directly or indirectly by their activities. The Environmental Management activities instigated by SPDC are intended to implement the above policy which will be applied to all stages of this project from project feasibility to decommissioning. The projects' HSE-MS is fully aligned to SPDC's corporate HSE programmes.

7.3: Environmental Assessment

Environmental Assessment is a project-targeted process whereby established procedures are used for examining and assessing environmental effects, both direct and indirect, from feasibility studies, pre-conceptual design, conceptual design, detailed design, site preparation and construction, commissioning, operation and maintenance and abandonment. The Environmental Assessment began as soon as the project team was assembled, including an Environmental focal point. The role of an environmental focal point is to advise the project manager and ensure that environmental matters are fully considered, and that impacts of the project on the environment, and of the environment on the project, are minimised. SPDC has established procedures for assessing the impacts of projects on the environment. These procedures include:

- Identifying the source and characteristics of all wastes generated;
- Quantifying emissions and discharges to the environment;
- Quantifying and qualifying land-take and its direct effect on terrestrial ecology.

In assessing the environment of this project, it has been determined that:

- The environment is ecologically rich and sensitive, therefore, extreme care needs to be taken to minimise adverse impacts.
- There is the need to minimise the land-take for temporary use.
- Identifying sensitive marine habitats prior to commencement of construction operations, and taking special care to avoid them during construction will minimise damage to aquatic fauna. These areas include mangrove shorelines, tidal flats, marshes, etc.
- All oil and chemical spills, gas leaks and fire contingency plans must be well in place before operation commences. In this connection, plans should at least provide for:

a) Responsibilities and task priorities,
b) Emergency reporting system,
c) Communication network,
d) Environmental sensitivity ranking and clear response strategy,
e) Resources and supportive equipment, and
f) Reporting procedures.

This environmental assessment will continue to evolve along with the project, and is in fact the iterative process of impact mitigation, monitoring and audit and will continue throughout the life of this project.

Basis for Monitoring / Surveillance

This section must answer the following questions:

(a) Why do we monitor? - (Monitoring Objectives);
(b) What do we monitor? - (Impact Indicators);
(c) How do we monitor and at what frequency? - (Monitoring Programme).

The project activities for the Saghara AGS Project are outlined in Chapter 3 of this report. Based on the project activities, baseline data and the identified impacts, the monitoring objectives are given below.

Monitoring Objectives

To measure and quantify the impacts of the project development on the receiving environment, the following objectives are established to:

- create local data bank on the impact of dredging on aquatic ecosystem, for future development of predictive models;
- compare effluent quality and quantity with design specifications, impact predictions and with SPDC / statutory standards;
- monitor emissions and discharges at all stages of project development to ensure they meet local, national and SPDC standards;
- determine whether environmental changes are results of development or a result of natural variation;
- determine the effectiveness of the ameliorating measures;
- determine long term impact.
- determine the duration of return to normalcy of the water quality of the project area,
- enrich our data bank.

Impact Indicators to be monitored

In identifying impact indicators, priority is given to environmentally sensitive areas, which in this case, is the Saghara field. The project area is a Brownfield, with a flowstation, pipe/flowlines and dredged slots, and thus has residual identified impacts from past studies. Based on the results of baseline studies and consideration of FMEnv / DPR limits, Table 8.1 gives the proposed monitoring programme for the Saghara AGS project.

7.4: Monitoring Focal Point

During all phases of project development (site preparation, construction/installation, operations, maintenance, mothballing and abandonment), SPDC shall incorporate into the project team, an appropriately qualified environmental specialist, who will function as an Environmental Adviser

(EA), to liaise with the Contractor, Quality Assurance Engineers and relevant SPDC departments on all environmental matters. The specialist shall be the focal point for all environmental matters, which will include all actions relating to detailed design reviews and monitoring of construction, operation, mothballing and decommissioning/abandonment phases of the project.

Resourcing

Shell Petroleum Development Company (SPDC) considers environmental management as an important aspect of project procedures. Consequently, in any project for which project management team is set up, an environmental specialist always forms an integral part of the team. In this project, an environmental focal point has been appointed to liaise between the engineering project managers and the environmental specialist consultants as well as advises on all environmental issues in conformity with SPDC's HSE policy. Shell Petroleum Development Company (SPDC) recognises the need to use external environmental consultants to supplement in-house environmental specialists. To this end, the environmental consultants will continue to provide expert advice to the SPDC environmental managers throughout the development of this project.

7.5: Environmental Audits

Shell Petroleum Development Company as part of its programme on environmental management had instituted audit schemes aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management. This audit is developed and reviewed annually by SPDC environmental audit committee. The audits are focused on areas of project perceived as having the highest environmental risk.

SPDC integrated audit programme is such that external members such as SIPM or other Shell companies could participate. It is recognised that to be truly effective, these audits need to be conducted within the overall structured management systems. The structured approach is aimed at disseminating information, providing advice and assistance in its application, and at corporate assurance of performance in meeting the environmental requirements/targets.

7.6: Responsibilities and Training

Within SPDC, environmental protection, like safety, is a line responsibility for which staff at all levels has accountability. The environmental specialist assists the line management with advice on environmental matters from an expert point of view. However, responsibility and accountability is clearly defined, from senior management who allocate resources and monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace and surrounding area. All staff will be made aware of their responsibilities through induction and training courses as outlined in the projects' HSE-MS document. In addition, procedures, guidelines and notices will advise staff on how to respond in the event of an environmental emergency. The Shell Environmental Affairs

Department (West) is responsible for monitoring and auditing the environmental activities of this project.

Table 7.1: Environmental Management Plan (EMP) of Saghara AGS Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
All Phases	Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase time of delivery and cost;	H	SPDC shall make extensive use of yard pre-fabrication in order to minimise site construction activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March)	L	Compliance monitoring/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
	Fatality, damage to assets due bad weather	H	SPDC and Contractors shall make extensive use of yard pre-fabrication in order to minimise site construction	M	Site reports	Weekly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			activities. SPDC shall schedule site preparation and construction activities in the dry season (October to March)				
	Third Party Agitation	H	Relevant stakeholders/legacy issues shall be identified Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns Effective	M	Site Reports Community Engagement Reports Government Engagement reports	Monthly/Quarterly	SPDC/ DPR/FM Env

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
			liaison/communication channels (CIC/CROs) from the communities to the project execution team shall be established. Adequate and prompt compensation shall be made Effective Implementation of PGMoU				
	Deprivation of personal liberty, injury, fatality due to Kidnapping	H	SPDC shall strictly implement its Project Security Plan	L	Security plan, Security records Site reports	Weekly	SPDC/ FMEnv/ DPR
PREMOBILIZATION AND MOBILIZATION SITE PREPARATIO	Increased erosion potential due to removal of	L	SPDC shall minimise bush clearing to what is required for	L	Site reports	Weekly /Monthly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
N RoW Clearance	vegetation canopies and road paving		construction activities SPDC shall avoid de-stumping as much as possible within the RoW				
	Loss of habitats for wildlife.	L	SPDC shall minimise land-take as much as practicable SPDC shall pay adequate compensation for loss economic trees/plants	L	Site reports Community engagement records Compensation records	Weekly/ Monthly/ Quarterly	SPDC/ FMEnv/ DPR
	Irreversible alteration of drainage pattern of the RoW.	L	SPDC shall deploy low pressure swamp Boggy	L	Site reports Safety records	Weekly/ Quarterly	SPDC/ FMEnv/ DPR
	Income to local workers that may be employed	P	N/A (impact is beneficial)	P	• Employment records • Register of contractors • Community	Quarterly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
	for the bush clearing activities				engagement sessions		
	Water related disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing.	H	Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on communicable diseases related to water and sexual behaviour. Step-up HIV/AIDS awareness programmes. Augment the supply and	M	• Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) • Health awareness session	• Weekly • Monthly • Quarterly • Periodically	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
			issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified.				
	Increase in cases of sexually transmitted disease and other disease strains may result through migrant workers.	H	Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for	M	• Health awareness session • Health records	• Quarterly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
			workers and local hands that will be employed				
	Injuries and accidents from not following approved work procedures and non-used of Personal Protective Equipment (PPE)	H	SPDC shall ensure the provision and enforcement of the use of appropriate PPEs on site. SPDC shall provide adequate First Aid and functional medevac system on site. SPDC shall ensure that approved detailed Job Hazard Analysis (JHA) is provided by the contractor and that all the	L	.Site reports	• Daily • Weekly • Weekly • Monthly • Weekly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			controls and barriers are adhered to. SPDC shall ensure that daily tool box meetings are held				
	Increased in suspended solids in water	H	Use of silt curtain to prevent migration of plant matter, debris	L	• Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR
	Discharge of feacal waste into the water will contaminate surface water sources and increase water related	H	Treat all waste water to DPR standards prior disposal Provision of mobile toilets for its work-force SPDC shall regularly monitor the quality of	M	• Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	disease (cholera etc).		effluent to ensure that it meets regulatory standards SPDC shall adhere to its waste management procedure				
	Temporary disruption of local fishing/harvesting activities. Fish spawning habitat may also be destroyed.	H	SPDC shall ensure strict compliance with good marine journey management practice, including sensitisation of quarter masters / boat masters on how to pass fishing and commercial boat	L	• Marine Journey management reports	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR
	Water traffic disruption with	H	SPDC shall ensure proper scheduling of supply boat	L	• Marine Journey management reports • Accident	• Daily • Weekly • Weekly	

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	possible increase in marine accidents		movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC policy.		Investigation reports • Stakeholder (Government) consultation report	• Monthly • Weekly	SPDC/ FMEnv/ DPR
CONSTRUCTI	In tidal swamps,	H	SPDC shall deploy the	L	• Environmental Compliance	Weekly/Monthly/	SPDC/ FMEnv/

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
ON Trenching/ Backfilling	trenching and backfilling will increase surface water sediment loading and suspended solids.		most appropriate technology (silt curtain), to minimize loss of benthic organisms.		Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Quarterly • Periodically	DPR
	Irreversible soil compaction which may alter the topography and drainage pattern of the RoW.	M	SPDC shall use low pressure tracked equipment for construction	L	Site inspection reports	Weekly /Monthly	SPDC/ FMEnv/ DPR
	Improper disposal of backfilling residue will alter the natural drainage pattern of	M	SPDC shall ensure that no soil mounds are left after back-filling	L	• Site inspection reports	• Weekly/ • Monthly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	the area.						
Optical Fibre Cable Laying	Exposure to radioactivity and release of chemicals from pipe weld non destructive testing	H	SPDC shall provide radiation counter to workers for monitoring individual radiation levels. SPDC shall provide and enforce the use of protective aprons. SPDC shall ensure that the activity is carried out in accordance with standard procedures.	L	• Accident Investigation reports • Site inspection reports • Environmental Compliance Monitoring Reports	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
Welding / NDT	Welding will cause occupational impacts from release	M	SPDC shall enforce the use of appropriate PPEs.	L	• Accident Investigation reports • Site inspection reports	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	of toxic fumes				• Environmental Compliance Monitoring Reports		
	Employment opportunities	P	Positive impact	P	•Employment records •Community engagement sessions • Register of contractors	• Quarterly	SPDC/ FMEnv/ DPR
	Increased potential for injuries to personnel and damage to assets during heavy lift and positioning activities.	H	SPDC shall ensure the use of well trained personnel, and appropriate PPEs Implement its HSE policy on lifting and hoisting	L	• Accident Investigation reports • Site inspection reports • Environmental Compliance Monitoring Reports	• Daily • Weekly • Weekly • Monthly • Weekly	SPDC/ FMEnv/ DPR
Coating/Wrapping	Leaks and spills of diesel fuel and	M	SPDC shall ensure best engineering of pipeline	L	•Environmental Compliance Monitoring Reports	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
	lubricants into water.		design, construction and installation. Design to incorporate auto leak detection for pipelines. SPDC shall establish effective gas leak monitoring programme for the pipelines				
	Improper disposal of lay barge deck drainage will contaminate surface water and sediment.	M	SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge into the	L	• Environmental Compliance Monitoring Reports • Waste management reports	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			receiving environment				
	Contamination of water with paints and corrosion inhibitors.	M	SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment.	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
	Discharge of untreated test water into the receiving environment.	M	SPDC shall ensure that appropriate containment (drip pans) and clean up procedures are adopted	L	• Environmental Compliance monitoring report/ • Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
Hydrostatic Testing	Disturbance of riverbed topography.	M	SPDC shall use the best available technology (fluidized bed) to minimize disturbance to riverbed topography	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) • Site inspection reports	Weekly/Monthly/ Quarterly • Periodically	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
River Crossing	Salt water intrusion into ground water, through ELPS (hydraulic seepage around the circumference of the pipe at river crossing	H	SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet pilling for the shoreline approach, The use of shore protection techniques to achieve rapid stability of the excavated area for the shore approach area after the installation of offshore section of pipeline	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) Site inspection reports	Weekly /Monthly /Quarterly Periodically	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
	Disaggregation of benthic habitats and loss of benthic organisms.	M	SPDC shall adopt due diligence (exercise care) to minimize adverse impacts on benthic organisms	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly • Periodically	SPDC/ FMEnv/ DPR
	Shoreline erosion	M	SPDC shall carry-out shore protection in areas susceptible to shoreline erosion	L	• Site inspection reports	• Weekly/ • Monthly	SPDC/ FMEnv/ DPR
	Injuries and accidents from not following approved work procedures and non-use of Personal Protective Equipment PPE	H	SPDC shall ensure the use of well trained personnel, and the use of appropriate PPEs	L	• Accident Investigation reports • Site inspection reports	• Daily • Weekly • Weekly • Monthly • Weekly	SPDC/ FMEnv/ DPR
	The size	H	SPDC shall	L	• Marine Journey	• Daily/	SPDC/

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
	and number of barges conveying equipment, materials and personnel, and the associated waves will endanger small canoes/boats and limit fishing activities.		ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Institute good marine journey management system in-line with SPDC		management records • Accident Investigation reports	• Weekly	FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			policy.				
Water traffic	Increased income to local workers	P	Positive impact	P	• Employment records • Register of contractors • Community engagement sessions	Quarterly	SPDC/ FMEnv/ DPR
	Disruption of fishing activities	H	SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities,	L	• Site inspection reports • Environmental Compliance Monitoring Reports Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			of impending work and route plan, Institute good marine journey management system in-line with SPDC policy.				
	Water related disease may increase due to poor sanitation practices when more pressure is put on already inadequate state of housing facilities.	H	SPDC shall step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. SPDC shall organise awareness session on communicable diseases related to water and	M	• Health awareness sessions • Community engagement sessions	Quarterly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
			sexual behaviour. Step-up HIV/AIDS awareness programmes. Augment the supply and issue of condoms to workers on the project and possibly extend to commercial sex workers in the vicinity if identified.				
	Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through	H	SPDC shall step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives.	M	• Health awareness sessions • Community engagement sessions	Quarterly	SPDC/ FMEnv/ DPR

Project Activity	**Description of Impact**	**Rating Before Mitigation**	**Mitigation Measures**	**Rating After Mitigation**	**Parameters to be Monitored**	**Monitoring Frequency**	**Responsible/ Action Party**
	migrant workers.		SPDC shall organise awareness session on and sexually transmitted diseases, sexual behaviour for workers and local hands that will be employed				
	Improvement of socioeconomic activities and quality of life of residents	P	Positive impact	P	• Employment records • Register of contractors • Community engagement sessions	Quarterly	SPDC/ FMEnv/ DPR
Power generation and supply to Communities	Improper disposal of oily sludge from pigging will pollute surface	M	SPDC shall ensure that effluents and solid wastes are collected for off-site disposal SPDC shall	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) • Waste	Weekly/Monthly/ Quarterly • Periodically	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	water and sediments		transfer all pigging sludges to the saver pit		management records		
Commissioning and Operation of Pipelines and Manifold Pigging Corrosion Control	Water pollution by corrosion inhibitors	M	SPDC shall not discharge corrosion inhibitor dosed water into the rivers or creeks without treatment	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM)	Weekly/Monthly/ Quarterly • Periodically	SPDC/ FMEnv/ DPR
	Gas emissions from pipelines damage due to sabotage.	H	SPDC shall intensify its pipeline surveillance plan	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) • Waste management records	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
	Accidents from demolition activities - explosions, falling	H	SPDC shall provide adequate and relevant training to all staff especially	L	• Employment/Training records • Certification of workforce • Emergency response plan	• Daily • Weekly • /Monthly • Quarterly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	objects etc, especially when unskilled personnel are employed for the works.		local hands SPDC shall adopt safe operating procedures consistent with good statutory and SPDC HSE requirement SPDC shall its HSE Policy on Hoisting and Lifting		• HAZID register • Pep-talk records • Compliance monitoring • Toolbox meetings • Job Hazard Analysis (JHA) Studies • Accident Investigation reports		
MOTHBALLING Engineering Work for Preservation	Contamination of surface water from large volumes of flush water produced during shut down	M	SPDC shall ensure the use of an environmental barge to contain large volumes of flush water	L	• Environmental Compliance monitoring report • Waste management reports • IMM	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR
	Harmful X-rays from non-destructive testing	H	SPDC shall provide radiation counter to workers for	L	• Environmental Compliance monitoring report • Waste management	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	(NDT)/ examination to ascertain the integrity of equipment and suitability for preservation.		monitoring individual radiation levels. SPDC shall provide and enforce the use of protective aprons. SPDC shall ensure that the activity is carried out in accordance with standard procedures.		reports • IMM • Accident Investigation reports		
	Solid waste generated during Engineering work for preservation	M	All wastes emanating from engineering works for preservation shall be segregated and removed from the facility in accordance with SPDC Swamp	L	• Environmental Compliance monitoring report • Waste management reports • IMM	Weekly/Monthly/ Quarterly Periodically	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			Procedure for Waste Management				
	Mothballing of Saghara Flowstation will improve the air quality of the field.	P	Positive impact	P	• Employment records • Register of contractors • Community engagement sessions	Quarterly	SPDC/ FMEnv/ DPR
	Poor aesthetic features from abandoned structures on site.	M	All wastes emanating from engineering works for preservation shall be segregated and removed from the facility in accordance with SPDC Swamp Procedure for Waste Management	L	• Site inspection reports • Waste management reports	• Weekly/ • Monthly	SPDC/ FMEnv/ DPR
	Employment opportunitie	P	Positive impact	P	• Employment records • Register of	Quarterly	SPDC/ FMEnv/ DPR

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	s				contractors • Community engagement sessions		
	Pollution by all solids and oily/chemical waste generated during shut down process.	H	SPDC shall ensure that any spilled oil or chemical must be immediately cleaned to bring the station to SPDC acceptable shutdown state. SPDC shall use appropriate SHOC cards when handling chemicals and paints and follow SPDC Swamp Procedures for waste management	L	• Environmental Compliance Monitoring Reports/ Impact Mitigation Monitoring reports (IMM) • Waste management reports	Weekly/Monthly/ Quarterly • periodically	SPDC/ FMEnv/ DPR

7.7: Oil and Gas Contingency Planning

Despite all care and diligence exercised in project execution, accidents do occur. Accidents could occur from equipment failure or third party sabotage, all to the detriment of the environment. Consequently, oil and gas contingency plans are usually made to handle such accidental spills.

Although serious incident is unlikely for a gas pipeline, SPDC West has in place an oil spill contingency plan, which has been activated; regularly updated with regular and periodic exercises conducted by the Department of Petroleum Resources. The SSAGG projects' contingency plan shall derive from and link to SPDC’s plan.

7.8: Consultation

SPDC has established and maintained effective communications with authorities in government agencies (FMENV and DPR) and other relevant groups or parties. By so doing, it has been SPDC's intention to:

- avoid conflict by addressing issues promptly;
- ensure that any fears or apprehensions about the nature, scale and impacts of the proposed project have been fully addressed;
- avoid any misunderstanding about the project.

These objectives have been addressed by a strategy of communications. SPDC’s environmental management team had established sound working relationships with FMENV and DPR, whose representatives are participating fully in all stages of environmental impact assessment studies. SPDC will present the preliminary report of the EIA to FMENV/DPR in compliance with approved guidelines. To further strengthen this communication base, SPDC's Public and Government Affairs Department (PAGW) has a number of communication initiatives planned, including:

- organisation of open fora, conferences and exhibitions to disseminate information and promote awareness;
- publication in the national and local news papers of SPDC's intention to undertake such a project, in accordance with the Pipelines Act of 1965;
- consultative meetings with officials of the Delta State Government in charge of the environmental issues, leaders of the Delta State House of Assembly Committee on the environment and the leaders/members of the host communities that could be affected by the project to discuss key concerns and explain the project development activities.

7.9: Future Commitments

Throughout the planning of this project, SPDC will continue to consult with the public, statutory authorities and affected individuals as well as local communities in order to ensure that construction and operation have minimum adverse environmental impacts.

To further support its policy on the environment, SPDC would undertake to:

- prepare a detailed restoration and after-care plan for reinstatement of the pipeline working width;
- monitor all environmentally sensitive areas during construction and operation to ensure compliance with SPDC's and statutory standards;
- land take for temporary use, which will require clearance, will be kept to the barest minimum, and restoration after use will be undertaken;
- at crossings of rivers normally subjected to commercial and industrial traffic, construction time will be reduced to minimum and restoration of river banks to avoid erosion will be undertaken;
- construction criteria for all major river and stream crossings will be discussed and agreed with NIWA and other appropriate authorities before commencement of work.

7.10: Waste Management

Any development project involving bush clearing, ditching and dredging in a tidal swampy environment is bound to encounter waste management problems which need to be handled in compliance with the Petroleum (Drilling & Productions) Regulations, 1969, Sections 25, 36, 49 and (b), (c) and (d), which stipulate *inter alia* that:

"The licencee or leasee shall <u>adopt all practical precautions</u>, including the provision of up-to-date equipment... to prevent the pollution of inland waters, rivers, creeks, water courses, the territorial waters of Nigeria or the high seas by oil, mud or other fluids or substances which might contaminate the water, banks or shoreline or which might cause harm or destruction to fresh water or marine life, and where any such pollution occurs or has occurred, shall <u>take prompt steps</u> to control and, if possible, end it;"...etc.

SPDC has an effective waste management scheme in place and this project will comply with that scheme.

Sources and Characteristics of Wastes

Site Preparation and Construction/Commissioning

Solid wastes likely to arise from above activities include:

Felled trees, domestic/industrial refuse, clay and sand (dredge spoils), grits, scrap metals. **Expected aqueous wastes include**: Chemicals (Glycol), oil and grease, dredge water run-off, soil and sanitary wastes, cement slurries, corrosion inhibitors, pipe test water and sludge.

Emissions include: Combustion products from construction engines, welding gas, noise, heat and light.

Residuals

An attempt has been made to quantify some residuals from site preparation and construction activities (Table 7.2), which must be disposed of in accordance with SPDC, waste disposal guidelines (Table 7.3).

Table 7.2: Anticipated Residuals from site preparation and construction

Type	Source	Quantity (est.)	Disposal plan
Top soil spoils	Site stripping	5028 m^3	Spread evenly over ROW
Subsoil spoils	Ditching	10,056m^3	Spread evenly over ROW
Shrubs/vegetation	Bush clearing	142390 Nos	Allow to biodegrade *insitu*
Trunks/stumps	Site stripping	-	Chop and stockpile
Sewage	Personnel	<450^3/month	Treat and dispose into creek
Scraps	Cut-offs/Damages	70 tons	Segregate into usable & non-usable & return to yard
Grit blast chips	Pipe surface cleaning	To be determined	Land fill
Paints/tar	Surface finishing	To be determined	Incinerate
Exhaust Gas Emissions	Internal Combustion Engines	To be determined	Drain into oil pit, recover & recycle
Lubricants	Plant Servicing at construction sites	To be determined	Recover oil & recycle
Condensate slug	Slug catcher/pipeline	380m^3/pigging	Channel into creek
Containers	Storage facilities	To be determined	Return to base
Run-off water	Dredging/drainage	To be determined	Direct back to Creek
Dredge spoil	Dredging	45,000 – 230,000 m^3	Treat & return to creek
Noise	Engines, piling	78-106 dBA	Wear ear protectors
Hydrotest water	pipeline hydrotest	3732m^3	Treat & discharge to creek
Domestic sewage	Logistic centre,	16640 m^3	Segregate and dispose according to SPDC Waste Disposal Plans in Swamp
Food Waste	Contractors house boats, Logistic centre,	15595 m^3	Waste disposal Contractor
Packing materials	Contractors house boats /kitchens	9356.7 m^3	Incinerate in off-site incinerator
Waste batteries	Construction sites, kitchen, offices	100kgs	Recycle

Table 7.3: Classified Waste Treatment/Disposal Options

Waste Types	Management Option							
	Thermal Dissorption Plant at Forcados Terminal	Recycle	Returned to manufacturer/supplier	Reused	Dumped at SPDC landfill	Skipped and dumped in deep offshore	Incineration	Utilized by host communities
Drill cuttings	P/A	NA	NA	NA	**X**	X	NA	X
Drilling mud (WBM)	NA	NA	NA	A	X	P/A	NA	X
Drilling fluids and chemicals	NA	NA	A	A	X	X	NA	X
Lube oils	NA	P/A	A	A	X		NA	X
Spent paints and solvents	NA	A	P/A	NA	X	X	NA	X
Grit (from blasting)	NA	NA	NA	P/A	A	NA	NA	A
Spent batteries (alkaline)	X	A	P/A	NA	X	X	X	X
Wood scraps	NA	P/A	NA	A	X	NA	NA	X
Empty drums and containers	NA	P/A	A	A	X	NA	NA	X
Scrap metal and junk	NA	P/A	A	A	X	NA	NA	X
Oily sludge	P/A	A	NA	NA	X	X	A	X
Empty food containers	NA	P/A	A	NA	A	NA	NA	X
Food wastes	NA	NA	NA	NA	P/A	NA	NA	NA
Office (Paper) waste	NA	P/A	NA	A	NA	X	X	X
Medical wastes	NA	X	NA	X	X	X	P/A	X
Felled trees	NA	NA	NA	A	NA	NA	NA	P/A
Soiled sorbents and fabrics	NA	NA	NA	NA	X	X	P/A	X

CODE: P – Preferred; A – Acceptable; P/A – Preferred and Acceptable; X – Prohibited

NA – Not Applicable

System Operation and Maintenance

Solid Wastes: Domestic refuse, oily/sandy waxes, scrap metals, Industrial refuse;

Aqueous Wastes: Oil leaks and accidental spills, storm water run-off, maintenance lubricants and condensate leaks, soil and sanitary wastes, pigging sludges;

Gaseous Wastes: Exhaust gases, refrigerant leakage and other fugitive gas emissions, fire-fighting agents.

Abandonment

Solid Wastes: Clean-up process equipment, used pipeline, pumps, Surge vessel, flare stack, abandoned platform, domestic refuse, industrial refuse, used process equipment, spent batteries and fire extinguishers containers.

Aqueous Wastes: Domestics sewage, lubricants and grease, sludges, condensate, glycol.

Gaseous Wastes: Refrigerants, fire-fighting agents.

Solid Waste Management

Site Preparation and Construction

Solid wastes generated during all phases of project development fall into two categories - biodegradable and non-biodegradable. Vegetation / trunks and stumps which are by-products of ROW preparation would be chopped and spread out evenly on either side of the ROW so that local firewood traders could carry them away, otherwise they would biodegrade with time. In the like manner, residual soil from top soil stripping and trenching would be evenly spread after pipe burial so that mounds do not form and impede natural drainage.

Operation, Maintenance and Abandonment

Kitchen Waste, Packing Materials, Scraps and Containers

These wastes are sorted out into biodegradables and non-biodegradables. The bio-degradables are landfilled off-site on dry land while the non-biodegradables, such as plastics, are burnt in an on-site incinerator provided for the purpose. Scraps and containers are segregated into usables and un-usables. The un-usables are incinerated along with non-biodegradables while the usables are returned to base. The classification and quantities of solid waste disposed would be reported monthly.

Aqueous Waste Management

Site Preparation and Construction

The project area is flat, tidal, primarily swampy and receives about 2500 mm annual rainfall. It is naturally poorly drained, thus, it is important that no construction activity should block the storm run-off path particularly in relation to dredge spoils deposition. Where necessary, drainage should be provided for dredge water run-off. Construction of the CPF would provide adequate drainage channels for storm water run-off. A saver pit would be used in the drainage around the base camp to collect oil and grease from equipment maintenance areas. Pipe test water would be discharged into neighbouring stream parallel to stream surface to avoid stirring-up bottom sediments. Cement slurries, which would arise from pipe coating, would be handled in accordance with SPDC/DPR guidelines for effluent disposal in swamp environment.

Operation, Maintenance and Abandonment

Part of the Saghara AG Solution project includes modifications and tie-ins to integrate the new facilities and decommissioning of Saghara flowstation. This creates the possibility of oil leaks / accidental spills from the facilities. Any such oil spill would be handled in accordance with SPDC Oil Spill Contingency Plan, which is already in place.

Maintenance lubricants and condensate leaks in the Booster Stations and the CPF would be washed into the drainage channels which, along with storm water run-off would be channelled into saver pits from where oil will be recovered until the oil content of the remaining effluent is <20 ppm before it is discharged into the receiving environment in compliance with SPDC standards.

Pigging sludges would be subjected to process heat and recycled for recovery of gas and condensate. During abandonment, sludges and condensate would be collected and burnt in an incinerator. Any dehydrant left in the system would be washed off and disposed of according to the requirements of SPDC's Safe Handling of Chemicals (SHOC) system.

Results of the analysis of oil spills from multiplicity of sources within the Otumara/Saghara/Escravos Beach Fields from 2007 to 2012 are shown in Table 7.4. It is quite interesting to observe that most of the spills resulted from Sabotage and Equipment Failure. Equally interesting is the increasing. number of spills due to the aging of the pipelines (Corrision failure). This underpins the need for replacement of aging line pipes.

Table 7.4: Analysis of Oil Spill Records in Otumara/Saghara/Escravos Beach Fields (2007-2012)

		2007	2008	2009	2010	2011	2012
1	**Number of Spills**	9	7	21	12	13	2
2	**Total Quantity of Spills (bbls)**	7.8	157.41	78,410.31	2.37	44.90	NIL
3	**Cause of Spills**	SA = 33.3% EF = 66.7% OE =0% UK = 0% CR=0%	SA = 57.1% EF = 28.6% OE = 0% UK = 0% CR=14.3%	SA = 38.1% EF = 42.9% OE = 4.8% UK = 0% CR=9.5%	SA = 33.3% EF = 16.7% OE = 6.7% UK = 8.3% CR=25%	SA = 7.7% EF = 39% OE = 0% UK = 7.7% CR=61.5%	SA = 0% EF = 0% OE = 100% UK = 0% CR=0%
4	**Status of Spills**	WC = NDA WIP= NDA NAR= NDA	WC = NDA WIP= NDA NAR= NDA	WC =7 WIP= NDA NAR= NDA	WC = NDA WIP= NDA NAR=3	WC =3 WIP= 2 NAR=8	WC = NDA WIP= NDA NAR=1

Legend: SA = Sabotage

EF = Equipment failure; OE = Operational error; UK = Unknown cause; WC= work Completed; WIP= work in progress; NAR= No action required; CR= corrosion;
NDA = No Data Available

Gaseous Waste Management

Site Preparation and Construction

The gaseous waste resulting from this phase of project development is largely exhaust emissions from diesel-powered earthmovers, laybarge engines and dredging/piling power systems. The main components of this exhaust stream are Carbon Dioxide (CO_2), Carbon Monoxide (CO), Oxides of Nitrogen (NO / NO_2). These emissions, largely CO_2 and particulate depend on the combustion efficiency of the engines. Shell will monitor and quantify these emissions from each source during construction, and will ensure that the equipment used are in good mechanical condition and have high combustion efficiency.

Operation, Maintenance and Abandonment

The main objective of this project is to limit routine gas flaring to 10% of gas production with the possibility of full gas flaring if and when the main compressor fails. With all the crude oil pump gas engines replaced with electric motors, emissions will be severely reduced. The main source of emissions will be the gas turbine at Otumara, and the fugitives. The exhaust stream consists of CO_2, CO, NO / NO_2, SO_2, CH_4 and VOC.

The quantities of atmospheric emissions from a gas turbine depend on:

- Fuel - The quality of fuel gas and its combustion characteristics
- Power Output - The thermal efficiency is proportional to the size of the turbine, hence, bigger turbines have lower atmospheric emissions per unit of power output.

- Age - Mechanical efficiency decreases with turbine age, hence more emissions with increasing age.
- Load - Thermal efficiency decreases with decreasing driven load, hence emission levels of unburnt hydrocarbons and carbon monoxide increase significantly.

Past studies of exhaust emissions (Shell Gabon, 1993) from gas gathering stations show that 99% by weight of all emissions is CO_2. SPDC will during detailed design, conduct technical review to assess the advantages and implications of installing and "low NO_x" burners to ensure that these emissions are minimised.

Fugitive emissions are defined as those emissions, which occur as a result of leaks from components such as pipe connections, valves, rotating shafts and other components. Shell will continue to identify, monitor and inventorise all wastes and emissions with a view to minimising them through judicious application of newly developed technologies.

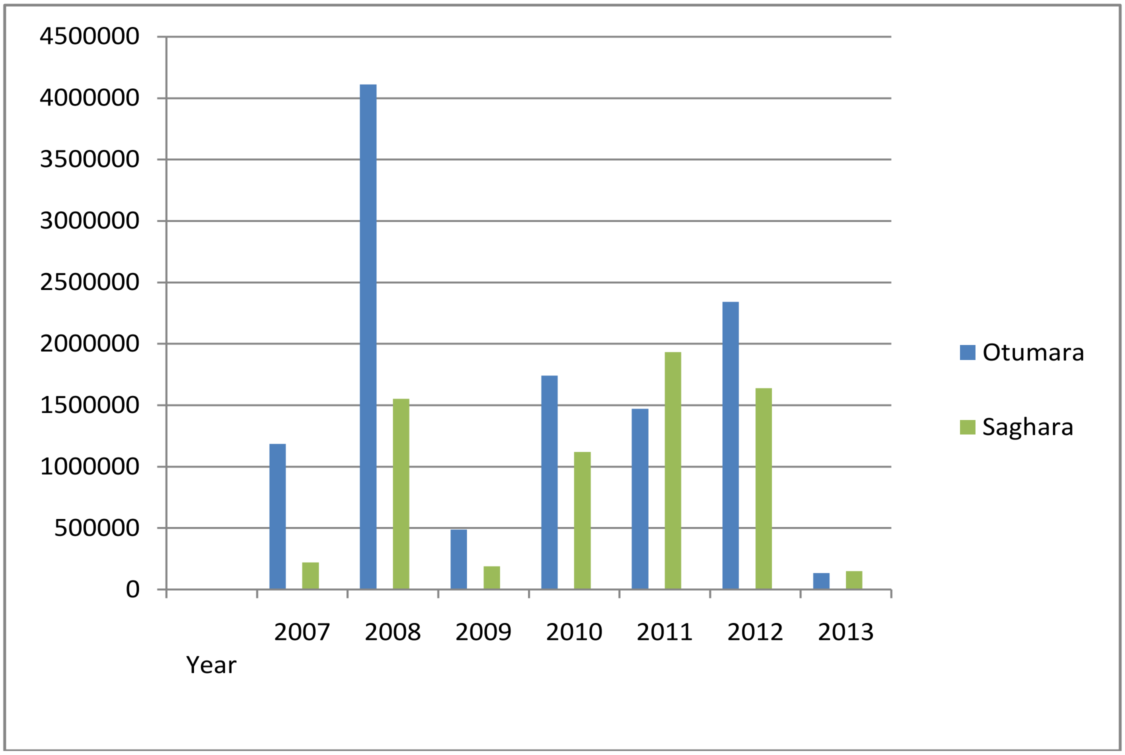

Fig. 7.1: Otumara and Saghara Gas Flare Records (scf/d)

Table 7.5: Green House Gas Emission Scenario in 2012 and 2017

GHG	Tonnes/day	
	2012	2017
CO_2	270,105,916	84,959,980
CH_4	5216	1640.60
N_2O	4934	1551.98

*Predictions derived from current study

The gas flares in Otumara/Saghara Fields from 2007 to 2013 are shown in Fig. 7.1, while calculated Green House Gas emissions in both fields are compared in Table 7.5 for the years 2012 and 2017, when the Gas Plant is expected to be functional The table shows significant reduction in gas flares and GHG emissions, thus justifying the project.

Non-operational Gas Flares

Section 3.3.3 of this report outlined the conditions for gas flaring at the CPF and the flowstations after the commissioning of the project in 2015. If this happens, all the Associated Gas produced in the field, less 20mmscf/d gas turbine consumption, will be flared. The CPF will still be equipped with pilot flares to facilitate emergency flaring when the need arises. Because of the possibility of this emergency flaring, it is recommended that vertical flare stacks be used. There should be some audible warning system against an impending emergency gas flare, which will likely come as an explosion.

CHAPTER EIGHT
CONCLUSIONS AND RECOMMENDATION

The results of the study showed that the air quality of Saghara field will substantially improve as a result of Mothballing of the Flowstation. Thus, the project will enhance air quality and reduce Nigeria’s contribution to global warming potential.All construction activities will take place on the existing RoW, hence no additional land will be required. Since no dredging is involved, the ecology of the project area will not be significantly compromised. The project will provide employment opportunities for young people during all phases of the development. The extension of electric power to the communities will enhance socioeconomic activities in the project area. Based on the foregoing, we pray that this EIA Report be approved for implementation.

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GLOSSARY AND DEFINITION OF TERMS

Air Quality: The concentration in air of one or more pollutants.

Algae: Extremely simple unicellular or multicellular plants which utilize the process of photosynthesis for life.

Aquifer: An underground water-bearing layer of porous rock, e.g. sandstone, in which water can be stored and through which it can flow after it has infiltrated from either the surface or another underground source.

Bacteria: Class of small organisms usually 1 µm in diameter, unicellular or coccoid, do not possess chlorophyll and multiply rapidly, by division.

Benthos: The plants and animals that live in and on the bottom of a water body.

Biochemical Oxygen Demand: A standard water treatment test which is an empirical measurement of the relative oxygen requirement of waste waters, effluents and polluted waters. It measures the amount of oxygen utilized during a specific incubation period, usually 5 days, for the biochemical degradation of organic material.

Biodegradation: The ability of natural decay processes to break down man-made and natural compounds to their constituent elements and compounds, for assimilation in, and by, the biological renewal cycles, is decomposed to carbon dioxide and water.

Biosphere: The transition zone between solid earth and the upper atmosphere, where most living things are found.

Biological concentration: The mechanism whereby filter feeders such as oysters and other shellfish concentrate heavy metals or other stable compounds present in dilute concentrations in sea or fresh water.

Biological indicator: The use of living organisms of plants and animals to detect environmental changes.

Biomass: The mass of living organisms forming a prescribed population in a given area of earth's surface. It is usually expressed in grams per square metre (g/m^2)

Bioremediation: The use of biological methods to remediate/restore contaminated land. Typical methods make use of tailored microbes and break down phenols which are major contaminants.

Borehole: A hole drilled into the ground to tap an aquifer for water supplies or gas field for oil or gas. Once the well has been drilled it must be completed, that is, the hole is cased to prevent collapse with a slotted casing to allow water to enter.

Carbon dioxide: Gas produced by the complete combustion of carbonaceous materials, by decay of organisms such as aerobic decomposers, by fermentation, and by the action of acid on limestone. It is exhaled by plants and animals and utilized in photosynthesis in the carbon cycle.

Carbon monoxide: A colourless odourless gas, lighter than air, formed as a result of incomplete combustion. It is a chemical poison when inhaled, as it is absorbed into the blood stream where it combines with haemoglobin of blood cells and thus deprive the brain and heart tissues of oxygen.

Cathodic protection: Cathodic protection works by applying a d.c. power source to reverse the natural flow of electrical current caused by galvanic corrosion. This stops the steel reinforcement in a structure from rusting.

Chemical Oxygen Demand: The amount of oxygen consumed in the complete oxidation of carbonaceous matter in an effluent sample. This is done in a standard test, which uses potassium dichromate as the oxidizing agent.

Clay: Fine-grained sedimentary rock of low permeability which is capable of being shaped when moist. Consists of fine grains less than 4 µm in diameter.

Coliforms: A group of bacteria whose absence from drinking water is a guarantee of freedom from pathogenic bacteria.

Contaminant: A compound which is present in the environment in concentrations higher than the background level, but not necessarily causing a negative impact.

Contingency plan: A document setting forth an organised, planned and coordinated course of action to be followed in order to prevent pollution incidents, and limit potential pollution in case of fire, explosion or discharges of hazardous waste constituents which could threaten human health and the environment.

Cost-benefit analysis: A techniques which purports to evaluate the social costs and social benefits of investment projects in order to help decide whether or not such projects should be undertaken.

Crude oil: Petroleum in its natural form before it is subjected to any refining process.

Decibel: A logarithmic measure used to compare the sound level of interest with a reference level. If we are concerned with sound power then reference is made to the smallest sound power that can be heard by someone with normal hearing at 1000 Hz.

Decommissioning: The final closing down and putting into a state of safety of an industrial plant or device when it has come to the end of its useful life.

Decomposers: Organisms, usually bacteria or fungi, which use dead plants or animals as sources of food. They break down this material, obtaining the energy needed for life and releasing minerals and nutrients back into the environment to be assimilated by other plant and animal life.

Dispersion: The dilution and reduction of concentration of pollutants in either air or water. Air pollution dispersion mechanisms are a function of the prevailing meteorological conditions.

Disposal: The introduction of waste into the environment through any discharge, deposit, emission or release to any land, water or air by means of facilities designed, constructed and operated so as to minimize the effect on the environment.

Dissolved oxygen: The amount of oxygen dissolved in a stream, river or lake is an indication of the degree of health of the stream and its ability to support a balanced aquatic ecosystem. The oxygen comes from the atmosphere by solution and from photosynthesis of water plants.

Ecological indicators: Organisms whose presence in a particular area indicates the occurrence of a particular set of water, soil and climatic conditions.

Ecology: The study of the relationships between living organisms and between organisms and the environment, especially animal and plant communities, their energy flows and their interactions with their surroundings.

Ecosystem: The plants, animals and microbes that live in a defined zone and the physical environment in which they live comprise together an ecosystem. The ecosystem embraces the food chain through which energy flows together with the biological cycles necessary for the recycling of essential nutrients.

Environment: The air, land, water and other external conditions or influences in which man, animals and plants live or develop.

Environmental audit: This is an account by manufacturers and industries of the products produced and their effects on the environment - energy use policies, materials use policies, waste output and their effects on the environment.

Environmental impact: A change in environmental quality. The word ‘impact’ connotes that a value judgement has been made on the importance of an environmental effect or change.

Environmental impact assessment: An activity designed to identify and predict the impacts of petroleum operations on the surrounding biogeophysical environment including man’s health and well being and to interpret and disseminate information about those impacts.

Environmental impact statement: Assembling the results of the environmental impact assessment into a document which contains a discussion of beneficial and adverse effects considered to be relevant to the petroleum operations.

Environmental quality: The state of the environment as perceived objectively in terms of measurements of its components, or subjectively in terms of its attributes such as beauty and worth.

Environmental sensitivity: The susceptibility of a particular environment or area to any disturbance.

Estuary: Tidal coastal body of water where salinity is intermediate between fresh and salt water.

Eutrophication: The natural ageing of a lake or land-locked body of water which results in organic material being produced in abundance due to a ready supply of nutrients accumulated by man over a period of time.

Fauna: The animals of a distinct region.

Flora: The plants of a distinct region.

Freshwater: Surface and subsurface water in its natural state useful for domestic livestock, irrigation, industrial, municipal and recreational purposes and which will support aquatic life and contains less than 0.5 ‰ salinity

Fungi: Simple plants either unicellular or made up of cellular filaments; they contain no chlorophyll. They are agents of decay in all natural organic materials, food, timber, plant debris, etc.

Artificial Gas lift: Associated gas re-injected into a producing oil well, to augment the natural hydrostatic pressure.

Greenhouse effect: The mechanism whereby incoming solar radiation is trapped by a glass sheet or the presence of carbon dioxide and other greenhouse gases in the atmosphere. As these gases are transparent to solar radiation, the short-wave incoming radiation is transmitted. However they are opaque to long wave re-radiation from the earth's surface or from any other object underneath, thus heat is trapped and the underlying surface is thereby warmed.

Greenhouse gases: Collective term for those gases that have influence in the greenhouse effect, that is, chlorofluorocarbons, carbon dioxide, methane, nitrous oxide, ozone and water vapour.

Groundwater: Water occurring within the saturation zone of an aquifer is the only part of all subsurface water which is properly referred to as groundwater or phreatic water. Groundwater may be of variable chemical quality ranging from wholesome potable waters to highly mineralized brines.

Habitat: The chemical, physical and biological setting in which a plant or animal lives.

Hazardous waste: Refuse which because of its inherent nature and quantity requires special disposal techniques to avoid creating health hazards, nuisances or environmental pollution. Hazardous wastes are toxins or poisons, corrosives, irritants, strong sensitizers, flammables, explosives, infectious wastes condemned foods, etc. Flammable wastes include explosive plastics, paper, paper products and the like.

Hazen unit: A unit of measurement for colour in water. It is based on the colour produced by 1 mg platinum per litre in the presence of a cobalt-based compound.

Heavy metal: Any of the following elements: antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, or zinc.

Hydrocarbons: Chemical compounds consisting wholly of hydrogen and carbon.

Hydrogen sulphide: Dense colourless gas with a smell of rotten eggs which is extremely toxic. It is produced under anaerobic decay conditions and can accumulate in sewers.

Hydrology: The science concerned with the occurrence and circulation of water in all its phases and modes and the relationship of these to man.

Inorganic matter: Matter which is mineral in origin and does not contain carbon compounds, except as carbonates, carbides, etc.

Insolation: The amount of direct solar radiation incident per unit horizontal area at a given level, measured in mW/m^2.

$LC_{50.}$: The lethal concentration of a substance in air or water necessary to kill 50% of test organisms within a specified time under standard conditions.

$LC\text{-}_{50.}$: The lethal dosage of a substance necessary to kill 50% of a sample population of test animals as determined from exposure to the substance, by any route other than inhalation within a specified time under standardized conditions.

Leachate: Any liquid, including suspended materials which it contains, which has percolated through or drained from special waste facility.

Marine water: Includes estuarine and coastal water, where estuarine means a semi-enclosed coastal body of water having free connection to the sea and having a chloride ion concentration in excess of 1000 mg/L.

Microbes: Microscopic organisms, usually bacteria of which some are pathogenic, e.g. *Salmonella*, which is associated with food poisoning in man. They are essentially scavengers of organic material breaking down dead plant and animal remains, sewage and even toxic wastes that are organic in origin.

Micron: One-millionth of a metre, hence the more correct term micrometre. It is commonly used for particle sizing. Symbol µm in SI units.

Minamata disease: Minamata is a town on the west coast of Kyushu Island (Japan) where an extreme case of heavy metal poisoning from methyl mercury ingested in the staple fish diet of the inhabitants caused severe disablement and death between 1953 and 1956. The symptoms include numbness in fingers and lips and difficulty in speech and hearing.

Noise: Sound that is socially or medically undesirable, that is, any sound that intrudes, disturbs or annoys. Very high levels of sound can cause hearing damage.

Nutrients: The raw material necessary for life which are consumed during the metabolic process of nutrition. Their type and consumption vary according to the particular plant or animal species. The main categories are proteins, carbohydrates, fats, inorganic salts, minerals and water.

Oligotrophic: An aquatic environment which has low concentrations of nutrients present and therefore has low plant and animal life productivity.

Organic matter: Material containing carbon combined with hydrogen often with other elements (oxygen, nitrogen), e.g. plastics, vegetable matter.

Pathogen: A living organism usually a micro-organism that causes disease.

Petroleum: A naturally occurring mixture of predominantly hydrocarbons in the gaseous, liquid or solid phase.

pH: A measure of the alkaline or acid strength of a substance. The pH value of any solution in water is expressed on a logarithmic scale to the base 10. It is defined and calculated as the logarithm of the reciprocal of the hydrogen-ion concentration of a solution.

Photosynthesis: The process whereby plants utilize radiant energy from the sun and carbon dioxide from the atmosphere, in the presence of chlorophyll, to manufacture organic matter.

Phytoplankton: Free floating minute plants in sea, lake and river surface waters where sufficient sunlight is available for photosynthesis.

Pig: A scraping tool forced through a pipeline or flowline to clean out accumulations of water, wax, rust, scale, and debris from the walls of the pipe.

Pollutant: A contaminant exerting significantly adverse effects on biota including ecological systems.

Pollution: Pollution is the introduction into the environment of substances or effects that are potentially harmful or interfere with man's use of his environment or interfere with species or habitats.

Recompletion: A drilling process which brings oil and gas wells into production.

Refuse: Discarded materials, substances or objects.

Remediate: To remove, eliminate, limit, correct, counteract, or mitigate the negative effects on the environment or human health of one or more contaminations.

Receiving water: Any body of surface water into which a discharge of leachate or effluent may flow. Receiving waters wholly contained within a permitee's property are not included in this definition, provided that pollutants in such waters cannot be transported outside the property.

Run-off: The volume of water derived from rain falling on a surface and which does not permeate into the soil.

Salinity: Total amount of dissolved material expressed in terms of kilograms of material per million kilograms of feed water, that is, parts per million (ppm) of total dissolved solids.

Sample: A part of a population selected with the object of estimating some characteristics of the whole population. Can be random or spot.

Sediment: The deposit of silt and accumulated organic and/or inorganic materials at the bottom of rivers, lakes, seas, etc.

Silt: Normally a wet mixture of particles between 4 and 60 μm diameter often found in the bottom of streams, rivers, etc. Intermediate between clay and mud.

Species: In botany or zoology, a group of closely-related individuals showing constant differences from allied groups.

Standard deviation: The most common measure of spread or deviation in a set of observations. It is the square root of the average of the squares of the differences (Variance) of each observation from the mean of those observations.

Tar balls: Lumps of oil, weathered to a high density, semi-solid state.

Total dissolved solids: The solids residue after evaporating a sample of water or effluent expressed in mg/litre.

Toxicity: The capability of a poisonous (toxic) compound to produce deleterious effects in organisms.

Treatment: The handling or processing of special waste in such a manner as to change the physical, chemical or biological character or composition of the special waste in order to eliminate or reduce the volume, or one or more hazardous properties of the special waste.

Waste: Any unavoidable material resulting from an up-stream operation for which there is no economic demand and which must be disposed of.

Waste oil: Automotive lubricating oil, cutting oil, fuel oil, gear oil, hydraulic oil or any other refined petroleum based oil or synthetic oil where the oils through use, storage or handling have become unsuitable for their original purpose due to the presence of impurities or loss of original properties.

Weathering: Natural influences such as temperature, wind, light, bacteria, that alter the physical and chemical properties of oil.

Wetland: Any land such as a tidal flat, marsh, swamp, bog or fen which is frequently inundated and for that reason has developed an organic soil and occurs in an area which is lower lying than its surroundings.

Ultraviolet radiation: Radiation which falls between visible light waves and X-rays. The longest UV waves have wave lengths slightly less than those of violet light, the limit of the human eye.

Variance: A statistical term - the square of the standard deviation.

Volatile organic compounds: Organic compounds, (e.g. ethylene, propylene, benzene, styrene, acetone) which evaporate readily and contribute to air pollution directly or through chemical or photochemical reactions to produce secondary air pollutants, primarily ozone and peroxyacetyl nitrate.

Water table: The upper surface of the saturation zone below which all void spaces are filled with water.

Zooplankton: The floating, drifting or weakly swimming aquatic animal life of the open water.

APPENDICES
APPENDIX 1

Aquatic Environment

Methodology and locations of sampling station

Standard and routine limnological and fishery assessment methods were employed for the acquisition of data for these components of the study. In the hydrobiology studies, the physical features of the water bodies including their depth profiles, transparency, temperature and current velocity were determined. The biological resources studied were zooplankton, phytoplankton, benthos and fish.

A total of nine stations including controls were sited along the slots and creeks within the study area were sampled during both seasons

a. Hydrobiology/Fisheries

Field sampling procedures

At each of the sampling stations, the methods listed in Table below were used for the indicated parameters. Replicate measurements were made where appropriate.

Methods employed for fisheries and hydrobiology studies

S/NO.	PARAMETER	METHOD
1	Sediment	Eckman grab
2	Flow velocity	Meter rule, buoy and timer
3	Depth	Calibrated pole
4	Transparency	Secchi disc
5	pH	pH metre
6	Dissolved Oxygen	Winkler method
7	Temperature	In situ using mercury – in glass thermometer
8	Phytoplankton	55 micron plankton net
9	Zooplankton	55 micron two net
10	Benthos	Eckman grab
11	Fish	Direct observation; structured and unstructured interviews.
12	Statistical analysis	Margalets index (d) of taxa richness; Shannon – Wienner index of general diversity (H)

Sediment samples were collected at every site where water samples were obtained. Eckman Grab was used to obtain sediment samples. These samples were transferred into sterile polyethylene medicine sachets. All sachets were appropriately labelled. The samples were preserved in ice chests and transported to the laboratory for analysis.

At each of the stations indicated above, the following hydrobiological measurements and samples were taken for analysis in the laboratory:

- Water temperature (0°C);
- pH;
- maximum depth (m);
- stream velocity (surface water velocity);
- phytoplankton samples;
- zooplankton samples; and
- benthic macro-invertebrate samples.

Surface water velocity was measured at the various sample locations using a buoy, a meter rule and a timer. The measurements were taken at near shore and midstream of the Imo River. The depths of the river were determined using a calibrated pole.

Replicate samples of the biological resources were also taken at each station as outlined below:

Phytoplankton and Zooplankton

Zooplankton samples were collected 60cm below water surface using a 55μm mesh tow net with a diameter of 18cm. The net was towed at the specified depth for at least 5 minutes and at a speed of about 8km/hour at each surface water sample station. Aliquot of water sample from water sampler fixed in iodine-lugol solution was used for phytoplankton. The concentrates of zooplankton were emptied into polyethylene bottles and preserved in buffered 4% formalin solution.

Benthos (Bottom Sediment)

Benthos (bottom sediment) samples for laboratory analyses were collected from river water and swamp/flood plain locations. The sediment was collected using an Eckman Grab ($0.0225m^2$) and sieved using a 0.5mm mesh. The grab was lowered from a canoe at both the near –shore and mid-stream sections at each station. The material scooped up from the bottom was first washed into a 0.5mm sieve and the residue along with all the recovered organisms transferred into a wide mouthed sample jar and preserved in 5% formalin into which was added Rose Bengal and transported to the laboratory. The samples were preserved in 5% formalin solution and stored in plastic containers.

Fisheries

Fish samples were surveyed at three fish landing sites of the three major communities Ugboegungun, Ugborodo and Deghele. Information on fisheries was obtained through direct analysis of the catch from fishermen operating in the Escravos River and from unstructured interviews conducted with selected fishermen, elders and chiefs in each of the communities. During the interview sessions, information on the following were obtained and recorded:

(i) Types of fishing gear used;
(ii) The number of fishermen in each community;
(iii) The average catch per fishermen per day; and
(iv) The types and number of fish caught were obtained, weighed and recorded.

The data obtained was analyzed and used to produce information on the structure of the fisheries, catch statistics and checklist of commonly occurring fish species.

Water Chemistry/Microbiology

A stainless steel grab was used to collect surface water samples at the designated locations and at both top (a few cm below surface) and bottom (1-3m below surface) of the river. The actual bottom location depends on the depth of the river. The following parameters were measured in the field:

The pH was measured using a portable pH meter (Corning M-90 Checkmate Deluxe field system).Other parameters include, Total Dissolved Solids (TDS), Dissolved Oxygen (DO)and Temperature. Corning M-90 Checkmate Deluxe field system has probes for each of these measurements. Amber bottles of 250ml capacity were used to collect water samples for heavy and trace metals. These samples were acidified to pH of 2 in the field using concentrated nitric acid. All the other samples for physicochemical measurements were transported to the laboratory in ice coolers. Surface water samples were collected at the designated sampling points as in water chemistry. Water samples were taken and compounded into one sample. Sterile 20ml plastic containers with plastic screw caps were used to transport the samples.

Soil Chemistry/Microbiology

Soil and a control samples were collected from 10 sites.

Surface (0 – 15cm) and sub-surface (15 – 30cm) soil samples were collected at these locations using the Dutch Hand Auger. Soil samples for microbial analyses were collected in sterilized 100ml McCartney bottles and stored in an ice chest. The samples for hydrocarbon analyses were collected in glass jars and those for physicochemical analyses in polyethylene bags.

Vegetation and Wildlife

The materials used for the field work include polythene bags, large jute bags, laundry pen, labeling tapes, specimen bottles, 70% ethanol, formal acetic acid (FAA), hand lens, improvised hook and measuring/calibrated tapes. Sampling for diversity and abundance was carried out in blocks of 5 and $50m^2$ each, which were selected at random from the manifold location and oil well location to nearby settlements. Direct species counts were taken within the sampling blocks, which also served as quadrants. Leaf and stem materials were taken in specimen bottles containing 70% ethanol, fixative stain solution and formal acetic acid (FAA) for laboratory histochemical analyses.

Plants were examined in vivo for signs and evidence of environmentally induced stress as well as disease conditions. General health condition of the vegetation was visually evaluated. Plant materials that could not be identified in the forest (on-site) were taken for identification with taxonomic keys and flora in the laboratory.

The wildlife assessment of this study involved a survey of amphibians, reptiles, birds and mammals within the Study Area. Experienced hunters in the area were located through personal contacts and in the first instance, were asked to give account of the variety of local animals using vernacular names.). The names given by the hunters are most often generic, covering several similar species or even whole families. As a result, confirmation of the species present was made by presenting to the hunters colour photographs of the skins of some of the animals and photographs of snakes. Additional confirmation was made through sighting and vocalization when the Assessment Team went to the bushes within the study area.

Information on the wildlife of the Niger Delta is limited. For the amphibians, reptiles and birds, additional information was obtained from biodiversity studies conducted in the Niger Delta by SPDC. Additional information on mammals were also obtained from similar studies.

Air Quality

To effectively assess an air quality in an area, information on the ambient air levels and their spatial and temporal variability is required. Before doing this however, air must be sampled.

The objective of air sampling and analysis is to adequately characterize air pollution for the region of interest at minimum expenditure of time and money. Moreover, the characterization is usually based on the intended use of the data and this use includes the following:

(a) checking adherence to air quality standards;

(b) observing pollution trends and relating any changes to emission variations;

(c) developing and evaluating abatement strategies;

(d) assessing health effects or plant damage which may have arisen from exposure to air pollutants (this will normally include geographic and temporal distributions);

(e) developing and applying a warning system for prevention of undesired air pollution episodes; and

(f) developing and testing pollutant diffusion models.

Sampling Scheme

Measurements were made with a group of instruments, which were moved from one fixed measuring point to another in a predetermined manner. These measurements are then related to meteorological data made at the same time or obtained from a synoptic meteorological station.

a. Sampling Locations

A total of eight (8) sampling stations including control were used for this exercise. These sampling stations are presented in Table 4.2

Sample Collection

At each sampling station, eight (8) discrete, one hourly samples were collected to enable us analyse for particulate matter suspended in the air, nitrogen oxides as nitrogen oxide, sulphur dioxide, hydrogen sulphide and ammonia. Carbon monoxide levels were directly obtained using a NEOTOX CO monitor.

The World Health Organisation (WHO) has selected methods of analysing air pollutants. These methods are based on those adopted by the United States Environmental Protection Agency (EPA), EEC, etc. (WHO, 1986). The Federal Ministry of Environment has adopted these methods for the purpose of surveillance and monitoring air pollutants pending the development of her standard methods. These methods, as listed below, were used in this study.

Sampling Methods for Air Quality Parameters

S/No.	Parameters	Methods Used
1	Sulphur dioxide	Pararosaniline method (West-Gaeke)
2	Nitrogen dioxide	Saltzman method
3	Carbon monoxide	CO monitor
4	Suspended particulate matter	Gravimetric – high volume sampler
5	Hydrogen Sulphide (H_2S)	Impinger train with alkaline suspension of cadmium hydroxide
6	Heavy metals	Atomic Absorption Spectrophotometer (after digestion of sample filters)
7	Ammonia (NH_3)	Phenate method

The group of equipment for air quality sampling was moved from sampling station to sampling station after each round of sampling was concluded at a particular sampling location. For practical reasons, measurements were not made at night. Some weather conditions were, therefore, not covered.

Supporting Measurements

The following supporting measurements were made:

(i) Wind direction and Speed
(ii) Air temperature
(iii) Relative humidity

Noise levels were measured using a hand-held battery operated noise level meter (EXTECH INSTRUMENTS – Digital Sound Level Meter Model No. 407750) around the facility and within the community.

Waste Management

The various sources of SPDC-generated wastes and the local waste disposal techniques in the project area were identified. This included identification of local waste management techniques and/or the ultimate destination of wastes.

Geology / Hydrogeology

Four boreholes were sited and drilled in the area. They were drilled by the percussion method using a manually operated light weight rig mounted on a tripod. During drilling, soil samples were regularly taken at one metre interval, visually described and a field litholog was prepared. The samples were then stored in polythene bags, sealed and transported to the laboratory for further studies. At each borehole site, the following field data were collected:

- Ground elevation above mean sea level
- Depth of borehole
- Static water level
- Hydraulic head

Methods used in collecting environmental samples for this study.

Environmental components	Methods*
Meteorology	Literature survey, field studies with rain gauge, Thermograph, Wind vane, EXTECH INSTRUMENTS-Hygro-Thermometer+Infra Red Thermometer, Model No. RH 101
Air Quality Noise	Impinger trains for gases, USEPA High-Volume sampler EXTECH INSTRUMENTS – Digital Sound Level Meter Model No. 407750
Vegetation	Transects, Quadrats, key informant interviews, Focus Group Discussion (FGD), Questionnaires and Direct observations
Land use/cover	Observations, interviews and sample collections. Environmental baseline survey (EBS) by remote sensing (satellite imagery interpretation), Direct physical observations
Fauna (Wildlife) Terrestrial invertebrates, Amphibians, Reptiles, Birds, Mammals	Direct observations, key informant interviews, Focus Group Discussions (FGD)
Geology and Hydrogeology	Boreholes drilling (percussion), sampling and measurements
Surface water/ Hydrodynamics	Observations, water sampler, current meter, pH meter, DO meter, sediment grab, TDS meter, Turbid meter and conductivity meter
Soil Quality	Soil samples with an auger and description of each sample with Munsell colours chart.
Microbiology	Collection of water samples with Hydro bios water sampler into sterile McCartney bottles; Soil samples with soil auger into aluminium foil Sediments samples with van Veen grab sampler into aluminium foil.
Aquatic biology Sediment / Benthos Phytoplankton Zooplankton Fish species and Fisheries	 Collection with Eckman grab Collection with 55 micron plankton net Collection with 55 micron two plankton net Direct observations, structured and unstructured interviews and laboratory analyses
Waste Management	Physical examination, inventorisation and walk-through survey
Statistical analysis for hydrobiology	Margalets index (d) of taxa richness; Shannon – Wiener index of general diversity (H)

Laboratory Procedure/Data Analysis

Quality Assurance/Quality Control for Laboratory analysis and generation of data

Possible sources of error in laboratory analysis include contamination of reagents and materials, lack of sensitivity of equipment, lack of calibrations, poor data entry and interpretation.
Glassware and other containers to be used for each analysis were thoroughly cleansed as appropriate for each parameter. All glassware used for oil and grease determination was pre-rinsed with Analar grade xylene. Glassware for determination of metals were pre-soaked in dilute nitric acid and then rinsed well with distilled water.

All reagents and chemicals of high purity (mostly Analar grade) were used. Freshly distilled water prepared in our laboratory was used for all dilutions. The various instruments and equipment for measuring physico-chemical parameters were used while in good working condition. Periodic control checks were usually carried out on such instruments/equipment and performance records maintained. The United States National Bureau of Standards (NBS) certified mass standards were used to check the laboratory balances. The pH meters were calibrated using HACH commercial buffer standards. Using appropriate colour standards of diluted potassium dichromate or potassium permanganate solutions frequently checked the wavelength settings and sensitivities of the absorption spectrophotometer. For analytical determination requiring the use of calibration curves, such curves were plotted using standard solutions prepared from analytical grade reagents. Records of such calibration curves were maintained and frequent re-calibration checks were carried out. Analytical blanks were incorporated per specific batches of samples to compensate for the sample preparation and determination steps. All the analyses were replicated and the means reported.

Chain of samples custody procedure

There is a Master register for all samples brought into the laboratory. Following registration of the sample, a SAMPLE DATA SHEET containing pertinent information on the sample was opened for each sample. The information includes:

- sample reference number,
- nature or type of sample,
- site of collection,
- date and time of collection,
- mode of preservation (depends on nature of material) and analytical data from the field and results of laboratory analyses of representative samples.

Appropriate methods were used in storing the remaining stock materials and sub samples. Samples for storage were kept in labelled compartments on shelves in a storage room. Samples sent to cooperating laboratories were recorded in the Master Register, accompanied by essential data pertaining to the sample material and appropriate custody transfer forms were filled.

Evaluation of results

Raw data obtained from the instrumental measurement were used in calculating the concentrations of the various parameters, using standardized formulae. All such calculations were crosschecked. Outlying values were deleted from the replicate data before calculation of mean concentrations. A quick identification of results, which deviate from the normal trend, was usually done. Some of the relationships used to evaluate the results include cation-anion balance. The sum of the anion concentration in meq/1 should be equal to the sum of the cations concentration also in meq/1. Differences within 5% are acceptable.

$$\% \text{ Difference} = \frac{(\text{cations}) \text{ minus } (\text{anions})}{(\text{cations}) \text{ plus } (\text{anions})}$$

The above check on ionic balance was carried out. Also, calculated and observed conductivity measurements and IDS data are compared, to check reliability and accuracy of data.

Laboratory/Data Analysis

Vegetation

Specimens or samples (mostly complete with folia and floral components) which represent the different species observed to occur at the ecological zones were collected using polythene bags. The collected plant specimens/samples were taken to the herbarium for further processing.

The plant samples were flattened-out on flimsies and absorbents and packaged with ventilators in the plant press for drying in the oven. The dried plants were separated and properly identified with appropriate labels for easy reference. These samples were then preserved in the herbarium.

Plant Pathology

A general survey of the state of health of the vegetation within the study area and outside was carried out by visual inspection. Assessment was carried out by looking at the health conditions of the plants (whether diseased or normal) along the grid lines and between grids. Ransom assessment was also carried out at several locations within the community bushes. The number of diseased plants along and between the grid lines and the random sites were recorded. The disease incidence for each location was calculated using the formula.

$$\text{Disease Incidence} = \frac{\text{Number of disease plant}}{\text{Total number of plants inspected}} \times 100$$

i. Fungal Pathogens

Plant diseases caused by biotic and abiotic factors were examined in the study. The standard blotter method was used for the detection of fungal pathogens. Cut pieces of diseased plant parts (leaves, stems, floral parts, etc) of each plant type collected were surface-sterilized with 70% ethyl alcohol, rinsed with sterile distilled water and plated on three layers of water soaked filter paper (diameter 9cm) in autoclaved glass Petri dishes. Plates were kept in an incubator at 25±2°C in complete darkness for 7 days for the fungi to sporulate. At the 8th day, each of the plant sections in the Petri dishes were examined under a stereobinocular microscope (6-50x) for fungal growth and identification. Identifications were confirmed by examining slide preparations of the fruiting structures under a compound microscope. Three Petri dishes were used for each plant and a minimum of ten plant sections were placed per plate.

ii Bacterial Pathogens

For detection of bacteria from diseased plants, samples were examined for symptoms (water-soaked zones) and with a scalpel, small pieces of the plants were cut in such a way that the pieces had both healthy and diseased parts. The plant pieces were covered with a cover slide after a drop of water was added. The preparation was examined under a compound microscope for presence of bacterial ooze. Where bacterial ooze was observed, another similar plant piece was placed in a drop of water in a Petri dish and kept for 10 – 15 minutes to allow bacteria to ooze out in the drop of water. Bacteria were then isolated, characterised and identified.

Plant Tissue Analysis

Fresh leaf samples were oven-dried, blended into small particles with mortar and pestle and one gram weighed out into conical flasks. The samples were digested by adding concentrated nitric acid, perchloric acid and sulphuric acid in the ratio 10:4:1 by volume. The flask and mixture were shaken, followed immediately by heating at 100°C on a water bath for 2 hours. The flask and its content were allowed to cool, filtered and distilled water added to make up the solution to the 100ml mark. The concentrations of the heavy metals (V and Ni) were then determined using an atomic absorption spectrophotometer (AAS).

Hydrogeology

Groundwater Flow Determination:

Groundwater flows in the direction of decreasing head. Boreholes were drilled in a triangular manner and the depth to water table in each borehole was measured using an electric water level indicator. The elevation of each borehole location above mean sea level was also measured by the surveyor. This elevation was confirmed from the topographical map of the area.

Air Quality

Analytical methods are unique to each pollutant and are therefore discussed separately below:

Sulphur dioxide (SO_2)

Sulphur dioxide is determined by many procedures of widely differing sensitivity and specificity. In this study, gas bubbler devices were used based on the pararosaniline method. In this method, SO_2 is absorbed from air in a solution of potassium tetrachloromercurate. A dichlorosulfitomercurate complex that resists oxidation by oxygen in the air is formed. The complex is made to react with pararosaniline and formaldehyde to form the intensely coloured pararosaniline methyl sulphonic acid. The intensity of the colour produced is measured by means of a spectrophotometer and is related directly to the amount of SO_2 present in the corresponding air sample by means of a calibration curve.

The pararosaniline method is based on the Schiff Reaction which was first used as a test for formaldehyde and later modified for used as test for SO_2 for use in sampling and analyzing ambient air. Many modifications have been proposed. The method presented here, however, is an adaptation of the procedure used by the USEPA. A major advantage of this method is the relative stability of samples after collection. Also, the method has been refined to the point where the effects of known interferences have been minimized or eliminate. Therefore, it is specific for SO_2. Concentrations of SO_2 in the range of $25\mu g/m_3$ to $1000\mu g/m_3$ can be measured.

Nitrogen dioxide (NO_2)

A manual method (Saltzman method) was used. This method is based on the specific reaction of nitrite ion with diazotizing-coupling reagents to form a deeply coloured azo dye which is measured spectrophotometrically at 550nm.

The NO_2 in the ambient air is drawn by bubbler devices and converted to nitrite ion through contact with an absorbing solution containing the diazotizing-coupling reagents (absorbing solution). This method has been used extensively in the United States and Europe and has been tested by many workers (WHO, 1976). The method is standardized by using sodium nitrite standards. Standardization is based on the empirical observation that 0.74 mole of $NaNO_2$ produces the same colour as 1 mole of NO_2 (WHO, 1976). Using $NaNO_2$ for standardization is much more convenient than preparing accurately known gas samples. The concentration of NO_2 in the sample is read from a calibration curve and related to the volume of air sampled in cubic meters (m^3).

The Saltzman method is intended for the manual determination of NO_2 in the atmosphere in the concentration range of a few, to about $9{,}400\mu g/m^3$ (5.0ppm) at flow rates of up to 0.6 liter/minute of sampled air. The Saltzman method is sensitive enough to detect low concentrations of NO_2 of the order of a few $\mu g/m^3$. The detailed procedure is given in “Selected methods of Measuring Air Pollutants.

Carbon monoxide (CO)

Carbon monoxide measurement was done by an automatic monitor (NEOTOX CO MONITOR). The principle of operation is believed to be based on Non Dispersive Infra Red (NDIR) methods.

Ammonia (NH_3)

A manual (Phenate) method employing bubbler devices was used. The principle of the method is the formation of an intensely blue compound, indophenol, formed by the reaction of ammonia, hypoclorite and phenol, catalyzed by a manganous salt. The intensity of the colour is read at 130nm in a spectrophotometer and the amount of ammonia is read from the calibration curve and related to the amount of air sampled in cubic meter (m^3).

Suspended Particulate matter (SPM)

The method of determination of SPM is essentially a modification of the Environmental Protection Agency's (USEPA) Gravimetric method. In this procedure, a known volume of air is drawn through a glass fibre filter of known weight, fixed-area gabbed roof by means of a heavy-duty turbine blower at a constant flow rate ranging between 1.1 – 1.7m3/min. Reweighing of the filter after sampling under controlled conditions gives a direct measurement of particulate mass. Suspended particulates having diameters (Strokes equivalent diameter) between 0.1 and 100μm are removed from air stream by filtration on the glass fiber filter. The mass concentration ($\mu g/m^3$) of SPM in the air is determined by relating to the sampled air flow rate. For hydrogen sulphide in the air, the measured volume of air aspirated through an alkaline suspension of cadmium hydroxide gives cadmium sulphide as precipitate. This precipitated cadmium sulphide is collected and measured by the addition of a solution of N, N- dimethyl-p-phenylenediamine in H_2SO_4 and $FeCl_2$. Determination of hydrogen sulphide is by optical density of methylene blue with spectrophotometer. For hydrocarbons, the measured volume of air was analyzed for total hydrocarbons using the methods described below for total hydrocarbons in water and soil.
Using the dry-bulb and wet-bulb temperatures obtained during the fieldwork in conjunction with humidity charts, the properties of the moist air within the study area were determined.

Soil Studies

Physico-chemical Parameters:

pH:

Soil pH [in water (1:2; soil to water ratio)] was determined using air-dry soil samples (passed through a 2mm sieve). Twenty grams of the sample was placed in a 50ml beaker. Forty millilitres of distilled water was added and allowed to stand for 30 minutes. The soil suspension was stirred occasionally with a glass rod. The pH values were determined using a Philip's digital pH meter. The soil suspension was not stirred during the measurement. The results are reported as soil pH measured in water.

Conductivity:

The soil suspensions for pH determination were used for conductivity measurements. The suspensions were filtered and the conductivity values measured with a Philip's digital conductivity meter at room temperature (29.5°C).

Mechanical Analysis:

Sedimentation techniques were used to classify soil texture. 5% of sodium hexametaphosphate was prepared in distilled water and sodium carbonate added to bring final pH to 9.The solution was diluted to 1 liter. This is used as a dispersing agent.Fifty one grams of air dried 2mm sieved sample was weighed into a polythene container and stirred for 15 minutes on a high speed stirrer. The suspension was transferred to a 1 liter cylinder (tall form) and diluted to mark. It was stirred for 1 minute with a glass rod and immediately timing commenced for readings with bouyoucos hydrometer. Two readings were taken at 4 min. 48 secs and 5 hours. The amounts of silt and clay were determined from these readings.

Organic Carbon:

Walkley – Black method was used to estimate the amount of organic carbon in each soil sample. 10ml of 1N potassium dichromate was added to a flask containing 1 gram of soil and then swirled gently to disperse the soil. 20ml of conc. Sulphuric acid was added rapidly using automatic pipette, the flask swirled more vigorously for one minute and allowed to stand for 30 minutes on a white tile. At the end of this period, 100ml of distilled water was added. 3-4 drops of indicator (0.025M ferroin) were added and titrated with 0.5N ferrous sulphate. Percent organic carbon was calculated using the titre values. These values were used to estimate percent organic matter.

Total Nitrogen:

The regular macro-kjeldahl method was used to evaluate total nitrogen in soil. 10 gram of soil was weighed into a 500ml Macro-kjeldahl flask, 20ml of distilled water added and the flask swirled for a few minutes and allowed to stand for 30 minutes. 1 gram of prepared mercury catalyst was added and 30ml of conc. Sulphuric acid was rapidly added through an automatic pipette. The flask was heated gently until frothing ceased. Thereafter, the mixture was heated strongly to boil for 5 hours. At the end of this 100ml of distilled water was added to the flask after cooling. The digest was later transferred into another flask. The sand residue was washed with 50ml of boric acid indicator was added into an Erlenmeyer flask, which was placed under the condenser of the distillation apparatus. The new kjeldahl flask containing the digest was attached to the distillation unit. Distillation commenced after 150ml of 10N sodium hydroxide was poured through the distillation flask.

Distillation was stopped after collecting 150ml of the distillate. The amount of total n was determined by titrating the distillate with 0.01N standard sulphuric acid. The colour change at the end point was from green to pink.

Nitrate:

Extracting solution was first prepared by dissolving 100 gram of sodium acetate in about 500ml of distilled water and 30ml of 99.58 acetic acid added. This was diluted to 1 liter with distilled water.Five grams of soil was weighed into a shaking bottle, ¼ teaspoon of activated carbon added plus 20ml of the extracting solution. The bottle was agitated for 1 minute and the contents later filtered. One millilitre of the soil extract was transferred to a test-tube, 0.5ml of brucine reagent and 2ml of sulphuric acid were added. These were mixed for about 30 seconds and allowed to stand for 5 minutes. 2ml of distilled water was later added and mixing continued for about 30 seconds. The test-tube was left to air-cool for 15 minutes. The transmittance was measured, at 470nm, with spectronic 20. The amount of nitrate ions in the soil was evaluated from the laboratory graph prepared using standard nitrate solutions.

Phosphate:

The extracting solution for phosphate determination was prepared by adding 15ml of 1.ON ammonium fluoride and 25ml of 0.5N hydrochloric acid to 460ml distilled of distilled water. 1 gram of air-dried soil (passed through a 2mm sieve) was weighed into a centrifuge tube and 7ml of the extracting solution added. This was shaken for 1 minute and centrifuged. 2ml of the clear supernatant was transferred into a 20ml test tube. 5ml of distilled water and 2ml of ammonium solution were added. The contents were mixed once more. 1ml of stannous chloride dilute solution was added and mixed again. Within 20 minutes after this last mixing exercise, the % transmittance was measured on a spectronic 20 at 660nm wavelength. The amount of phosphate in the soil was determined from the standard curve prepared with phosphate standard solutions.

Sulphate:

The extracting solution was potassium dihydrogen phosphate solution containing 500 ppm phosphorus [Ensminger (1954); Fox et al, 1964]. 5 gram of soil was weighed into an Erlenmeyer flask and 25ml of the extracting solution added. This was agitated on a mechanical shaker. The suspension was filtered with a Whatman No. 42 filter paper.

10ml of the sample aliquot was pipetted into a 25ml volumetric flask. Distilled water was added to bring the volume to about 20ml. 1ml of gelatin-barium chloride reagent was added and the volume made up with distilled water. The content was mixed thoroughly and allowed to stand for 30 minutes. The % transmittance was determined at 420nm wavelength, in spectronic 20 (Tabataba, 1974).

The amount of sulphate in the soil was evaluated using the standard curve prepared with standard sulphate solutions.

Chloride:

The chloride content of the soil was determined by titrimetric method. 100 gram of soil was weighed into a 750ml reagent bottle and 500ml of water added. This was shaken by hand for 30 minutes. The suspension was filtered and 50ml distilled into a titration flask. This was titrated with 0.1N silver nitrate solution, using potassium chromate as indicator (Basset et al., 1978). Three concordant readings were taken and amount of chloride ions calculated in ppm.

THC:

The extractable total hydrocarbon content was determined by electrophotometric method. 10 gram of soil was weighed into an extracting flask and 10ml of normal hexane added. The suspension was shaken for 30 minutes and filtered. The % transmittance was determined at 420nm in spectronic 20. The calibration curve was prepared with Bonny light crude oil. The amount of THC in the soil was determined using this standard graph.

Exchangeable Cations:

30ml of 1N ammonium acetate solution was added to 5 gram of soil and shaken for 2 hours. The suspension was centrifuged and the clear supernatant decanted into a 100ml volumetric flask. 30ml of 1N ammonium acetate solution was again added to the residue above and shaken for 30 minutes. The clear supernatant was decanted into the same 100ml volumetric flask. This last step was repeated and the clear supernatant transferred into the same volumetric flask. Ammonium acetate was used to make up to the 100ml mark. Potassium and sodium ions were determined on a flame photometer. Magnesium, calcium and manganese were determined on an atomic absorption spectrophotometer. The results are expressed in meq/100g.

Heavy metals:

The soil samples were first digested using mixed acids 1ml perchloric acid, 4ml conc. Sulphuric acid, 3ml conc. Nitric acid and 1ml hydrochloric acid were added and swirled to disperse the sand. 5cm3 of deionized water was added and the crucible heated gently in a fume cupboard and later strongly to partial dryness. After cooling the crucible, deionized water was added and the suspension stirred with a glass rod. This was filtered into a 100ml volumetric flask and diluted to volume with deionized water. The heavy metal levels were determined using atomic absorption spectrophotometer

Porosity Determination

(a) Soil sample of known volume, V, was collected from the field.

(b) The soil was taken to the laboratory and its weight, Mw, determined. It was then preserved in its field condition where analysis was not done that day.

(c) The soil sample was then dried in an oven at a temperature of 105°C for 24 hours. The weight Ms, was determined.

(d) The specific gravity, Gs, of the soil particle was then determined, using the density bottle method. This was found to be approximately constant, so a constant value of 2.652 was used for all the samples.

(e) The volume of solids, Vs, was obtained from the expression,

$$M_s/V_s = G_sP_w$$

Where P_w = density of water.

Thus $V_s = M_s/G_sP_w$

(f) Having known V_s and V, the Volume of voids, Vv, was calculated from the expression $Vv = V - V_s$.

(g) Porosity, n, was then calculated from the formula

$$N = \frac{V_V}{V}$$

Permeability Determination

The permeability of a material is a measure of the ease with which it transmits fluid. This was determined for soils in the area to assess the ease with which fluids will flow through them.

Each soil material was dried to constant weight at 110°C. A set of five sieves with appropriate sizes was chosen and arranged in order of increasing fineness towards the bottom. The lowest one was the pan to hold the finest material. A lid was placed on the top sieve. The set was placed on a mechanical sieve shaker and sieving operations carried out for 10 minutes.

At the end of the sieving operations, the individual size fractions retained on each of the sieves were collected and the weight of each fraction separately determined. The percentage weight of the material retained on each sieve was calculated on the bases of the total weight of the material chosen for the test. The cumulative percentage by weight of the total sample passing through each of the sieves was then calculated. The size versus weight percent passing was then plotted on a semi-log graph paper. From the curve plotted for each sample the effective grain size (d10) was obtained.

Permeability was then estimated using Hazen's formula given below:

$$K = C\,(d_{10})^2$$

Where K = permeability (cm/s)

d_{10} = effective grain size (diameter such that 10% by weight of the porous matrix consists of grains smaller than it)

C = constant (100 if d_{10} is in cm and 1 if d_{10} is in mm).

Bulk Density Determination

Bulk density is the weight per unit volume of oven dry soil (i.e. unit weight of the soil).

A cylindrical measure was driven into the soil, and an undisturbed soil sample was obtained. The sample was taken to the laboratory for oven drying and weighing.

The bulk density was calculated from the expression

$$\text{Bulk density} = \frac{\text{Weight of oven dry soil (gm)}}{\text{Volume of oven dry soil (cm}^3\text{)}}$$

Soil Microbiology

The composite soil samples obtained at each location and compounded in sterile polythene bags were introduced into sterile bottles and adequately labelled. The samples were transported to the laboratory and stored in the refrigerator until ready for microbiological analysis.

Total viable counts of culturable, aerobic heterotrophic bacteria were obtained by preparing serial dilutions of water and soil samples in sterile physiological saline (0.85%w/w NaC1 in deionized water) and surface-plating unto sterile nutrient agar medium (Oxoid) in triplicate. Being environmental samples, culture plates were incubated at room temperature (29°C) for 48 hours before colony enumeration was performed. In order to determine the extent of microbial adaptation to hydrocarbon utilization in this field, hydrocarbon utilising bacteria and fungi were assayed for. The bacteria were enumerated after spread-inoculation of serial dilutions of samples onto mineral salts agar medium as described by. The composition of the medium was NaC1, 10.0g; $MgSO_4$. $7H_2O$, 0.42g; KCL, 0.29g; KH_2PO_4, 1.25g; $NaNO_3$, 0.42g; agar, 20g; deionized water, IL; the final pH was 7.2.

After autoclaving of the mixture of ingredients listed vide supra at 103.4KNm^{-2} for 15 min, filter-sterilized fungizone (an anti-fungal anti-biotic) was added at a concentration of 20μg/mL to inhibit fungal growth before the sterile medium was poured into Petri plates to cool and solidify. Upon solidification of the medium, a sterile 9cm filter paper (Whatman No. 1) saturated with Bonny light crude oil was placed in the inside cover of the plate of the inverted Petri dish. This technique ensured that hydrocarbons were supplied as sole carbon and energy sources for the micro organisms inoculated on the agar surface through vapour-phase transfer (Thysse and Van der Linden, 1961) and eliminated the possibility of growth of organisms on non- hydrocarbon sources present in the crude oil; (Odokuma and Okpokwasili, 1993). Bonny light crude oil was used because it is representative oil mixture commonly encountered under spillage conditions in the Niger Delta. The plates were incubated in the inverted position at room temperature for 7 days before hydrocarbon-utilizing micro organisms appearing on the plates were counted. Results reported are those of duplicate counts. In the analysis for yeasts and moulds (filamentous fungi), the methods described by Odokuma and Okpokwasili (1993) were adopted in this study.

Water Chemistry

In-situ Measurements

The following parameters were measured in the field:

(i) pH – This was measured using a portable pH-meter Corning m-90 checkmate deluxe field system)

(ii) Conductivity

(iii) Total Dissolved Solids (TDS)

(iv) Dissolved Oxygen (DO)

These parameters and those to be described below were determined as well for the borehole water samples in the laboratory.

Total alkalinity

Total alkalinity was measured by titrating 50ml of sample against 0.02N sulphuric acid solution using methyl orange indicator.

Chloride

The silver nitrate method (argentometri) was utilized to determine the chloride level in water. Water sample (50ml) was titrated against 0.1M silver nitrate solution using 0.5ml of potassium dichromate solution as indicator.

Sulphate

Sulphate was determined by the turbidimetric method. 50ml of water sample containing sulphate was reacted with 3mg of barium chloride in the presence of a conditioning agent of sodium chloride/hydrochloric acid and glycerol/ethyl alcohol. The absorbance of the resulting colloidal barium sulphate was measured in a colorimeter at a wavelength of 420nm.

Nitrate

Nitrate measurement was by brucine method. It involves the reaction of nitrate with brucine at elevated temp (60°C) to produce a yellow precipitate. The absorbance was read off at 420nm wavelength on a spectrophotomer.

Total hydrocarbon (THC)

Fifty mililitres of water sample and 50ml of Toluene were vigorously shaken for ten minutes in a 250ml Winchester bottle. The hydrocarbon extracted in the Toluene phase was determined by measuring the absorbance at 420nm wavelength in a spectrophotometer. The concentration of the hydrocarbon was calculated from a standard calibration curve.

The analytical protocols are given in the table below.

Table A.5: Analytical protocols

S/NO	PARAMETERS	METHODS/ TECHINIQUE	PROCEDURES
1.	pH	Digital pH meter	Glass electrode pH meter
2.	Conductivity	From the pH (soil in water) suspension using probe	
3.	Total alkalinity	Titrimetric method	Known volume of filtered water samples was titrated with 0.1N sulphuric acid using phenolphthalein and methyl-orange indicators.
4.	Dissolved Oxygen (DO)	Unmodified Winkler method	Titrating “fixed” samples with 0.025N sodium thiosulphate solution
5.	Biochemical Oxygen Demand (BOD)	Winkler method	Duplicate water samples were incubated in the dark at 25ºC for 5 days before the oxygen level is determined. This oxygen value obtained was subtracted from the value obtained from the samples fixed in the field.
6.	Chemical Oxygen Demand (COD)	Dichromate reflux method	Refluxing a water sample in the presence of potassium dichromate and sulphuric acid. The quantity of potassium dichromate consumed is proportional to the COD.
7.	Total Hardness	Titrimetric	The determination of calcium and magnesium ions in water samples using EDTA as a reagent.
8.	Total Suspended Solid (TSS)	Gravimetric method	Filtration and weighing
9.	Total Dissolved Solid (TDS)	Gravimetric method	Evaporating a known volume of the sample to dryness and the residue obtained yields the weight of the dissolved solids.
10.	NH_4^+-N	Colorimetric method	Nesslerization procedure
11.	NO_3 –N	Colorimetric method	Phenol – disulphonic acid used as colouring agent. Chloride ions interfere with this analysis and must be removed with glacial acetic acid and silver sulphate
12.	NO_2^- -N (nitrite-nitrogen)	Colorimetric method	Sulphanilic acid was used to develop the colour to be examined.
13.	Total Phosphorus (PO_4^{3-} -P)	Colorimetric method	Ascorbic acid procedure
14.	Chloride (Cl^-)	Argentometric method	0.1N silver nitrate is used to quantify chloride ions in the samples.
15.	Sulphate (SO_4^{2-})	Turbidimetric method	Gelatin-barium chloride reagent is used to precipitate and quantify sulphate spectrophotometrically at 420nm.
16.	Total hydrocarbon Content (THC)	Colorimetric method	n-Hexane will be used to extract total hydrocarbons in the samples and the values determined spectrophotometrically at 420nm
17.	Cations (Ca, Mg, Na, K)	Na and K will be quantified with flame photometric technique, Ca mg with Atomic Absorption Spectrophotometric (AAS) method.	If the samples are cloudy, they will be filtered before being introduced into the instruments.
18.	Heavy metals (Mn,	AAS method	If the samples are cloudy, filtered samples

S/NO	PARAMETERS	METHODS/ TECHINIQUE	PROCEDURES
	Pb, Cd, V, Ni, Hg, As and Cr)		will be used
19.	Turbidity	Turbidometric analysis	A turbidometer will be used
20.	Taste and Colour	Visual method for colour and physically tasting the samples for taste.	-

Heavy metals

The heavy metals in both the water and soil samples were analyzed using atomic absorption spectrophotometer.

Aquatic Microbiology

Enumeration of Total heterotrophic and hydrocarbon-utilizing micro organisms followed the procedures described for soil above.

For the bacteriological quality of the water samples, three water inocula regimes, using 10ml, 1ml and 0. 1ml from each water sample, were made in lactose broth in five replicate test tubes for each representative inoculum.

The test tubes inoculated with 10ml water sample had double-strength lactose broth while those inoculated with 1ml and 0. 1ml water sample had single strength lactose broth. Each tube of lactose broth contained an inverted Durham vial to trap any gas formed. The test-these were incubated at 35°C for 48h (+2h). Those tubes showing acid and gas for each replicate were enumerated and their MPN index read off the MPN table as presumptive total coliforms per 100ml. The tubes showing acid and gas were sub-cultured in fresh lactose broth tubes and incubated at 44.5°C (+0.2°C) for an additional period of 24h. Tubes showing acid and gas at the end of this incubation period were enumerated and their MPN index read off the MPN tables as presumptive faecal coliforms per 100ml. Both confirmed and completed tests were also conducted as appropriate using brilliant green lactose-bile broth (BGLB), eosin methylene blue (EMB) agar, lactose broth and nutrient agar.

APPENDIX 2

Health Aspects

This study was conducted using cross-sectional, descriptive design, consisting of epidemiological and environmental health survey. The tools and techniques of data collection were structured questionnaire, checklists, interviews and focus group discussions. Sample analyses were also carried out on domestic water sources, ambient air and urine. The data generated were analysed.Individual stages of the study are further discussed below:

Document review

This first step of the study includes the review of all relevant documents and literature that will contribute to the HIA study. Some of the documents reviewed include:

- Environmental Impact Assessment (EIA) Process Manual – a manual for EIA execution in SPDC – 2000.
- Environmental Impact Assessment Sectoral guidelines for oil and gas industry projects – Federal Ministry of Environment (FMEnv).
- Project objectives and technical details
- Previous HIA studies
- Health aspects of Environmental Assessment – World Bank – 1997 and
- National population commission: National census; Federal Republic of Nigeria.
- EIA Scoping workshop report for Saghara AGS Projects.

Community Consultations/Entry

Community consultations form a key component, and have indeed been used as a vital tool in this HIA study. This vital process was intended to secure the much-desired social license (permit) to operate in the host communities. The broad objectives of this consultation process were:

- To educate and enlighten the communities on the need for their involvement as partners in progress towards the successful conduct of the health assessment process, as this will assist the project team in managing the health concerns of the communities, as well as their immediate environment.
- To build up their trust in the project operators.
- To build trust and enhance the capacities of the host communities in health management, through participation in the identification of the pathways by which the health hazards may be introduced into the population.
- To form and promote partnership with all other stakeholders, such as non-governmental organisations (NGOs), through information exchange and participation in open forum and consultations.

During this study, consultations were carried out with communities and all relevant stakeholders prior to community entry and during each stage of the field work.

Health Survey

Epidemiological Survey

The study design was cross sectional.

Sample Size

A sample size of 5% of the total population of the study communities based on the 1991 national census figures was used in the study. These figures have been adjusted to 2003 using a projection of an annual growth rate of 3%.

Selection of study subjects

The multistage sampling technique was adopted in each town or village to select the study population. A sampling frame consisting of streets was drawn from which the required streets and households were selected using the simple random technique.

All the inhabitants in the selected houses were then administered questionnaires until the required sample size was met .A sample of the questionnaire are attached in appendix.

Medical Examinations were done (a specimen copy of the examination format is shown. Also, in-situ urine analysis (urinalysis) was conducted for 1% of the study subjects at the end of the interview.

Focus Group Discussions and Interviews

Focus group discussions were held in each of the study communities. The following focus groups were identified:

Teenagers and adolescents

- Adult males
- Adult females and
- Youth

Oral Interviews were also conducted. Those interviewed were mostly health personnel and community opinion leaders. The questions were related to the following;

- The health facilities available in the community,
- The common diseases in the community,
- Their health concerns related to the project.
- Their health expectations from the project.

Environmental Health Survey

This consist of walk through surveys using prepared check list of environmental health issues such as general level of sanitation, waste disposal practices, water supply and the availability of health and health related facilities. Photographs of relevant health activities/ facilities were taken. The main issues assessed included:

i. Types and quality of housing

ii. Sources of water
iii. Type of sewage disposal methods/facilities
iv. Methods of refuse disposal/ general physical environmental cleanliness.
v. Health facilities available
vi. Environment- Health interplay

Air Quality Measurement

The presence of air pollutants was determined with appropriate equipment and good analytical methodology.

The potential air pollutants measured were Suspended Particulate Matter (SPM), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Hydrogen Sulphide (H_2S), Ammonia (NH_3), Total Hydrocarbon (THC), Carbon monoxide (CO) and Carbon dioxide (CO_2). The instruments used include a high volume sampler, a train of impingers fitted with bubbler devices and an automatic gas monitor. The quality assurance and control (QA/QC) measures employed include sampling at approximately 1.5m above ground and away from buildings; impingers were covered with aluminum foil and replicated analysis. The methods of sampling used in this study are those recommended by the World Health Organization (WHO), which have been adopted by the Federal Ministry of Environment (FMEnv).

Noise Level Measurement

Noise levels were measured in decibels (dBA) using a portable hand held sound level meter (EXTECH–407735). Noise level measurements were carried out in all the communities.

APPENDIX 3
SOCIAL IMPACT ASSESSMENT QUESTIONNAIRE

Macgill Engineering & Technical Services Ltd has been commissioned to carry out a detailed Social Impact Assessment Study (SIA) for Saghara AGS Project. The result of this study will enable us evaluate possible socio-economic impacts so far, on your environment, and thus recommend ways to enhance positive impacts and minimize negative ones. Please kindly answer the following questions.

1.0 **NEIGBORHOOD/COMMUNITY/SETTLEMENT**

1.1 Name of interviewee………………………………….
1.2 Date of interview……………………………………..
1.3 Neighborhood/Community/Settlement……………….
1.4 Local Government Area………………………………
1.5 State…………………………………………………...

2.0 **RESPONDENTS PERSONAL INFORMATION**

2.1 **Sex** (Male/Female)……………………………………

2.2 **Age:**

2.2.1 10 – 20 years
2.2.2 21 – 30 years
2.2.3 31 – 40 years
2.2.4 41 – 50 years
2.2.5 51 - 60 years
2.2.6 61 – 60 years
Above 70 years

2.3 **How would you describe yourself in this Community/Neighborhood?**

2.3.1 Indigene
2.3.2 Settler
2.3.3 Visitor
2.3.4 Tenant

2.4 **How long have you lived in the Community/Neighborhood?**

2.4.1 Less than 5 years
2.4.2 6 – 10 years
2.4.3 11 – 15 years
2.4.4 16 – 20 years
2.4.5 Above 20 years

Marital Status

2.4.6 Single

2.4.7 Married
2.4.8 Divorced/Separated
2.4.9 Widow/Widower

2.6 What is your family type?
2.6.1 Nuclear family
2.6.2 Extended family
2.6.3 Polygamous
2.6.4 Other (specify)…………………….

2.7 **What position do you hold in the Community?**
2.7.1 Traditional Ruler
2.7.2 Religious Leader
2.7.3 Family Head
2.7.4 Chairman, Social Club
2.7.5 None
2.7.6 Other (specify)………………………………

2.8 What is your level of Education?
2.8.1 Primary
2.8.2 Secondary
2.8.3 Tertiary
2.8.4 Vocational
2.8.5 Adult education
2.8.6 No Formal Education

3.0 **DERMOGRAPHIC CHARACTERISTICS**

3.1 Sex of household head
3.1.1 Male
3.1.2. Female

3.2 **Family Size (Husband, Wife/Wives and Children)**
3.2.1 1 – 3
3.2.2 4 – 6
3.2.3 7 – 10
3.2.4 11 – 15
3.2.5 Above 15

3.3 **Sex distribution:** How many are:
3.3.1 Males…………………………………………..
3.3.2 Female…………………………………………
3.4 Age structure
3.4.1 Household members' age

Age	Male	Female	Total
0-4 years			
5-12			
13-18			
19-25			
26-59			
60-65			
Above 65			

3.5 Household Literacy

3.5.1 Education level of household members

School	Males	Females	Total
Primary			
Secondary			
Vocational/Tech			
Tertiary			
Any other			

3.6 How many births in your family in the last 12 months?

3.6.1 0
3.6.2 1
3.6.3 2
3.6.4 3
3.6.5 4

3.7 How many deaths in your family in the last 12 months? Kindly specify their age(s)

3.7.1 0
3.7.2 1……..
3.7.3 2……..
3.7.4 3……..
3.7.5 4……..

4.0 **ECONOMIC ENVIRONMENT**

4.1 **What is your primary Occupation?**

4.1.1 Farming
4.1.2 Fishing
4.1.3 Hunting
4.1.4 Civil Servant
4.1.5 Trading

4.1.6 Business
4.1.7 Artisan
4.1.8 Gin Distilling
4.1.9 Industrial Worker
4.1.10 Logging
4.1.11 Other (Specify)……………………………………….

4.2 **How long have you been in the Occupation?**
4.2.1 0 – 5 years
4.2.2 6 – 10 years
4.2.3 11- 20 years
4.2.4 21 – 30 years
4.2.5 Above 30 years

4.3 **Which of these is your secondary Occupation?**
4.3.1 Farming
4.3.2 Fishing
4.3.3 Hunting
4.3.4 Civil Servant
4.3.5 Trading
4.3.6 Business
4.3.7 Artisan
4.3.8 Gin Distilling
4.3.9 Industrial Worker
4.3.10 Logging
4.3.11 None
4.3.12 Other (Specify)……………………………………….

4.4 **If you are engaged in farming, what type of crop do you cultivate?**
4.4.1 Cassava
4.4.2 Maize
4.4.3 Melon
4.4.4 Yam
4.4.5 Beans
4.4.6 Cocoa yam
4.4.7 Plantain
4.4.8 Banana
4.4.9 Other (specify)……………………………………………

4.5 **How would you describe farm yield in the last five years?**
4.5.1 It has increased steadily

4.5.2 It has increased rapidly
4.5.3 It has declined steadily
4.5.4 It has declined rapidly
4.5.5 It is the same or stable

4.6 **If declining what do you think is responsible? (Record answer verbatim**
4.6.1 ……………………………………………….
4.6.2 ……………………………………………….

4.7 What type of crop management do you practice?
4.7.1 Sole cropping
4.7.2 Mixed cropping
4.7.3 Mixed farming
4.7.4 Other (specify)…………………………………
4.8 Where do you normally sell your produce?
4.8.1 At your farm
4.8.2 Local markets
4.8.3 Interstate markets
4.8.4 Export market
4.8.5 At home
4.8.6 Landing site
4.8.7 Hawking/House to house
4.8.8 Other (specify) …………………………………

4.9 How do you normally transport your farm produce?
4.9.1 Vehicle
4.9.2 Motor cycle
4.9.3 Bicycle
4.9.4 Head porterage
4.9.5 Wheelbarrow
4.9.6 Other (specify)…………………………………

4.10 **Give an estimated distance between your farm and the point where you sell your produce.**
4.10.1 0.5km
4.10.2 1km
4.10.3 2km
4.10.4 Above 2km
4.11 At present, do you have any access to agricultural credit? If yes, please state source

4.11.1 Government
4.11.2 Banks
4.11.3 NGOs
4.11.4 Relatives
4.11.5 Oil operating company………………………..
4.11.6 Other (specify)…………………………………….

4.12 What is your estimated income per month?

4.12.1 N1,000 -N5000
4.12.2 N5,001 – N10,000
4.12.3 N10,001 – N15,000
4.12.4 N15,001 – N20,000
4.12.5 N20,001 – N25,000
4.12.6 N25,001 – N30,000
4.12.7 N30,001 – N35, 000
4.12.8 N35,001 – N40,000
4.12.9 N40,001 – N45, 000
4.12.10 N45,001 – N50,000
4.12.11 N50,001 and above

4.13 How much do you realize from other activities/sources in a month?

4.13.1 N0.00 – 500.00
4.13.2 N501.00 – 1,000.00
4.13.3 N1, 001.00 – N1, 500.00
4.13.4 N1, 501.00 – 2,000.00
4.13.5 Above N2, 000.00
4.13.6 None

4.14 **How much do you spend on your family a week?**

4.14.1 N250.00 – N500. 00
4.14.2 N501.00 – N1, 000.00
4.14.3 N1, 001. 00 – N1, 500. 00
4.14.4 N1, 501.00 – N2, 000. 00
4.14.5 N2, 500. 00 – N3, 000. 00
4.14.6 N3, 001. 00 – N3, 500. 00
4.14.7 Other range. ……………………………………………….

4.15 On what do you mostly spend on your family a week?

4.15.1 Food items

4.15.2 Household item
4.15.3 Clothing
4.15.4 Education of Children
4.15.5 Medical Care
4.15.6 Other range (specify)……………………………….
4.15.7

4.16 How much are you able to save in a year?

4.16.1 N10, 000.00 – N20, 000 .00
4.16.2 N21, 000.00 – N30, 000.00
4.16.3 N31, 000.00 – N40, 000.00
4.16.4 N41, 000.00 – N50, 000.00
4.16.5 N51, 000.00 – N60, 000.00
4.16.6 Other range……………………………………………….
4.16.7 No savings

4.17 Which of these properties do you own?

4.17.1 Bicycle
4.17.2 Motor Cycle
4.17.3 Motor Vehicle
4.17.4 Out Board Engine Boat
4.17.5 Canoe
4.17.6 Generator
4.17.7 Television
4.17.8 Radio set
4.17.9 Gas cooker
4.17.10 Refrigerator
4.17.11 Cable (Dstv, HiTv etc.)
4.17.12 Other (Specify)…………………………………………

4.18 Please state the number of your household members who have attained 18 years and above but are not employed.

4.18.1 None
4.18.2 1
4.18.3 2
4.18.4 3
4.18.5 4
4.18.6 5
4.18.7 6

4.18.8 Others (specify)…………………………………………….

4.19 How many members of your household are employed in Crude Oil related Companies operating in this area?

4.19.1 None
4.19.2 1
4.19.3 2
4.19.4 3
4.19.5 4
4.19.6 5

4.20 **Does any member of your household have any form of technical training related to the operations of Oil Companies in the area? If yes how many?**

4.20.1 1
4.20.2 2
4.20.3 3
4.20.4 4
4.20.5 5

4.21 **Please briefly specify the nature of the training and indicate the number of person who has such training.**

4.20.1 …………………………………………….
4.20.2 …………………………………………….
4.20.3 ……………………………………………..
4.20.4 ……………………….……………………..

5.0 **SOCIAL/CULTURAL ENVIRONMENT**

5.1 What is your Religion?

5.1.1 Christianity
5.1.2 Islam
5.1.3 Traditional
5.1.4 Other (specify)………………………………………………….

5.2 **Which of the following do you have around this Neighborhood/ Community: (please show us the location)**

5.2.1 Shrines
5.2.2 Scared Ground/Forest…………………………………….
5.2.3 Historical/Archaeological site ……………………………
5.2.4 Religion House

5.2.5 Sacred plant/animal……………………………………….
5.2.6 Other (Specify)……………………………………………

5.3 Kindly state the names, date and purpose of traditional festivals in this community?

…………………………………………………………………….
…………………………………………………………………….
……………………………………………………………………...

5.4 Which of these social problems do you have in your Community/Neighborhood?

5.4.1 Youth/Juvenile delinquency/unrest
5.4.2 Land dispute
5.4.3 Chieftaincy problem
5.4.4 Inter-village problem
5.4.5 Inter- family problem
5.4.6 Unemployment
5.4.7 Other (Specify)………………………….

5.5 How is conflict resolved in this community?

5.5.1 Elders-in-Council
5.5.2 Religious leaders
5.5.3 Traditional Priest
5.5.4 Age grade
5.5.4 Family heads
5.5.5 Other (Specify)……………………………………………

5.6 **What is the nature of land ownership in this community?**

5.6.1 Personal
5.6.2 Family
5.6.3 Communal
5.6.4 Lease Hold
5.6.5 Free Hold
5.6.6 Other (specify)………………………………………………….

5.7 **Do you own any land in the Community? If yes, what is the size in hectares**

5.7.1 0 – 1
5.7.2 2 – 3
5.7.3 4 - 5
5.7.4 6 – 7
5.7.5 Above 7

5.8 **Are there any recreational/leisure facility in this community? If yes, kindly list them ………………………………………………**

5.9 What benefit do you expect from SPDC in the course of the execution of this project and subsequent operation in the area? Please rank them in order of importance by placing 1 against the most important, 2 against next importance etc.

5.9.1 Employment of indigenes
5.9.2 Scholarship for indigenes
5.9.3 Electricity
5.9.4 Primary School
5.9.5 Water Project
5.9.6 Health Centres
5.9.7 Others (specify)………………………………………..

5.10 What do you think have been the likely negative impact you may have experienced that is associated with SPDC operation in your community?

5.10.1 Increased social vices
5.10.2 Influx of people
5.10.3 Land take
5.10.4 Reduced farmland availability
5.10.5 Increased cost of living
5.10.6 Reduced school enrolment and retention
5.10.7 Decline in farm yield
5.10.8 Environmental pollution
5.10.9 Adulteration of culture
5.10.10 Increased motoring accident
5.10.11 None
5.10.12 Other (specify)………………………….

5.11 What do you think have been the likely positive impacts you may have experienced that is associated with SPDC operation in your community?

5.11.1 Increased employment
5.11.2 Improved level of education
5.11.3 Land compensation
5.11.4 Incentive for conceptual engagement
5.11.5 Increased sales
5.11.6 Provision of social amenities
5.11.7 None
5.11.8 Other (specify)………………………………

6.0 **HOUSING/PHYSICAL ENVIRONMENT**

6.1 **What type of house do you live in?**

6.1.1 One room apartment
6.1.2 A room and parlour
6.1.3 Flat
6.1.4 Self contain
6.1.5 Duplex
6.1.6 Other (specify)…………………………………

6.2 **How do you own the house you live in?**

6.2.1 Personal owned
6.2.2 Rented
6.2.3 Other (specify)………………………………

6.3 **What structural material is your house made of?**

6.3.1 Thatched/mud house
6.3.2 Zinc/mud
6.3.3 Zinc/plank
6.3.4 Zinc/block
6.3.5 Other (specify)…………………………………

6.4 **What in-house facility do you have in your housing type?**

6.4.1 Water closet/toilet
6.4.2 Bathroom
6.4.3 Shower
6.4.4 Kitchen
6.4.5 Plumbing fixtures
6.4.6 Other (specify)………………………………..

6.5 **What is your method of sewage disposal?**

6.5.1 Open surface privy
6.5.2 Pail (bucket) system
6.5.3 Shot-put/Bushes
6.5.4 Other (specify)..

6.6 **What is your source of water supply?**

6.6.1 Stream
6.6.2 Rain water harvest
6.6.3 Water bole hole
6.6.4 Pipe borne water
6.6.5 Hand dug well
6.6.6 Other (specify)…………………………………

6.7 **Except domestic use, what other purpose does this water source serve your household?**

- 6.7.1 Irrigation
- 6.7.2 Local processing industry (oil palm and cassava processing, etc.)
- 6.7.3 Economic benefits (e.g. sales)
- 6.7.4 Other (specify)……………………………….

6.8 **What is your source of cooking fuel?**

- 6.8.1 Firewood
- 6.8.2 Kerosene
- 6.8.3 Saw dust
- 6.8.4 Gas
- 6.8.5 Electricity stove
- 6.8.6 Other (specify)…………………………………

6.9 **What is your method of waste disposal?**

- 6.9.1 Dump in pit
- 6.9.2 Incineration/burning
- 6.9.3 Dump in nearby bushes
- 6.9.4 Designated place in the community
- 6.9.5 Other (specify)………………………….

6.10 **What are the common environmental problems in the Neighborhood/Community?**

- 6.10.1 Flooding
- 6.10.2 Shoreline Erosion
- 6.10.3 Deforestation
- 6.10.4 Indiscriminate waste dump
- 6.10.5 Oil spill
- 6.10.6 Gas flaring
- 6.10.7 Noise pollution
- 6.10.8 Thermal pollution
- 6.10.9 Others (Specify)…………………………………………………
- 6.10.10 No idea

6.11 **What do you think is important to improving quality of life in this community?**

- 6.11.1 Portable water supply
- 6.11.2 Lucrative employment

6.11.3 Art and culture
6.11.4 Security and safety
6.11.5 Provision and access to amenities and services
6.11.6 Serene natural environment
6.11.7 All of the above
6.11.8 Others (specify)……………….

6.12 **Which of these infrastructure facilities do you have in your community? Please tick as appropriate.**

6.12.1 Health centre
6.12.2 Water bore-hole
6.12.3 Primary school
6.12.4 Secondary school
6.12.5 Tertiary/technical institution
6.12.6 Tarred road(s)
6.12.7 Electricity
6.12.8 Cassava processing plant
6.12.9 Market stall
6.12.10Police station
6.12.11Other (specify)……………………………..

7.0 FISHERY, FOREST AND WILDLIFE

7.1 **Are you engaged in fishing activities? If yes, where do you usually fish?**

7.1.1 Rivers within a few nautical miles from the village
7.1.2 Open sea fishing
7.1.3 Fish pond

7.2 **What type of fishing craft do you use?**

7.2.1 Non-motorized dug-out canoe
7.2.2 Non-motorized plank canoe
7.2.3 Motorized dug-out canoe
7.2.4 Trawler
7.2.5 Other (specify)…………………………………

7.3 **What type of fishing gear do you use?**

7.3.1 Hand picking
7.3.2 Hook and line
7.3.3 Scoop net
7.3.4 Cast net Set net
7.3.5 Drift net
7.3.6 Purse seine net
7.3.7 Traps

7.3.8 Crayfish net
7.3.9 Trawl net
7.3.10 Other (specify) …………………………………

7.4 **Please list the types of fish you normally catch?**

7.4.1 ………………………………………………
7.4.2 ………………………………………………
7.4.3 ………………………………………………
7.4.4 ………………………………………………
7.4.5 ………………………………………………
7.4.6 ………………………………………………
7.4.7 ………………………………………………
7.4.8 ………………………………………………
7.4.9 ………………………………………………
7.4.10 ………………………………………………

7.5 **How much do you realize from fish sales in a month?**

7.5.1 N0.0 – N250.00
7.5.2 N250.00 – 500.00
7.5.3 N501.00 – 750.00
7.5.4 N751.00 – 1,000.00
7.5.5 N1001.00 – 1,500.00
7.5.6 N1, 501.00 – 1,750.00
7.5.7 N1, 751.00 – N2, 000.00
7.5.8 Above N2, 000.00

7.6 **How would you describe fish yield in the last five years?**

7.6.1 It has increased steadily
7.6.2 It has increased rapidly
7.6.3 It has declined steadily
7.6.4 It has declined rapidly
7.6.5 It is the same or stable

7.7 **If declining what do you think is responsible? (Record answer verbatim)**

7.7.1 ………………………………………………………
7.7.2 ………………………………………………………
7.7.3 ………………………………………………………

7.8 **Are you involved in forest resource exploitation in this community? If yes, what type of forest exploitation are you engaged in?**

7.8.1 Gathering of firewood
7.8.2 Hunting
7.8.3 Logging

7.8.4 Snail gathering
7.8.5 Non timber forest product gathering (herbs, roots, etc.)
7.8.6 Other (specify)…………………………………………

7.9 **Please list the type of timber found in this area.**
7.9.1 ………………………………………………
7.9.2 ………………………………………………
7.9.3 ………………………………………………
7.9.4 ………………………………………………
7.9.5 ………………………………………………
7.9.6 ………………………………………………
7.9.7 ………………………………………………
7.9.8 ………………………………………………
7.9.9 ………………………………………………

7.10 **What are the indigenous ways used in the community to conserve and protect the land, forest and water-bodies?**
7.10.1 Traditional injunctions/taboos
7.10.2 Sanctions
7.10.3 Fallow system
7.10.4 Other (specify)…………………………..

7.11 **Please list the type of wild animal and birds you normally see or catch in this area.**
7.11.1 ……………………………………………
7.11.2 …………………………………………….
7.11.3 …………………………………………...
7.11.4 …………………………………………..
7.11.5 …………………………………………..
7.11.6 …………………………………………..
7.11.7 …………………………………………..
7.11.8 …………………………………………..
7.11.9 …………………………………………..
7.11.10 …………………………………………..

7.12 **What are your expectations from the operation of SPDC in your community?**
7.12.1 ………………………………………
7.12.2 ……………………………………..
7.12.3 ……………………………………..

Thank You!

Appendix 5.2: HEALTH STUDY QUESTIONNAIRE

Macgill Engineering & Technical Services Ltd has been commissioned to carry out a detailed Health Impact Assessment Study (HIA) for OTUMARA AGG EER - BASED EIA. The result of this study will enable us evaluate possible positive health impacts and minimize negative ones. Please kindly answer the following questions.

(1) Name: ____

(2) Sex : ____

(3) Age : ____

(4) (i) Marital status: Married/Single (ii) Marriage Practice: Monogamy/ Polygamy

(iii)Number of wives______________(iv) No of children (with ages)________

(iv)Average No. of children per wife:____________________________

(5) Occupation:____

(6) Population Estimate of Community:________________________________

General Health Conditions

(7) Central Nervous System:

(i) Headache (Yes/No)___________________________

(ii) Regular dizziness (Yes/No)_____________________

(iii) Blurring of vision (Yes/No)______________________

(iv) Eye pains (Yes/No)_____________________________

(v) Ear pains (Yes/No)_____________________________

(vi) Abdominal sensations (Yes/No)__________________

(vii) Epilepsy (Yes/No)______________________________

(viii) Cases of mental disorder (Yes/No)_________________

(8) Cardiovascular System:

(i) Pulse (Good/Abnormal)

(ii) Blood pressure (Good/Abnormal)

(9) Respiratory System:

(i) Cough (Yes/No)___________________________

(ii) Chest pain (Yes/No)_________________________

(iii) Consistent catarrh (Yes/No)___________________

(iv) Noisy breathing (Yes/No)_____________________

(v) Breathlessness (Yes/No)______________________

(vi) Case of Asthma (Yes/No)_____________________

(10) Gastro Intestinal System:

(i) Any mouth disease (Yes/No)__________________
(ii) Difficulty in swallowing food (Yes/No)__________
(iii) Lack of appetite (Yes/No)______________________
(iv) Too much appetite (Yes/No)____________________
(v) Frequent constipation (Yes/No)_________________
(vi) Difficulty in stooling (Yes/No)__________________
(vii) Vomiting (Yes/No)____________________________
(viii) Heart burn (Yes/No)___________________________
(ix) Frequent stomach ache (Yes/No)________________
(x) Frequent dysentery/diarrhea (Yes/No)___________

(11) Urogenital System:

(i) Did you urinate properly (Yes/No)____________________________
(ii) Sexual habits (Good/Poor/Abnormal)__________________________
(iii) Any discharge from the urinogenitals (Yes/No)_________________
(iv) Any irregular/abnormal menstrual cycle? (Yes/No)______________
(v) Specify cases of miscarriage and still births (Yes/No)____________

(12) Skin and Musclo-Skeletal System:

(i) Skin rashes (Yes/No)____
(ii) Patches of skin discoloration (Yes/No)_________________________
(iii) Body deformities (Specify)___________________________________
(iv) Skin swelling/nodules (Yes/No)________________________________

(13)What diseases do you suffer from in this Community?

Disease	Very frequent	Occasionally	Very rare	Non-existent
Malaria fever				
Measles				
Whooping cough				
Pneumonia				
Chicken pox				
Fever				
Typhoid				
Cholera				
Gonorrhoea/Syphilis (STDs)				
Scabies/Skin rashes				
Diarrhoea				
Other communicable diseases				

Disease	Very frequent	Occasionally	Very rare	Non-existent
Rheumatism Sores/injuries/accidents Stomach ache Mental illness Cancer Other diseases (specify)				

(14) For how long have the diseases been with you?___________________________

(15) How do you think your health problems are acquired?______________________

(16) Are they associated with water, air, food, plants, animals, other people or the environment, your occupation or developmental project in the area?__________

(17) What can you say about your general state of health?(Very good/Average/Poor/Very poor____

(19) (i) Do you have a hospital? (Yes/No) Provide the name:____________

(ii) Do you have a hospital? (Yes/No) Provide the name:___________

(iii) Do you have a chemist shops (Yes/No) How many?____________

(iv) Are they Government and owned/company owned /privately owned?

(19) Provide the name and location of the nearest hospital to you? (If no hospital in your Community)____

(20) How often do you go to hospital? (Frequent/occasionally/rarely/not at all)____

(21) Do you get effective treatment in the hospital you attend? (Yes, very good/ Average/Poor /Very poor/Nil)____

(22) Do you utilize traditional doctors and herbalists? (Yes and very common/Yes but few/Yes but very rare/None)

(23) Do you have any these health services

(i) Diagnostic laboratories (Yes/No)___________________________

(ii) Primary health care centres (Yes/No)________________________

(iii) Immunization centres (Yes/No)_____________________________

(iv) Health education centres (Yes/No)___________________________

(v) Maternity centres (Yes/No)__________________________________

(vi) Family planning centres (Yes/No)___________________________
(vii) Health status in the Community (Yes/No)____________________

(24) What are the common diseases in the Community?

Disease	Very frequent	Occasionally	Very rare	Non-existent
Malaria fever Measles Whooping cough Pneumonia Chicken pox Fever Typhoid Cholera Gonorrhoea/Syphilis (STDs) Scabies/Skin rashes Diarrhoea Other communicable diseases Rheumatism Sores/injuries/accidents Stomach ache Mental illness Cancer Other diseases (specify)				

(25) What are the birth rates in the Community (Appr. No/Year)_____________
(26) What are the death rates in the community (Appr.No/Year)_____________
(27) Life expectancy (Years)____
(29) Maternal mortality level (high/average/low/nil)_______________________

(29) Child mortality level (high/average/low/nil)__________________________
(30) Childhood communicable diseases:_________________________________
(31) Common adult diseases:____

(32) Knowledge of people about major diseases and health issues:_____________

(33) Attitude of people to the major diseases and health problems:______________

(34) Health practices in the Community:__________________________________

(35) Health seeking behaviours:____

(36) Previous impacts of health interrelations Social and Environment issues on health____ _____

(37) Do you smoke cigarette? (Yes/No)_________________________________

(39) (i) Do you drink alcohol? (Yes/No)_____________________________

(ii) Would say you drink excessively (Yes/No)___________________

(39) (i) Do you indulge in prostitution or patronize Prostitution? (Yes/No)_

(ii) Have you had any of the sexually transmitted diseases (STDs) (Yes/No)____

(iii) Name it (Gonorrhoea/Sphilis/HIV AIDS)__________________

(iv) Is prostitution a business in the Community? (Yes/No)_______

(40) How do you spend your time of leisure?______________________________

(41) Are there any facility donated to your Community by Government Organization or individual that is beneficial to the Community?(Yes/No) Specify:____

(42) (i) Do people migrate often into the Community and settle with the Indigenes? (Yes/No)______________________________________

(ii) Who are they and how long they stay?_______________________

(iii) Has there been any disease outbreak as a result of such migration? Clarify (Yes/No)____

(43) (i) Do you feed well or have a balanced diet? (Yes/No)____________

(ii) State the common food or food or food types in the Community (Yam/Beans/Plantain/Garri)_______________________________

(44) Are there continuous inter-tribal dispute or fights within your Community or between your Community and other ones (Yes/No)___________

(45) Would you say your Community is a very peaceful one (Yes/No)__________ Clarify____

(46) What is the nature of the house you live in? (Poor hut with thatched roof/semi modern

(47) (i) What are the nature of the roads (Poor ungraded earth roads/Tarred roads)

(ii) Are there regular road traffic accidents? (Yes/No)_______________

(49) Do you have light/electricity supply (Yes/No)___________________________

(49) What is your source of water supply (Ring well/Bore hole/Tap water/River or Stream/Pond)____

(50) What type of toilet do you use? (Bush/Open pit latrine/Covered pit latrine/Bucket)____

(51) What is your method of waste disposal? (Dumping/Burying/Burning)describe it____

(52) Do you have flooding and erosion problems? (Yes/No)________________

(53) Do you experience air, water and land pollution due to oil or chemical spillage or emissions? Describe it_________________________________

(54) Do you experience noise pollution/disturbance or explosions? (Yes/No) Describe it____

(55) Are there any destruction of farm lands, soil and water bodies due to any development projects in the Community? (Yes/No)____________________

(56) State some common diseases vectors in the community (Flies/Mosquitoes Tse –tse flies, Rats, Mosquitos ____

(57) (i) State domestic animal in the community (Dog/Cat/Sheep/Goat/Fowls/Pigs)________________________

(ii) Are they confined in pens or left to roam about?______________

(59) (i) Are there dangers of snake bites (Yes/No)___________________

Are there dangers of insect bites (Yes/No)___________________

(ii) Are there dangers of attack by dangerous animals (e.g Lion/Tiger/Crocodiles) (Yes/No)_________________________

(59) (i) Has there been an epidemic (Outbreak of Disease) in the community?(Yes/No)

(ii) Name the disease and the cause__________________________

(60 How do you think the oil development project will affect health in your Community

(61) What are your recommendations for having good health in the community with the oil development project______________________________

(62) What are your concerns for good health in the community? (List in order of priority)

____

____

____

____

____

____

UGBORODO COMMUNITY
UGBORODO

Warri South-West LGA
Delta State

23Th July, 2012

Sir,

TO WHOM IT MAY CONCERN
AUTHORITY TO WORK IN ESCRAVOS, OTUMARA & SAGHARA FIELDS

We write to certify that the Company, MACGILL ENGINEERING & TECHNICAL SERVICES, has met with our community and permission has been granted them. They are, therefore, permitted to mobilise to our locality, **Escravos, Otumara & Saghara ,** to carry out Environmental Evaluation Studies along SPDC Pipeline ROW to Escravos), without any hindrance from the community. This authority takes effect from when the contactor mobilise to site and for a period of **One Year on call-off basis.** 1 Unskilled worker per field from Otumara & Saghara fields and 4 unskilled from Escravos at a daily rate of N2,500.00 per person per day worked.

0ne HSE shall be engaged from the three Otumara, Saghara & Escravos Fields

Thank you.

Yours faithfully,
For: **UGBORODO COMMUNITY**

ISAAC BOTOSAN
UGBORODO COMMUNITY

Appendix 4

FMEnv TECHNICAL COMMENTS AND SPDC's RESPONSES ON THE EIA DRAFT REPORT OF THE PROPOSED SAGHARA AGS PROJECT

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
Executive Summary		
1	Specify currently producing wells and their exact locations	
2	List existing manifolds	
3	Include the following laws Delta State Ecology Law,2006 Bendel State Forestry Law Cap 59, 1976 Delta State Waste Management Law, 2004 Delta State Revenue Edict, 1997 Delta State Internal Revenue Consolidation Law, 2009 Endangered Species, 1985 Act	Included in ES 1.4 page xviii and xix
4	To achieve gas flare-out within the Otumara Node by 2009. The date and statement is not realistic, specify new acceptable date forbetter project management	This statement has been modified to read "Achieve Flares down and thus minimize impact on the environment and enhance the socio-economic development of the host communities in the area through sustainable development of the project over its life cycle" -page xviii
5	Include Local Government Area	This has been included-Warri South LGA in Delta State-page xxi
6	Total length of flowlines needs to be specified. Distance between the other flowlines must be specified	This has been done in xx and xxi
7	Quantify the value of the project Project value should be established and specified Project value is expected to be specified and quantified Please note that eliminating routine gas flaring does not constitute the value of the project, rather an advantage	The value of the project is included in ES 2.1
Chapter 1: Introduction		
8	Include FMEnv Oil and Gas Sectorial Guidelines was not sited NOSDRA Act 2006	Included in section 1.4

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
	Delta State Ecology Law,2006 Bendel State Forestry Law Cap 59, 1976 Delta State Waste Management Law, 2004 Delta State Revenue Edict, 1997 Delta State Internal Revenue Consolidation Law, 2009 Endangered Species, 1985 Act	
9	The study approach for this EIA is basically desk top……..relating to the project area' Any evidence of approval to use secondary data from the Ministry?	The report has been rewritten to include a two season data gathering exercise. The wet season in August 2012 while the dry season in January 2013
10	Map of Nigeria, Map of Delta State and site location Map in relation to Delta state should be presented in the report	The following maps have been included: Map of Nigeria in Fig 1.1, Map of Delta State showing project site in Fig 1.2 and Map of Saghara Field in Chapter 3 Fig 3.1
Chapter 2- Project Justification		
11	Project justification should include a project reduction (%) in relation to SPDC's aggregate gas flare. This is significant to the set of deadline on gas flare phase out Nigeria	The mothballing of Saghara flowstation will stop 1750000scf/d from been flared.
12	SPDC has proven technologies. What are these?	No new technology will be employed-Table 2.1
Chapter 3: Project description		
13	This is not clearly stated. The process for a project covers the following: • Conceptual Design • Detailed Engineering Design • Pre-construction survey and landtake • Construction phase involving excavation, filling, casting, welding and radiography • Pre-commission • Pipe laying and tie-in process • Decommissioning and abandonment • Operation and maintenance	These sections have been clearly explained in the report- Section 3.3

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
14	When is decommissioning of affected existing facility in Saghara coming into effect?	Demobilization is Q2 2015
15	Utilized portion of the land after decommissioning will be remediated before handing same to the owners" what portion (area) are the owners expecting from SPDC on this project?	The facilities and will be mothballed and preserved for future use. During construction contaminated site will be remediated. No land will be handed over.
16	Currently there is no infrastructure to the neighbouring communities from the flowstation." After operating these since 1972 no infrastructure to the neighbouring communities, do you have anything in mind as a parting gift for the community during decommissioning?	The three major communities will benefit from electrification programme. There are also other benefits contained in the Project global Memorandum of Understanding
17	The Ministry will have to be informed before any step is taken concerning decommissioning plan please	Noted
18	No project schedule No information on hydrotest water No information on number of river crossing of the pipeline Scanty information on method of crossing No information on design characteristics of pipeline No information on positive increase in crude oil production	Project schedule is in 3.9 while others are contained in section 3.6
Chapter 4: Description of the Environment		
19	Map showing the study area and sampling locations	Included
20	Did you follow due process in using secondary baseline data information from the Ministry?	The report has been rewritten to include a two season data gathering exercise. The wet season in August 2012 while the dry season in January 2013-section 4.1
21	Any evidence of ground truthing of the data obtained in the various reports referred to in the EIA draft report	The report has been rewritten to include a two season data gathering exercise. The wet season in August 2012 while the dry season in January 2013

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
22	Consultation is different from scoping or ground-truthing. Scoping workshop forum cannot offer necessary and required information. Proceedings of scoping workshop take to appendix	Noted
23	No effort was made to give the extent/proportion of the vegetation types described	This has been addressed in section 4.7
24	General structure and physiognomy of plants	This has been addressed in section 4.7
25	Information on woody plant densities	This has been addressed in section 4.7
26	Information on ethnobotany	This has been addressed in Table 4.7.1a page 73
27	Information on land uses and quantifying same	This has been addressed in Table 4.7.1b page 73
28	Information on the level of hunting/hunting pressure is not indicated, including hunting methods and cultural protection	Information contained in section 4.8
29	There was no seasonal information provided for physical parameters and heavy metals	Information presented in Tables 4.4.1a, 4.2.1b and 4.4.2
30	Period/ Time of sampling	Information presented in section 4.1
31	Unit for TDS, DO	Included in Tables 4.4.1a, 4.2.1b and 4.4.2 (mg/l)
32	THC, oil and grease listed under exchangeable cations	THC, oil and grease listed on their own
33	Critical phytoplankton descriptors that will help in revealing the status of primary producers/ the environment are not included in this report. Species distribution, richness, diversity, community structure and biomass(abundance)	Phytoplankton descriptors have been included in section 4.5
34	Your report indicated that the people are more of fishermen suggesting that they depend on fish resources for livelihood but your report did not project this. The report only provided information on the fishes and not the fisheries as the title suggested. Fisheries information should include the fishes and other (fisheries) related	Information contained in section 4.6 and 4.10.4

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
	information. These include: who are the fisher folks, what is the population, what is the proportion of male/female, Adult/young, gear deployment/target species, fishing pressure, Catch deployment/ and target species, fishing pressure, catch per unit of effort, fish landing sites/trade routes	
35	Show sampling map including distribution of boreholes	Shown I Fig 4.1
36	Ensure mitigation measures that will reduce or eliminate surface water pollution	This has been included in table 7.1
37	Charge on exchangeable anions for calcium is misleading	Charges in the anions and cations have been removed
38	A copy of the questionnaire should be attached	This has been included in appendix 3
39	Value of the report will be enhanced if data on the residents accessibility to the basic infrastructure and facility are included in the report	This has been included on the section of social infrastructure in section 4.10
40	88.97% of the people drink from stream/pond/river/rain water. Only 0.24% have access to pipe-borne water from Chevron, Nigeria Limited. Does the Project intend to have any contribution to welfare improvement of the people having been in operation since 1972? So if any so what are they?. Name the stream ponds that people are drinking from	The three major communities will benefit from an electrification programme. There are also other benefits contained in the Project global Memorandum of Understanding. The people harvest rain water, hand dug wells and water from Cheveron tank farm.
41	Access to basic social services such as water, health education, power-supply….. is very poor. What are the chances of the Project improving upon the situation? Even as Chevron Nigeria limited is having plans	The three major communities will benefit from an electrification programme. There are also other benefits contained in the Project Global Memorandum of Understanding.
42	Community Power Situation. Oil Companies are part of factorization of the executive committee of communities leading to creation of tension and sometimes multiple negotiations between the industry and the community? How do you intend to reverse this trend?	SPDC will engage the communities through the Project Global Memorandum of Understanding.

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
43	Malaria was identified as the commonness causes of morbidity and mortality rate in the area based on Saghara flowstation Field EER of 2001 that lacked empirical data. Many of the ailments were listed as respiratory trct infections, fever, skin diseases etc. If these ailments in the area lack empirical data, what then is the basis for your claim in the report giving in your spatial boundary of the entire LGA for the study	More recent data have been acquired in a fresh survey 2012/2013(Section 4.11)
44	The Escravos EIA study report SPDC 1998 quarries the suitability of the water given by SPDC for drinking owing to the high iron content. Is SPDC doing anything to change the situation?	The PGMoU provides funds for Projects such as Drilling deeper boreholes depending on the need of the communities. It is a function of what they collectively want.
Chapter 5: **Project Activities and Sensitivities Interactions**		
45	Under mobilization of materials and personnel on page 5-27 the following should be included, waste management and safety of personnel	This has been captured in Tables 5.2b and 5.5 of Chapter 5
46	Under clearing of Right of Way(RoW) loss of vegetation should be included	This has been captured in Tables 5.2b and 5.5 of Chapter 5
47	No impacts on possible flue outbreak, on drinking water source, on the FLB/boat house and decommissioning impact of the existing facilities	This has been captured in Tables 5.2b and 5.5 of Chapter 5. The Saghara flowstation would be mothballed and preserved. Operations here will stop
Chapter 6		
48	Impact on disruption of fishing/water transport activities. The mitigation is not monitorable e.g. SPDC to ensure that right of water ways sufficiently accommodates the interests of communities. The question is how?	Additional mitigation measures have been introduced in Table 6.1. these include: SPDC shall ensure proper scheduling of supply boat movements so as not to interfere significantly with artisanal fishing and commercial boat activities. SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
		plan, Institute good marine journey management system in-line with SPDC policy. Sensitization of quarter masters / boat masters on how to pass fishing and commercial boat
49	Impact of trenching/excavation. Nothing is said on alternative water source during the period of trenching as a mitigation measure	Mitigation measures have been introduced in Table 6.1 for the impact of this activity these include: Use of silt curtain to prevent migration of plant matter, debris Treat all waste water to regulatory standards prior disposal Provision of mobile toilets for its work-force SPDC shall regularly monitor the quality of effluent to ensure that it meets regulatory standards SPDC shall adhere to its waste management procedure Provision of potable water is also included in the PGMoU
50	Impact from pipe-laying. Increase in employment as a positive impact. To sustain its entrepreneurial skill Development for communities shall be encouraged by SPDC. Have you identified any entrepreneurial skill that you intend to encourage? Name them	There is provision for development of entrepreneurial skills in the PGMoU
51	Impact from backfilling causing turbidity of the water bodies. Only awareness and no further action as mitigation is not good enough. Provide alternative water supply for drinking knowing fully well that over 80% of the people drink/use the river from the report	Turbidity of the water bodies will be mitigated by the following ways in Table 6.1: Use of silt curtain to prevent migration of plant matter, debris Treat all waste water to regulatory standards prior disposal Provision of mobile toilets for its work-force Regularly monitor the quality of effluent to ensure that it meets regulatory standards

S/N	FMEnv COMMENTS	SPDC'S RESPONSES
		Adhere to its waste management procedure Ensure that no soil mounds are left after back-filling Ensure best engineering of pipeline design, construction and installation. Design to incorporate auto leak detection for pipelines Provision of potable water is also included in the PGMoU
52	Impact from wastes generation causing third party agitation to be addressed by giving prompt attention to the cause of the agitation	This has been addressed in Tables 6.1 and 7.1
53	Introduce the action party column and include Regulators as part of the monitoring team	This has been addressed in Tables 7.1