

**The Shell Petroleum Development Company of Nigeria Limited
Operator for the NNPC/Shell/NAOC/Total E&P Joint Venture**

**ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF DODO
NORTH NON-ASSOCIATED GAS (NAG) WELLS
DEVELOPMENT PROJECT IN EKEREMOR LOCAL
GOVERNMENT AREA, BAYELSA STATE**

FINAL REPORT

**SUBMITTED TO THE FEDERAL MINISTRY OF
ENVIRONMENT, ABUJA**

APRIL, 2015

STATUS PAGE

**Title: ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF DODO NORTH
NON-ASSOCIATED GAS (NAG) WELLS DEVELOPMENT PROJECT IN
EKEREMOR LOCAL GOVERNMENT AREA, BAYELSA STATE**

Originator: The Shell Petroleum Development Company of Nigeria Limited

Author: Approved by:

Document Number: SPDC

Date:

Version: 02

Security:

Change History:

Version	Date	Pages	Reason
02		Whole Document	Final Report

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
AG	Associated Gas
AGG	Associated Gathering Gas
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
AQ	Air Quality
As	Arsenic
BCA	Benisede Catchment Area
Bcf	Billion cubic feet
BOD ₅	Biochemical Oxygen Demand
Bscf	Billion standard cubic feet
Ca	Calcium
CAPEX	Capital Expenditure
CAS	Catch Assessment Survey
CBO	Community Based Organization
CBR	Crude Birth Rate
Cd	Cadmium
CDR	Crude Death Rate
CDC	Community Development Council
CEC	Cation Exchange Capacity
CITES	Convention on International Trade in Endangered Species
cm	Centimeter
COD	Chemical Oxygen Demand
CO	Carbon monoxide
Cr	Chromium
CRI	Cutting Re-Injection
Cu	Copper
dB (A)	Decibel
DO	Dissolved Oxygen
DOMGAS	Domestic Gas
DPR	Department of Petroleum Resources
DPT	Diphtheria Pertussis Tetanus
EC	Electrical Conductivity
EGASPIN	Environmental Guidelines and Standards for Petroleum Industries in Nigeria
EIA	Environmental Impact Assessment
ELPS	Escravos Lagos Pipeline System
EMP	Environmental Management Plan
EPC	Engineering Procurement and Contracting

EPF	Early Production Facility
E&P	Exploration and Production
FDP	Field Development Plan
Fe	Iron
FEED	Front-End Engineering Design
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FID	Final Investment Decision
FMEnv	Federal Ministry of Environment
Ft	Feet
GEM	Gender Empowerment Measure
GHF	Gas Handling Facility
GPS	Global Positioning System
GIIP	Gas Initially in Place
GW	Groundwater
HAZID	Hazard Identification
HAZOP	Hazard Operability
HDI	Human Development Index
Hg	Mercury
HIA	Health Impact Assessment
HIV	Human Immunodeficiency Virus
HNO ₃	Nitric Acid
HPI	Human Poverty Index
HSE	Health, Safety and Environment
HSE-MS	Health, Safety and Environment Management System
HSSE	Health Safety Security and Environment
HUB	Hydrocarbon Utilizing Bacteria
HUF	Hydrocarbon Utilizing Fungi
IA	Impact Assessment
IFC	International Finance Corporation
ISO	International Organization for Standardization
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
Mn	Manganese
Na	Sodium
NAG	Non Associated Gas
NAOC	Nigerian Agip Oil Company
NDHS	Niger Delta Health Survey
NDPC	Niger Delta Peace Coalition
NDT	Non Destructive Test
NDUTH	Niger Delta University Teaching Hospital
NERC	National Electricity Regulatory Commission
NFA	No Further Activity
NGO	Non-Governmental Organization
NH ₄ ⁺	Ammonium ion
NIMET	Nigerian Meteorology Agency
NIWA	National Inland Waterways Authority
Ni	Nickel
NNPC	Nigerian National Petroleum Corporation
NPF	Nigeria Police Force
°	Degree
°C	Degree Celsius
OML	Oil Mining License
OGGS	Oil Gas Gathering System
P	Phosphorus
Pb	Lead
pH	Hydrogen ion concentration
PO ₄ ⁻	Tetraoxophosphate (VI) ion
ppm	Parts Per Million
PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
PHCN	Power Holding Company of Nigeria
RH	Relative Humidity
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
SHOC	Safe Handling of Chemicals
SIA	Social Impact Assessment
SMART	Specific, Measurable, Achievable, Realistic and Time-based
SPDC	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
SPM	Suspended Particulate Matter
SW	Surface Water
SWL	Static Water Level
Tcf	Trillion cubic feet
TF	Total fungi
TDS	Total Dissolved Solids
THC	Total Hydrocarbon
THC	Total Hydrocarbon Content
ToR	Terms of Reference
TOC	Total Organic Compound
Tscf	Trillion standard cubic feet
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
TPH	Total Petroleum Hydrocarbon
UR	Ultimate Recovery
V	Vanadium
VAR	Value Assurance Review
VEG	Vegetation
VOC	Volatile Organic Carbon
WHO	World Health Organization
Zn	Zinc
%	Percentage
‰	Parts per thousand
µg/l	Microgram per liter
µS	Micro Siemens

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EXECUTIVE SUMMARY

ES1.1: Introduction

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of its Joint Venture partners (Nigerian National Petroleum Corporation (NNPC), Nigerian Agip Oil Company (NAOC), and Total E&P) plans to embark on the Dodo-North Non-Associated Gas (NAG) Wells Project to meet the business objectives of domestic gas supply and gas flares down. Dodo North is a partially appraised field and yet to be produced. The field, which is located in SPDC's OML 35 and about 65 km South of Warri, was discovered in 1981 and to date a total of 2 wells have been drilled in the field. Hydrocarbon has been discovered in 10 reservoirs. Out of the 10 reservoirs 9 are pure NAG reservoirs and one reservoir (U5000X) has 10ft of oil rim. Dodo North is surrounded by Opomoyo, Orubou and Opukushi fields. These fields are in the same structural setting with Dodo North, separated by saddles, and sharing the same stratigraphic elements. Dodo North field development was strategically considered a quick win to produce gas essential to meet the domestic gas obligation of 100MMscfd agreed with the Federal Government due to its proximity to the Tunu Central Processing Facility (CPF) and the flexibility of drilling new wells on existing location with minimal land-takes. The Dodo North wells shall have a peak individual production capacity of 100MMscfd which shall be regulated to make up Associated Gas (AG) volumes, maintain domestic gas obligation of 100MMscfd over the next 10years and maintain effective reservoir management. An Environmental Impact Assessment (EIA) for the project has been carried out in accordance with statutory requirements of Nigeria and SPDC HSSE policy.

ES 1.2: Administrative and Legislative 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, National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007. Other regulations include Forestry Law CAP 51, 1994, Land Use Act of 1978, Bayelsa State Environment and Development Planning Authority Edict 1998, Public Health Law – CAP 103 of the Laws of Eastern Nigeria 1963, Bayelsa State Forestry Law 1998, Bayelsa State Land Use (Environmental Degradation/Protection) Charge Law 2005. 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.

ES 1.3: EIA Objectives

The objectives of the EIA study are to:

- Determine the baseline conditions of the environment (Biophysical, Socio-economic and Health)
- Determine and evaluate the potential impacts of the proposed project activities on the biophysical environment of the area.
- Identify and evaluate the potential socio-economic effects of the project on the communities including impacts on cultural properties, social infrastructures, natural resources and lifestyles / values.
- Identify and evaluate health impacts that may result from the different phases of the project.
- Develop cost-effective mitigation measures and appropriate Environmental (biophysical, social and health) Management Plan (EMP).

ES 1.4: Project Location

The proposed project area is at the Dodo-North Field which is situated in the Southern boundary of OML 35, in the coastal swamp area, approximately Seventy kilometers (70km) West of Yenagoa. It is located within Ekeremor LGA in Bayelsa State. Dodo River is the main water body draining the area. The inhabitants of the project area are mostly Ijaw speaking communities. The project area is located within the equatorial belt that experiences rainfall for most of the year. The proposed project is situated in N101394 and E362449.72 and N101352.44 and E362447.64. A land size of about 11hectares will be utilized.

ES 1.5: Project Objectives

The objectives of the Dodo North NAG Wells Project are:

- Align with government's aspirations by contributing about 100mmscf/day of gas from the Southern Swamp Area to the domestic gas network.
- 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.

- develop additional new oil and gas in the node (90.4 mmbbl with 54.3 bcf AG and ~268 Bcf NAG).
- enhance Company reputation through execution of capital projects that has attendant benefits to host and impacted communities.

ES 1.6: Execution Strategy and Cost

Shell Petroleum Development Company (SPDC) has existing contracts covering the wide variety of well engineering flowline installations and commissioning services that will be required for the drilling and completion of these wells. The total project cost is \$344.184million. This comprises of \$75.606 million for flowlines and manifold/bulkline and \$67.328million for wells, \$192.855million for NAG CPF at Tunu and \$8.395 for EIA studies and sustainable community development.

The base economic indicators show an NPV (7%) of \$ 20.5 million, a UTC of US\$13.0 per bbl and VIR (7%) of 0.26. Drain hole length of 60 ft and tubing size of 7inch have been recommended for the two drainage points developing the U6000X reservoir. The U1000X and U5000X reservoirs will be developed with a drain hole length of 20ft and tubing size of 7inch. The Economics assumes Dodo North will pay the full cost of the NAG facility. However, future development in the node will utilise the NAG facility to sustain supply beyond depletion of the Dodo North reservoirs.

ES 1.7: Project Justification

One of the objectives of the Nigeria Gas Master Plan is to generate enough gas into the Nigeria Domestic Gas market and SPDC is committed to this plan. Southern Swamp is one of the sources of SPDC's gas portfolio. To guarantee the sustenance of a minimum of 100 MMScf/d of Gas supply over a period of ten years from the Southern Swamp Associated Gas Solutions plus (SSAGS+) project to the Western Domestic Gas Market, it is planned that 2 NAG wells will be drilled from existing location at Dodo North to supplement the AG volumes from the Southern Swamp Node.

The Dodo North NAG Development (i.e. drilling of 2 NAG wells and laying of a Bulkline) is an integral and strategic component of the SSAGS+ Project. The SSAGS+ Project obtained EIA approval from FMEnv in 2003 but the project was stalled in 2006 due to a combination of security situation in the Niger Delta area and funding challenges. The previous SSAGS+ Project scope had 51oil wells while the revised scope currently being progressed has only 18 but with the inclusion of 2NAG wells from Dodo North.

The EIA approval for the SSAGS+ project has been revalidated by FMEnv (ref. FMEnv/CDONF/EIA/123:208/Vol III/223) of 7th June 2013 upon completion of one season sampling and updating of the EIA Report by SPDC. However, this approval did not cover Dodo North NAG wells and hence the need to prepare a supplementary EIA Report to cover Dodo North.

ES 2.1: Project Options

The project alternatives considered were;

- No Project Option
- Drill from new location
- Drill from existing location

The project options chosen were drill from existing location. The advantages of the drill from existing location are these; No land take, No additional Capital Expenditure, Employment opportunities, Contract opportunities, No negative impact on project schedule, Minimal vegetation clearing and Source of revenue to Federal Government. The disadvantages of this option are these: Increase pressure on existing facility, Dredging required for preparation of the location. But the volume/impacted area will be smaller compared to option 2.

Project Alternatives

The Project alternatives for the proposed Dodo North NAG Wells Development Project spans from Drilling options, Route selection to Drilling options. In order to optimize the use of existing processing facilities and minimize environmental impact, SPDC plans to do the following: Reuse same well slot for DN-001 and spud two new wells to target reservoirs; Use instrumented protection system to derate design pressure for the bulkline to the flowing tubing head pressure; Open cut dredging to depth of 4.5m below LLWS and minimum 3m top of pipe cover and Open Cut trench backfilled with 1m top of pipe cover (within the swamp terrain and shallow non navigable creeks).

ES 2.2: Project Sustainability

Economic sustainability

Dodo North NAG Wells have large reserves of Non-Associated Gas and oil. There are therefore proven reserves of gas that can economically and commercially support the project. There is high demand for natural gas in the international and domestic market. The host communities will benefit from the project through local contracting and employment opportunities, increased cash flow and stimulation of local economies within the communities and Stimulation of local economy and markets from increased demand for food, and other products in the local market.

Technical sustainability

Dodo North NAG Wells are technically sustainable because of SPDC's proven gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Proven technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project.

Environmental sustainability

Facilities and flowline (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.

ES 3.1: Proposed Work Scope

- Drill 2 Non Associated Gas (NAG) wells (DN 001 and DN 002) on existing well slots to minimize additional land take.
- Lay Gas Flow Line: 10” x 10km bulkline from Dodo North Well 1 and 2 (DN 001 and 002) to Tunu CPF

Summary of Project Activities

The summary of the project activities includes but not limited to the following:

- Land acquisition;
- Premobilization/Mobilization: Rig Move (including personnel, equipment and supplies logistics),
- Construction: Site clearing, Location preparation/dredging, Drilling campaign (Well drilling, Casing and cementing, Completion and perforation, Well testing, Flowline hook – up), Laying, Backfilling and Site Restoration, Beveling, Fitting and Welding, Non Destructive Weld Inspection / Testing
- Demobilization: Transportation of equipment and personnel
- Operation and maintenance
- Decommissioning and Abandonment

The envisaged waste streams to be generated from the proposed project activities include Muds, Cuttings, Cement, Brine discharge, Sand consolidation fluid, Sewage, Industrial and domestic wastes, Rig bilge etc.

Wells (Drilling & Completion) and Schedule

Well drill campaign shall involve side tracking from existing appraisal wells located at 362449.7 East, 101394 North and 362447.6 East, 101352.4 North respectively for Dodo North 1 and 2 (DN 001 and DN 002) NAG wells. Both wells will be drilled in March and May 2014 respectively. Drilling and Completion activities will be executed as part of the development. The project activities is envisaged to begin in July 2015 (Secure EIA approval for Dodo North Wells) and concluded in June 2016 (Site demobilization).

Well Decommissioning/Abandonment

The wells that have no economic value will be decommissioned and abandoned in line with SPDC Well Abandonment Policy. On reaching the end of the project life span (25years), a decommissioning team shall be set up to plan and implement the guidelines for decommissioning/abandonment to ensure that the best and practicable methods available are employed to clean up the project site.

ES 4.1: Environmental status

The environmental (biophysical, social and health) baseline status was produced based on a first-season (wet season as approved by the Regulators) field exercise carried out between 1st and 11th August, 2012. The EIA of SSAGG 2003 served as the second season (Dry Season) for biophysical parameters, while the EIA of Benisede catchment Area Phase 1 2004 was used for aquatic microbiological results for dry season. The laboratory analysis was carried out by Thermosteel Nigeria Limited, Warri, Delta State.

The baseline was produced based on a one-season (wet season) field exercise carried out between 1st and 11th August, 2012 as approved by the regulators (See Appendix VII). The EIA of SSAGG 2003 served as second season (Dry Season) for biophysical parameters, while the EIA of Benisede catchment Area Phase 1 2004 was used for aquatic microbiological results for dry season. The numbers of samples collected during the data gathering exercise were: Air quality (7 and 2 controls); Soil (35 and 2 controls); Surface water (17 and 2 controls); Sediment (17 and 2 controls) and Groundwater (6 and 2 controls).

Study Locations

The sampling points were geo-referenced using Global Positioning System (GPS). 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.

Climate, Meteorology, Ambient Air Quality and Noise

Wind

The sampled areas are located about 70 km West of Yenagoa, an area which is under the Tropical Wet climate zone. Analysis of climatic data obtained from Port Harcourt and Warri synoptic stations show that the prevailing wind directions are South Westerly between March and October, which roughly coincides with the rainy season, whereas the North Easterly wind are rather frequent between November and February during the dry season. The surface wind speed measured during field studies ranged from 0.1 to 0.5 m/s for 64% of the time, 0.6 to 1.0 m/s for 28% of the time and greater than 1.0 m/s for 8% of the time. Average wind speeds measured at the sampling sites were 1.88 m/s during the dry season (2003) and 1.46 m/s during the wet season at Tunu (2012), whereas at Dodo North they were 1.33 m/s and 0.97 m/s respectively.

Rainfall

The project area is located within the equatorial belt that experiences rainfall for most of the year. A ten-year historical climatic data covering 1997 to 2008 confirms that rainfall is recorded all year round. The average monthly rainfall data 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.

Relative Humidity

The relative humidity (RH) values of the study area are high all year round with an average of 78.5%, which is typical of equatorial climate. Humidity values naturally exceeded 85% during the rainy season under the influence of the moisture laden South Westerly wind. Relative humidity measured during the field work ranged from 72.9 to 97.50 %. During the dry season, RH was 75.65% at Tunu (2003) and 71.27 at Dodo North (2003), whereas during the wet season, it was 84.42 and 86.33% respectively.

Temperature

The study area experience uniformly high temperatures throughout the year because of high insolation. The highest mean monthly maximum temperature of 33.6°C occurs in February while the lowest value of 27.3°C is experienced in July, during the peak period of the wet season. The ambient temperatures recorded during the field survey ranged from moderate to high i.e. 25.3 to 31.0°C with an average of 28.15 °C. Average temperature was 30.5 °C at Tunu (2003) during the dry season and 27.44 °C during the wet season (2012), whereas, it was 32.27°C at Dodo North during the dry season and 26.85°C (2003).

Noise and Vibration

On the average, noise was 71.4 dB(A) at Tunu during the dry season and was significantly lower, being 43.21 dB(A) during the wet season. A similar pattern was observed at Dodo North; noise being 75.05 dB(A) during the dry season and 38.73 dB(A) during the wet season. However, all the measurements taken fell below FMEnv/DPR permissible limit of 90 dB(A) for 8 hr exposure limits and are all within acceptable limit.

Air Quality

During both seasons, NH₃, SO₂, NO₂ and NO were not detected (<0.01 ppm). Carbon mono oxide (CO) was not detected during the wet season in both stations, but low concentration was recorded during the dry season being 1.31 ppm at Tunu and 1.88 ppm at Dodo North. The CO therefore fell within the DPR/FMEnv regulatory limits of 10 – 20 ppm. Similarly, H₂S was not detected in the wet season whereas in the dry season H₂S was 0.91 ppm at Tunu but was significantly lower at Dodo North being 0.21 ppm. During the dry season, SPM was higher in Tunu than Dodo North, but lower during the wet season. At Tunu, SPM was 45.53 µg/m³ during the dry season and 0.97 µg/m³ during the wet season, whereas at Dodo North, SPM was 18.23 µg/m³ during the dry season and 1.65 µg/m³ during the wet season. These values were several orders lower than the permissible DPR/FMEnv limits of 250 µg/m³ and World Bank limit of 150 - 230 µg/m³. Volatile Organic Compounds (VOCs) was 0.02 µg/m³ in Tunu and 0.24 µg/m³ in Dodo North.

Soil Physico-chemistry

Soil texture in both dry and wet seasons was mainly sand, pockets of silty clay were observed beyond the coastlines. Loamy sand texture was found around Tamogbene. Mean soil temperature was 27.08 in the area and 27.30°C in the control surface soil, which are favorable for microbiological transformations. Mean surface soil pH was 3.60 and 4.24 in dry and wet season respectively and that of the control was 4.41. This indicates extreme acidity that is typical of mangrove swamp soils. Exchangeable Ca and Mg of the soil in both seasons were low but with sufficient K in the dry season. Heavy metal concentrations occurred in safe concentrations, except iron that was generally high in both season in the area and the control soils. Higher Fe concentration in the mangrove swamp soils has been reported in the Niger Delta.

Vegetation/ Land Use

The vegetation of the area is mainly mangrove swamp forest. A total of 5 species of tree plants, 2 species each of ferns and hydrophytes were identified in the mangrove swamp forest. The commonest trees were *Rhizophora mangle* and *Rhizophora racemosa* (red mangrove). The vegetation cover varies from 70 to 80%. Common plantation crops include sugar cane (*Saccharum officinarum*), plantain (*Musa paradisiaca*), cassava (*Manihot* spp.), and cocoyam (*Colocasia esculenta*). Uncontrolled and exploitative commercial lumbering which is fairly widespread across the study area was higher in Tamogbene.

Aquatic Studies

The major rivers sampled were the Ramos and Dodo River. Other creeks and creeklets sampled were tributaries of these major rivers.

Water Physicochemistry

The pH ranged from slightly acidic to slightly alkaline in the wet (6.12-7.70) and dry season (5.53-7.95). These pH values were generally within the DPR/FMEnv limits of 6.0 – 9.0 except at the dry season where a pH of 5.53 was recorded. Temperatures were generally higher in the dry season (23.87-28.5°C) than wet season (29.1-32.6°C). Temperatures recorded during both seasons are generally lower than the DPR/FMEnv limits of 40 °C.

Three turbidity related parameters were measured including colour, TSS and turbidity. The colour of the water was lower in the wet season (4.9-15.0 pt-Co) than dry season (0-133 pt-Co). A similar pattern was observed for turbidity. Turbidity values of 2.15-8.65 and 0-20 NTU were recorded during the wet and dry season respectively. This is not unusual because of the diluting effect of rainfall on turbidity, though surface runoff can also increase turbidity during the wet season. It is therefore suspected that flooding might have been responsible for the higher TSS in the wet season (15-16997 mg/l) than the dry season (125-600 mg/l). These values were several orders lower than the DPR/FMEnv limits of 30 mg/l. The TDS levels were directly correlated to the EC values and ranged from 15 to 16997mg/l and 870 to 13000mg/l in the wet season and dry season

respectively. The high TDS levels in the dry season maybe attributed to the effects high temperature resulting in evaporation of water molecules leaving saturated molecules in the water column.

Dissolved Oxygen (DO) was higher in the dry season (5.5-9.8 mg/l) than wet season (3.20-8.25 mg/l) and within the DPR/FMEnv limits of 30 mg/l. However, Biological Oxygen demand (BOD_5) was lower during the wet season (1.99-7.20 mg/l) than dry season (2.6-7.7 mg/l), but lower than the DPR/FMEnv limits of 10 mg/l. Chemical Oxygen Demand (COD) was lower in the wet season (5.0-8.9 mg/l) than dry season (2.4-43.2 mg/l), though lower than the DPR/FMEnv limits of 40 mg/l. All the hydrocarbon related parameters were low (<0.1) in both seasons including THC, TPH, PAH and phenols except for the dry season where THC ranged from 0.7 – 4.7 mg/l, but was still lower than the DPR/FMEnv limits of 7 mg/l.

The electric conductivity during the wet season (20-32070 $\mu\text{S}/\text{cm}$) was slightly higher than the dry season (1761-26000 $\mu\text{S}/\text{cm}$). TDS being directly correlated with conductivity exhibited the same pattern being slightly higher in the wet season. Sulphate was similarly higher during the wet season (0.320-103.34 mg/l) than dry season (6-18.7 mg/l). Chloride was higher during the dry season (562-12116 mg/l) than wet season (5-7100 mg/l), but was significantly lower than the DPR/FMEnv limits of 2000 mg/l. Other anions occurred in traces (<0.1 mg/l) such as carbonate, phosphate, hydrogen sulphide, cyanide, nitrite and ammonia whereas nitrate was <2 mg/l in both seasons.

The major metals in the study area are sodium and calcium followed by magnesium, while potassium occurred in low concentration (23.4-28.2 mg/l) during the dry season. Sodium was higher during the dry season (223-7091 mg/l) than wet season (1-4176mg/l). Calcium was higher during the wet season (3-2819mg/l) than dry season (12.8-280.8 mg/l). Similarly, magnesium was higher during the wet season (1-1689mg/l) than dry season (0.5-371.8 mg/l). Some metals occurred in the order of 1 – 10 mg/l (Cd, Pb, Fe), some metals occurred in the range of 11-20 mg/l (Zn) and others from 21 – 30 mg/l (Cu, Cr, Ni) all the other heavy metals occurred mostly in trace concentrations mostly below equipment detection limits (V, Hg, As, Ba) and <0.6 mg/l (Mn) in both seasons. Heavy metal concentrations were mostly recorded during the wet season, but occurred in traces during the dry season.

Water Microbiology

During the wet season, the population of the Total Heterotrophic Bacteria (THB) in the water samples ranged from 1.9 - 6.1 x 10⁴ cfu/ ml with an average of 4.2±1.0 x 10⁴ cfu/ml, which is in the range found in river waters in the Niger Delta region. The population of Hydrocarbon Utilizing Bacteria (HUB) is in the range of 1.4-3.7 x 10²cfu/ml with a mean of 2.6±0.6 x 10²cfu/ml, thus accounting for almost 50% of the heterotrophic population. This high proportion of HUB indicate that the area have been exposed to petroleum hydrocarbons despite the fact that the concentration of organics (THC, TPH, PAH, phenols) in the water is currently low. Isolated bacteria from the surface waters

include *Bacillus* sp, *Pseudomonas* sp, *Staphylococcus* sp and *Escherichia* sp. The order of predominance is *Bacillus* sp > *Pseudomonas* sp > *Staphylococcus* sp > *Escherichia* sp. The population of the Total Fungi count (TF) in the water sample was at least one order lower than their bacteria counterparts. TF ranged from 1.4-3.7 x 10³cfu/ml with a mean of 2.6±0.6 x 10³cfu/ml. The population of Hydrocarbon Utilizing Fungi (HUF) ranged from 0.4-1.9 x 10³cfu/ml with a mean of 1.0±0.4 x 10³cfu/ml, thus accounting for nearly 100% of the total heterotrophic population. Again, such high proportion of hydrocarbon degraders suggests that the area have been exposed to hydrocarbons either of petroleum or vegetative origin. Fungi isolated from the surface waters include *Penicillium* sp, *Mucor* sp, *Cladosporium* sp and *Candida* sp. The order of predominance is *Mucor* sp>*Penicillium* sp > *Candida* sp >*Cladosporium* sp >*Aspergillus* sp.

Sediment physicochemical characteristics

The pH of the sediment is acidic both in the wet (4.83±0.59) and dry (4.56) seasons. This is not unusual in mangrove ecosystems of the Niger Delta. Exchangeable acidity was 1.09±0.16 cmol/kg in the wet season and 1.65cmol/kg in the dry season. Cation Exchange Capacity was 1.49±0.21 cmol/kg in the wet season. Temperature was 26.89±0.18 °C in the wet season. Electrical Conductivity was several orders higher in the dry season (3925.74µS/cm) than wet season (176.04±159.86 µS/cm). This is expected because of the dilution effect of the flood water during the wet season. Total nitrogen was several orders higher in the wet season (8.77±5.73 g/kg) than dry season (0.50 g/kg). Phosphate was 3.22±2.75 mg/kg, which was within the DPR intervention levels of 0.3-5.2 mg/kg.

Sodium concentration in the sediment is higher than calcium, potassium and magnesium. Sodium was several orders higher in the wet season (80.76±60.53 mg/kg) than in the dry season (4.17 mg/kg). In terms of dominance, potassium is next to sodium. Potassium was also several orders higher in the wet season (15.83±22.97 mg/kg) than dry season (0.92 mg/kg). Calcium and magnesium occurred at almost the same levels in the sediments. Calcium was slightly higher in the dry season (7.57 mg/kg) than wet season (7.47±2.49 mg/kg). Magnesium contraction in the dry season (8.27mg/kg) was twice that of wet season (4.33±1.44mg/kg).

Several heavy metals were analyzed in the sediments. In both seasons, many of the metals occurred in traces i.e. ranging from <0.001 to 0.1 mg/kg such as Ba, Hg, and V. Next in dominance is Cd, which was reported in the wet season in the range of 2.55-8.64mg/kg with a mean of 4.88±0.64mg/kg. This level of Cd is within the DPR target/intervention value of 0.8-12 mg/kg. The concentration of Ni, Cr, Pb and Cu were in the range of 16 – 20 mg/kg in the wet season, whereas these parameters were several orders lower in the dry season. All these parameters were within the intervention values. Zinc was several orders higher in the wet season (93.81±167.03 mg/kg) than the dry season (5.59 mg/kg), though lower than the intervention values of 140-720mg/kg. Among the heavy metals, Fe had the highest concentration, of 322.32±201.72 mg/kg in the wet season and 1418.30 mg/kg in the dry season. The high level of Fe is not unusual in the Niger Delta.

Total Organic Carbon (TOC) was within the DPR intervention levels of 0.3-10 mg/kg in both seasons, being 4.47 ± 1.95 mg/kg in the wet season and 6.19 mg/kg in the dry season. TPH in the wet season (6.27 ± 2.07 mg/kg) was twice that of the dry season (3.56 mg/kg).

Sediment Microbiology

In the wet season, the Total Heterotrophic Bacteria (THB) population ranged from 1.22- 5.50×10^5 cfu/g with a mean of $3.22 \pm 1.23 \times 10^5$ cfu/g. Hydrocarbon Utilizing Bacteria (HUB) population ranged from $1.32 - 2.90 \times 10^3$ cfu/g with a mean of $2.25 \pm 0.43 \times 10^3$ cfu/g. Hence, the percentage of hydrocarbon utilizers is about 50% of the heterotrophic species indicating that the area may have been exposed to oil either of petroleum or vegetable origin. Bacteria species isolated from the sediments include *Staphylococcus* sp, *Bacillus* sp., *Pseudomonas* sp, and *Escherichia* sp. Likewise, Total Fungi (TF) ranged from $1.67 - 3.68 \times 10^4$ cfu/g with a mean of $3.07 \pm 0.64 \times 10^4$ cfu/g. Hydrocarbon Utilizing Fungi (HUF) ranged from $1.02 - 2.01 \times 10^2$ cfu/g with a mean of $1.58 \pm 0.23 \times 10^2$ cfu/g. Thus, HUF accounted for about 50% of the total heterotrophic population. Species of fungi isolated from the study area include *Mucor* sp, *Penicillium* sp, *Cladosporium* sp.

Aquatic Ecology

Phytoplankton

These are microscopic chlorophyll containing plants in the water column called algae. The phytoplankton comprised of 17 species belonging to the divisions Cyanophyta (blue green algae) with 7 species, Chlorophyta (green algae) with 5 species, Euglenophyta (euglenoids) with only 1 species, and Bacillariophyta (diatoms) with 4 species. The division Cyanophyta contributed the highest percentage to the total phytoplankton density, followed by Chlorophyta. The dry season phytoplankton comprised 16 species made up of the divisions Bacillariophyta, Cyanophyta and Euglenophyta, with Bacillariophyta dominating the population. The overall diversity of phytoplankton in the study area was also low, with Shannon diversity index values less than 2.0, indicating an unstable and perturbed environment.

Zooplankton

The wet season zooplankton community comprised 30 species made up of 8 protozoans, 7 rotifers, 3 ostracods, 6 cladocerans and 6 copepods. The cladocerans dominated the zooplankton community, contributing 40 % of the total population, followed by the ostracods (22 %) and copepods (17 %). The rotifers (11 %) and protozoans (10 %) were the least represented. The density of zooplankton in the study area was low, with the highest values occurring in the control locations SWC 1 and SWC 2 (Fig. 4.2.4.6.2). Similarly, the overall diversity which measures community stability was low, ranging from 0 to a maximum of 2.11 in SWC 1.

During the dry season, only ten (10) species belonging to Cladocera (2) and Copepoda (8) were recorded. The Rotifera, Protozoa and Ostracoda were not recorded during this season. The cladoceran group was poorly represented, with only two species, *Bosminopsis deitersi* (Bosminidae) and *Moinamicrura* (Moinidae). The Calanoida

comprised *Thermodiaptomus yabensis* and *Arcatiatonsi* (Diaptomidae), making up 5.1% of the Copepoda. The Cyclopoida comprised *Thermocyclops crassus*, *Cryptocyclops bicolor*, *Halicyclops korodiensis* and *Tropocyclops* sp. The Harpacticoida represented by *Bryocamptus birsteini* were insignificant.

Macrobenthic fauna

These are those organisms which are over 1.0 mm in size, living on or in the substrate. They may be infauna (living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids, chironomids and bivalve molluscs) or epifauna (living on the surface, either, crawling as mobile benthic inhabitants or attached to different types of substrates. The bottom dwelling macrobenthic invertebrates recorded during the wet season were represented by 12 species of Mollusca made up of 3 species of Bivalvia and 9 species of Gastropoda. The bivalves were dominated by *Egeriaparadoxa* and *Sphaerium occidentale*, while *Thais haematobium* and *Tympanotonus fuscatus* dominated the gastropod mollusks. The density of benthic fauna was low in all the stations. The overall diversity was also low, with zero Shannon diversity index (H') in most of the stations, a reflection of substrate instability.

The dry season benthic macroinvertebrate composition was more robust, made up of fifteen (15) macrobenthic invertebrate taxa comprising 3 Oligochaeta, 8 Polychaeta, 1 Decapoda and 3 Gastropoda. Of these macrofaunal groups, Polychaeta was dominant, contributing 68% to the total benthic density. The Oligochaete group comprised three families, Enchytraeidae, Naididae and Tubificidae each represented by a single species. *Enchytraeus* sp. was dominant.

Fisheries

Fisheries involve the utilization of harvestable aquatic organisms and represent complex interactions between the population of organisms being harvested, the population of fishermen, and environmental conditions. Fishing is the most common occupation in the area, although crop farming, lumbering and other occupations are available. Fishes studied were those caught by the local fisher folks during the study period.

Local paddle boats or dugout types are mainly used during fishing activities; the most commonly used fishing gears are gill nets (very common) and, filter nets, cast nets, and encircling nets in near and distant waters. Long lines, traps and the use of hand nets are common in all the locations studied. No modern fish pond was found in the whole of the areas visited, but local fish ponds created by constructing barriers in creeks and water inlets are common.

The catch per unit area is generally low as reported by the fishermen in the localities due to very high amount of rainfall causing migration of fishes. But in some locations in Tunu it was found to be high, especially with cat fish. This low catch per unit area has led to high prices in the whole of the communities.

Fisheries resources in the area are of diverse and multi-species due to fresh and brackish water conditions. Eleven fish species in fifteen families were identified. The Cichlidae is the most dominant family and had four different species while the Mochokidae had two species and other families were represented by single species. Shellfishes common in nearly all the locations include prawn and/or crayfish Atyidae and Palaemonidae. The prevailing condition factors showed that the fishes have favourable conditions to thrive. Heavy metal analysis in fish tissues revealed no evidence of bioaccumulation in the fish specimens examined.

Geology/Hydrogeology

The thick wedge of the Niger Delta sediments consists of the Benin formations (sands are mostly coarse-grained, pebbly, poorly sorted and contain pods and lenses of fine-grained sands), underlying deltaic Agbada formations (consists of interbedded sands and shales) and Akata formation (is a basal unit comprising of marine shales). This unit also comprises some sand beds. The thickness ranges from 600m to possibly 6,000 metres. The stratigraphy is uniform in all the boreholes. This comprises a muddy clayey sand top soil, a saturated silt and sand mélange that grade into silty sand substratum that makes the aquifer phreatic. In the wet season, concentrations of Hg, V, Ni, As, Pb, Cd and phenol occurred in trace amounts. Similarly, mean Fe, Cu, Cr, Zn, Mn and Ni contents of the area groundwater in the dry season were below WHO limits. Concentrations of nitrate, sulphate, carbonate, nitrite and ammonium ion were low; likelihood of groundwater pollution is rare in the area.

Mean THB and TF counts in the wet season were 3.95×10^4 and 3.73×10^3 cfu/ml while the controls were 4.10×10^4 and 3.79×10^3 cfu/ml respectively. Mean HUB and HUF counts in the wet season were 1.9×10^4 and 1.2×10^3 cfu/ml while the controls were 1.67×10^4 and 1.1×10^3 cfu/ml respectively. Results suggest high levels of organic carbon in groundwater. High microbial populations suggest potentially high recovery rate of the groundwater in the event of organic pollution.

Social Impact Assessment

The Dodo-North Project area covers the Amabuluo, Tamogbene (Ayama), Norgbene, Egbemo-Angalabiri and Agbidiana in Ekeremor Local Government Area of Bayelsa State.

Historical Perspective of the Community and Cultural Property

The natives of the project communities are largely of the Ekeremor tribe (Operemor, Operemo), which is an ancient Ijaw speaking ethnic community and historically, they settled in the area several thousand years before the arrival of the Portuguese on the coast of the Niger Delta in the 15th century. The natives have a common migration story and this is tied to their common language, festivals and taboos. According to oral tradition, they have close historical and kinship ties with the *Oporoma*, *Eastern Olodiana* and *Ogbe* tribes.

Belief Systems, Religion, Customs, and Cultural Heritage

The cultural heritage, migration pattern, and religion have considerable influence on the overall belief and value system of the people. There are other belief systems, which revolve around common taboos and traditional practices of doing some things at certain times. Typical prohibitions include killing of tortoise, python and the pure white coloured bird, damage of the red/white cocoyam by non-natives, entering of masquerade buildings or ancestral shrine sites by non-natives/members and sales of periwinkles. Though 97.3 % of the residents claimed to have strong Christian affiliation, there are strong influences of traditional religious beliefs in the area, especially among the natives. Specifically, some cultural practices are celebrated with a religious fervour in their seasons. Festivals are part of the cultural heritage of the people and such festivals like the *AsiOge festival* is celebrated among the Ekeremor natives each year for the promotion of cultural cohesion among the Ijaws, promotion of cultural dances, arts and play, and provision of entertainment and relaxation. Notable shrines in the area include *Okonusu and Baribe*. *Okilogboligbo* is known to be a very important sacred forest where women are forbidden to enter. Because of the cultural significance attached to the animals mentioned above, the natives have been ensuring that their habitats are protected. The community is patrilineal; therefore, inheritance rights are reserved for biological offsprings especially the male members of the household who may be obliged with education, welfare and such other benefits as the head of the family may be willing and able to afford.

Population Description

The Nigeria 2006 Census puts the population of Ekeremor LGA at 269,588; with males constituting 51 % (137,753) and females 49 % (131,835), but with a population growth rate of 2.553 %. The population figure is estimated to be about 310,883.5 comprising 57 % (179048.5) males and 43 % (173130.5) females as at 2012. This suggests an increase in population of the study area with implications on increased demand on social amenities. However, in the communities, males constituted about 61 % while females made up about 39 % of the population studied. Field survey shows an average of 8 persons per dwelling unit with about 37 % households having between 7 and 10 persons in a family. The age composition of the community reveals the characteristic trends and spread; persons below the 26 years age bracket constitute an overwhelming percentage of approximately 63 %, with overall household structure more typically pyramidal for the fishing communities. About 70 % of the communities members are married while 26.2 % are single, and polygamy is a common feature in the community as most men have between 2-4 wives. The modal educational attainment amongst the population in the communities is primary educational level, with about 70 % of the sampled population having the post primary education and close to one-tenth (8.1 %) having some forms of tertiary education.

Traditional Governance Structure

The traditional administrative structure of the communities is basically title holding, executive committees and youth association. The political administration is well structured with the paramount ruler/community chief at the apex of authority. The paramount ruler is called or addressed as the Amayanabo or king appointed. He is

assisted by a council of chiefs, CDC members, youths and women in day to day running the communities. Youth and women play administrative roles but care for themselves. Internal conflicts are rare, except minor domestic, fishing rights and resource ownership disputes that are easily resolved and settled with or without external mediations. Leadership conflict is non-existent among the residents. No external conflicts like inter-communal clashes. Generally there is high level of social cohesion and relational social capital among the residents resulting in formation and sustenance of various social groupings along gender and age dimensions. These social groups are effective vehicles for social mobilizations and also offer mutual support for their members during times of bereavement and festivities.

Livelihood Sources and quality of life

The occupational distribution of the people in the studied area reveals that majority (52 %) were fisher folks, 18 % were into trading while about 15 % were into non-fish or crop farming as a major occupation. The findings suggest that different occupation or income generating activities exist in the communities. About 10 % of the household heads were not involved in any income generating activities and this is an indication of high level of employment in the project area. Majority of the respondents earned between N5,000 and N10, 000 but the average weekly income is estimated to be about N15, 450.00. Respondents however noted that the income range is not consistent through the years as it changes with the seasons and festivities. Household expenditure followed the distribution of income level as majority spend between N5,000.00 and N10,000.00 weekly while in a week average expenses per household amounts to about N13, 971.00. Given that the average household size in the area is about 8 persons per family, it therefore implies that in a week per capita income and expenditure is about N1, 927.50 and N1, 746.37 respectively. Therefore, on the basis of one dollar or N160.00 per day poverty line thresholds, it can be inferred that majority of the residents are relatively poor. When asked to self-evaluate their poverty status most ranked themselves as very poor (71.9 %) while 28.1 % saw themselves as being averagely poor. Interestingly none perceived themselves as being non-poor. This self-evaluation by the respondents and the proportion of income spent daily, gives an insight into the high rate of poverty prevalent in the communities studied. A typical household in the communities lacks modern home assets probably because of low household purchasing power.

Social Infrastructure

There was lack of most basic amenities for quality living. Government presence at both state and local levels was minimal. Most communities' had primary and secondary schools, many of which were government owned and these schools suffer from inadequate staff and facilities such as tables and chairs. Some of the school buildings were dilapidated. Access to treated potable water supply is not available in the communities. Therefore, community members collect drinking water from shallow hand-dug wells, ponds, package water and natural rain harvesting, which are unsustainable, risky and contaminated sources of water for domestic use. Access to energy supply is grossly poor and erratic from the national grid of the Power Holding Company of Nigeria

(PHCN). Accessibility to the communities and settlements is largely limited and problematic; inter-community movement is strictly by water. Access to public communication facilities is limited. Waste management facilities are non-existent. Domestic wastes are disposed indiscriminately either into the surrounding bushes or water bodies. Housing types in the communities and settlements are overwhelmingly constructed of ephemeral materials derived from reeds, thatch and wood/planks. The housing types are evidently those of fishing settlements. None of the fishing settlements has a structured and well developed market place, but the tradable produces are either traded along the shore of the rivers/creeks or transported to Warri town by women for sale.

Lifestyle and social vices

Alcoholism has become a lifestyle in the community as about 80 percent of the community members take alcohol. There appears to be some level of discrimination against women, especially with respect to inheritance rights to land/buildings. Child work as an aspect of child entrepreneurship instead of child labour was a common feature in the communities as children are known to assist parents in their economic activities. The level of crime is low because the communities are homogenous except for the few non-indigenes. The commonest crime in the area is crude theft in the water bodies in the region. Although there is no form of social exclusion of the physically challenged persons but all are completely absorbed into the system in the communities, nevertheless there is no programme specifically designed to assist them.

Concerns and Expectations

The general populace in the area has a mixed outlook about the proposed Project. About 70 percent gave their full support while 18.5 percent said their support was with reservations. Similarly 11.2 percent had little support for the proposed project. Their lack of full support was borne out of fear that the project will only end up benefiting few individuals in the community. Equally of concern was that the proposed benefits of the project may be hijacked or diverted away by the community leadership who may take the funds and fail to apply such to development projects. Community residents hold high expectations of the proposed project in areas of provision of portable drinking water and equipping of the schools within the communities, providing gainful employment to indigenes and constant electricity. Community fears toward the project centered on the different forms of diseconomies that would accompany the project, which include contamination of local water supplies, increased incidence of ill health and disturbance as a result of noise/vibrations of the heavy equipment that will be used at project sites . Forceful acquisition of land without settlement of community/land owners and consequent conflict that may arise were the major social concerns expressed by community members.. Some members feared the coming of the project may encourage some youths to engage in active militancy as a means of getting money from the SPDC. To ensure that the whole communities benefit from any accruable benefits, the communities were generally emphatic that SPDC should stop dealing with “portfolio carrying chiefs”.

Health Baseline Status

The main communities in the Dodo North NAG Wells project area are the Amabolou Federated communities (i.e. Amabolou, Tamogbene and Norgbene) in Ekeremor LGA of Bayelsa State. In addition, the communities in the Tunu Field where the proposed new pipelines from the NAG Wells would terminate are Agbidiana and Egbemo-Angalabiri (Akpediana). All the project communities are “riverine” communities, because they are only accessible by water and their indigenous populations are predominantly fisher-folks.

Morbidity and Mortality Pattern

The Nigeria Malaria Indicator Survey of 2010 reported a malaria slide positive rate of 32.2% among children 6-59 months old in Bayelsa, showing the relative importance of malaria as a cause of febrile illness in the area. Integrated Disease Surveillance & Response data archive for 2012 showed that 453 cases of suspected malaria were recorded at all reporting health facilities in Ekeremor LGA, of which 35 warranted hospital admission and 65 were pregnant women. No death was recorded in the year.

Epidemic prone diseases were not prevalent but yet present in Bayelsa State in 2012. Analysis of the Weekly Epidemiology Report published by the Federal Ministry of Health on epidemic prone diseases for Week 52 revealed one case of Cerebro-Spinal Meningitis occurred; Cholera, 2 cases; Measles, 86 cases and Yellow Fever, 6 cases. However, there was no fatality recorded.

Non-communicable diseases have also been documented as important causes of ill health in Bayelsa State where the proposed project would be located. Stroke patients constituted 2.3% of the total hospital admissions and 9.3% of medical admissions at the Niger Delta University Teaching Hospital, Okolobiri, the only tertiary health institution in Bayelsa State. Hypertension was found in 89% of these individuals that had stroke.

Mortality (deaths) among the most vulnerable population groups, children under-five years and women of child-bearing age, have been reported to be high in Bayelsa State where the project communities are located. The Multiple Indicator Cluster Survey of 2011 reported that infants (under-1 year old) died at a rate of 107/1000 live births, which was higher than the average rates in the South-South zone and Nigeria as a whole.

Nutritional and Immunization Status

The 2011 Multiple Indicator Cluster Survey reported a prevalence of chronic and acute malnutrition as 15.9% and 7.3%, respectively in Bayelsa State where the project is located. However, these figures represent a decrease in the rates from the 2008 NDHS findings, and are lower than the South South and National averages. Bayelsa State DPT3 immunization coverage of 38.3% was below the averages for South-South zone and Nigeria.

Lifestyle and Health Knowledge, Attitude, Practice & Behaviour

The proportion of women and men with comprehensive knowledge of HIV/AIDS in Bayelsa State was found to be higher at 41.7% and 76.2%, respectively, than figures for South South zone and the National. However, in Bayelsa State, higher rates of multiple

sex partners were also found among women and men (2.7% and 22.1%) than the average rates for South-South zone and National. Qualitative information obtained from informal interviews with key informants in the communities in 2012 indicated that many of them had heard of HIV/AIDS; that polygamy was common; and there were allusions to preponderance of male infidelity.

Use of alcohol and tobacco was also reported from qualitative assessments. It was noted that, “alcoholic beverages were freely available and at all times in the communities, while about 20% of the adult males in the communities smoke cigarette”.

Health Care Infrastructure

Examination of records from Bayelsa State Ministry of Health revealed that government-owned health facilities exist in Ekeremor LGA, however they are in various states of functionality. Within the Dodo North NAG Wells project area, the distribution of health facilities shows that functional Primary Health Care centres were present in Tamogbene, Agbidiama, and Egbemo-Angalabiri communities, whereas Amabolou and Norgbene had none. Cottage Hospitals were also present at Tamogbene and Egbemo-Angalabiri.

The Cottage Hospital in Tamogbene was built by SPDC as part of its tri-partite community health partnership; the hospital was observed to be undergoing renovations during the field study. On the other hand, the Amabolou PHC Centre had remained uncompleted over the years the construction project was commenced.

Tertiary health care services, provided at the Niger Delta University Teaching Hospital (NDUTH), Okolobiri and the Federal Medical Centre, Yenagoa, were not within close reach of members of the project communities due to distance.

Medical Emergency Evacuation System was inadequate in the project area; none of the health care facilities in the communities had a boat ambulance, and were not served by any company-owned Emergency Medical Service due to security reasons and decline in industrial activities within the area.

Alternative health care was actively patronized in particular Patent Medicine Vendors and traditional medicine practitioners – evidence of Traditional Birth Attendants trained by an SPDC-supported project were observed in the project communities.

Access to Safe Drinking Water

Data from the 2011 Multiple Indicator Cluster Survey showed that less than one-third (27.5%) of households in Bayelsa State have access to improved drinking water sources such as pipe borne water source, public tap, tube well or borehole, and protected well or spring. Information obtained from the field supported this. Boreholes were available in the major settlements of Amabolou, Tamogbene and Egbemo-Angalabiri, however, most of the respondents reported that they relied on rainwater for drinking. Rainwater harvesting practices were observed during field visit.

Access to Sanitation Facility

Data from the 2011 Multiple Indicator Cluster Survey showed that only 8.4% of the households in Bayelsa State have access to improved sanitation facilities, that is either a toilet or a latrine,. An estimated 32.1% of the respondents use over-hung toilets and open defecation.

Waste Management

The wastes generated in the communities were mainly refuse and other domestic wastes. Open dumping of wastes was observed as prevalent; close to residential accommodation or by riverbanks, as enunciated by the Socio-economic baseline section of this report. Solid wastes constitute breeding sites for common vectors of diseases such as malaria, diarrheal illnesses. Leachates from the wastes are also a source of contamination of water bodies.

Housing Characteristics

The prevalent form of building materials in the major communities such as Tamogbene was cement blocks and corrugated iron roofing sheets. This contrasted with the housing conditions observed in the fishing camps, which were mainly mud walls with thatch roofs. Poor housing conditions have been implicated as risk factors for a number of diseases and health conditions such as respiratory illnesses and also malaria.

Reports showed that only 19.0% of the households in Bayelsa State own insecticide-treated mosquito nets 6.7% of sleep under them .

ES 5.1: Potential Impact Assessment

The assessment of the degree of alteration to natural conditions due to the project activities were carried out. The overall potential negative impacts of the project activities on the environment are minimal. Site preparation, drilling, dredging and pipeline laying are some of the activities which would adversely affect the environment. However, these negative impacts will be generally minimal, localized and short-term, particularly given the fact that the adverse impacts will be properly mitigated with the strict implementation of the Environmental Management Plan developed for the proposed project. Consequently, the long-term beneficial impact of the proposed project makes it more beneficial than adverse. Significant negative impacts of the proposed project include but not limited to the following:

- Air/Noise pollution from increased vehicular movement;
- Encroachment on cultural, historical and ecological resources;
- Erosion hazard arising from topographic changes;
- Increased morbidity from pressure on existing social amenities/infrastructure
- Increased social vices and incidence of STIs including HIV;
- Injuries/trauma and deaths;
- Interference with drainage pattern.
- Third party/community agitation.
- Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges;
- Disruption of fish spawning sites

Positive impacts of the proposed project include:

- Increase in employment opportunities;
- Increased cash flow and stimulation of local economies within the communities;
- Opportunity to re-use wastes such as firewood;
- Stimulation of local economy and markets from increased demand for food, and other products in the local market.

ES 6.1: Mitigation Measures

To ensure the successful execution of the Dodo North NAG project, SPDC shall apply the following measures:

- Ensuring that vegetation cutting / clearing activities are reduced to the barest minimum. The cutting of vegetation outside the designated areas and creation of access routes into the forest shall be prohibited.
- Effective journey management shall be applied (transport of heavy duty equipment and line pipes during peak traffic periods shall be avoided).
- HSE training and job hazard analysis shall be conducted to ensure that all staff observed safety rules at work places.
- SPDC shall identify the locations of burial sites and shrines to avoid damage during construction
- Exposure to high noise equipment shall be restricted to the recommended limits
- SPDC shall maintain fuel combustion engines at optimal operating conditions to reduce emissions of exhaust gases.
- Routine inspection of wellheads and other facilities shall be maintained to ensure facility integrity.
- SPDC shall regularly conduct monitoring of the project environment using an environmental monitoring plan.
- Excavation and other activities that may result in the alteration of the landscape and condition of the land cover shall be limited.
- SPDC shall manage wastes generated in accordance with regulatory requirements and standard practices.
- SPDC shall keep to the operational lifespan of the project.
- Appropriate warning signs shall be used to alert residents of the presence of machines/equipment during abandonment and decommissioning.
- SPDC shall embark on community development programmes in line with the needs of the people.
- SPDC shall activate her oil spill contingency plans to minimize impacts of oil spills and leaks on land and aquatic systems.

ES7.1: Environmental Management Plan

The Environmental Management Plan (EMP) for the proposed project incorporates various mitigation measures to ensure that adverse impacts associated with the development of the project are reduced to the lowest level. The EMP addresses waste management, environmental audit and environmental monitoring programmes of the

project. The waste management plan is targeted primarily at waste minimization, waste reuse and recycling.

The plan has taken into consideration, waste elimination by designing out unnecessary waste generating modules and incorporating waste reduction opportunities such as drilling of slim holes, use of slim width dredging, clearing of slim Right of Ways (RoWs) and cluster drilling. The Environmental Monitoring Programmes for the proposed project, which shall cover environmental components and discharge types, shall comply with DPR/FMEnv regulatory requirements.

ES8.1: Conclusion

The EIA of the Dodo North NAG Wells Project indicates that the environmental components that are likely to be adversely impacted are humans (communities and project site workers) air, soil, vegetation, water (surface and ground) quality, fisheries /wildlife, macrophytes and benthos. The EIA report has developed a well-articulated Environmental Management Plan to reduce the adverse impacts of the project on the environment to as low as reasonably possible levels.

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 Information

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of the Joint Venture partners (Nigerian National Petroleum Corporation, Nigerian Agip Oil Company, Shell and Total E&P), plans to embark on the Dodo-North Non-Associated Gas (NAG) Wells Project to meet the business objectives of domestic gas supply and gas flares down. Dodo North is a partially appraised field and yet to be produced. The field which is located in SPDC's OML 35 and about 70 West km of Yenagoa was discovered in 1981 and to date a total of 2 wells have been drilled in the field. Hydrocarbon has been discovered in 10 reservoirs. Out of the 10, 9 are pure NAG reservoirs and only one (U5000X) has 10ft of oil rim. Dodo North is surrounded by Opomoyo, Orubou and Opukushi fields. These fields are in the same structural setting with Dodo North, separated by saddles, and sharing the same stratigraphic elements.

Dodo North field development was strategically considered a quick win to produce swing gas essential to meet the domestic gas obligation of 100MMscfd agreed with the Federal Government due to its proximity to the Tunu CPF and the flexibility of drilling new wells on existing location with minimal land-takes. The Dodo North wells shall have a peak individual production capacity of 100MMscfd which shall be regulated to make up Associated Gas (AG) volumes, maintain domestic gas obligation of 100MMscfd over the next 10years and maintain effective reservoir management.

In line with this, an opportunity-reframing workshop was held in April 2010 for the Dodo North field NAG reservoirs development project. Following the workshop, an integrated subsurface review of the four largest gas bearing intervals in the Dodo North field (U1000X, U5000X, U6000X and U8000X reservoirs, ranked on the basis of Annual Review of Petroleum Resources (ARPR) reported volumes) was initiated to formulate an integrated reservoir development plan (RDP) for the 4 NAG reservoirs. In line with latest DPR regulation, the scope was expanded to encompass a Field Development Plan for Dodo North.

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

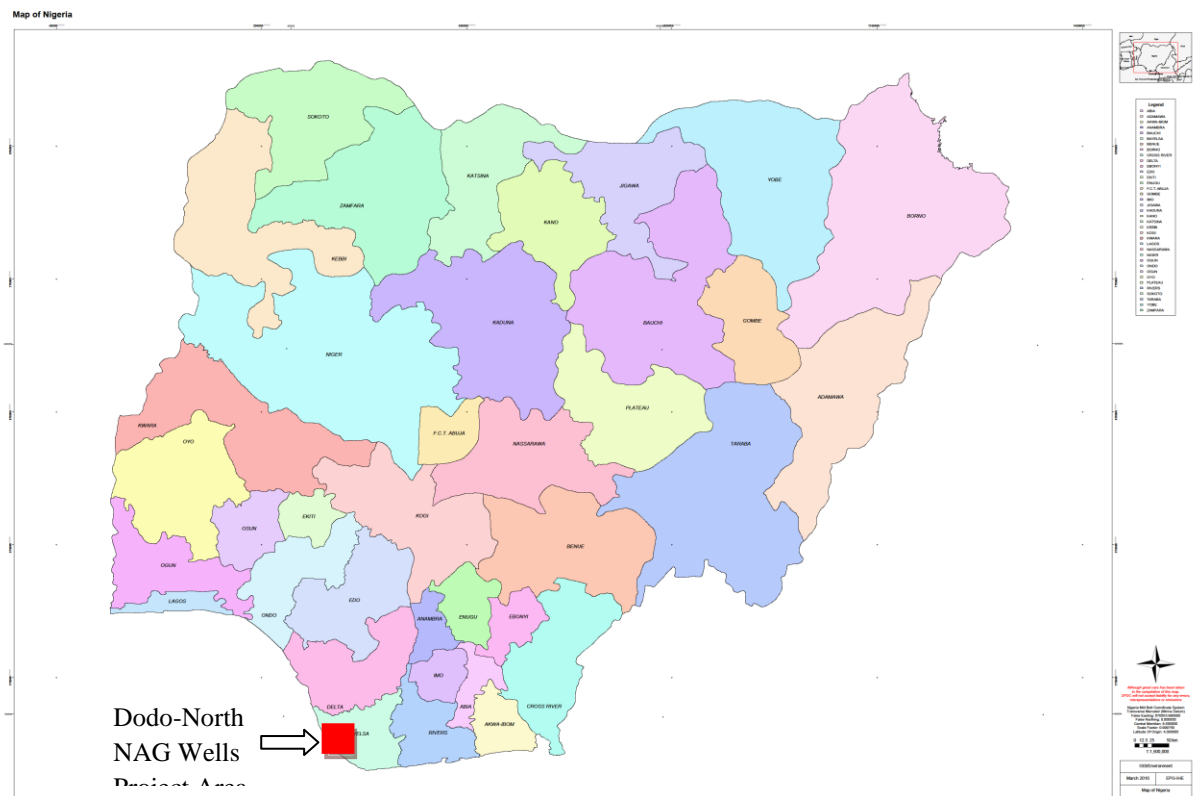


Fig 1.1a: Map of Nigeria Showing Dodo-North NAG Well Project Area

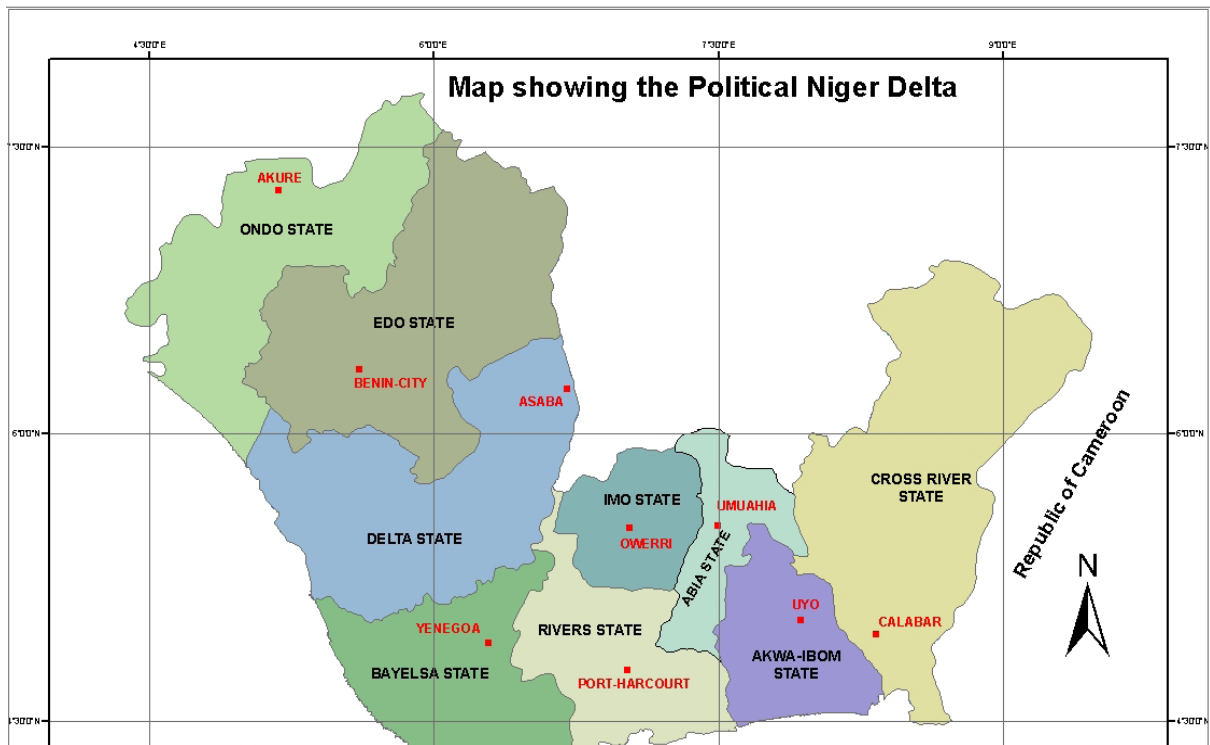


Fig 1.1b: Map of Niger Delta showing Bayelsa state

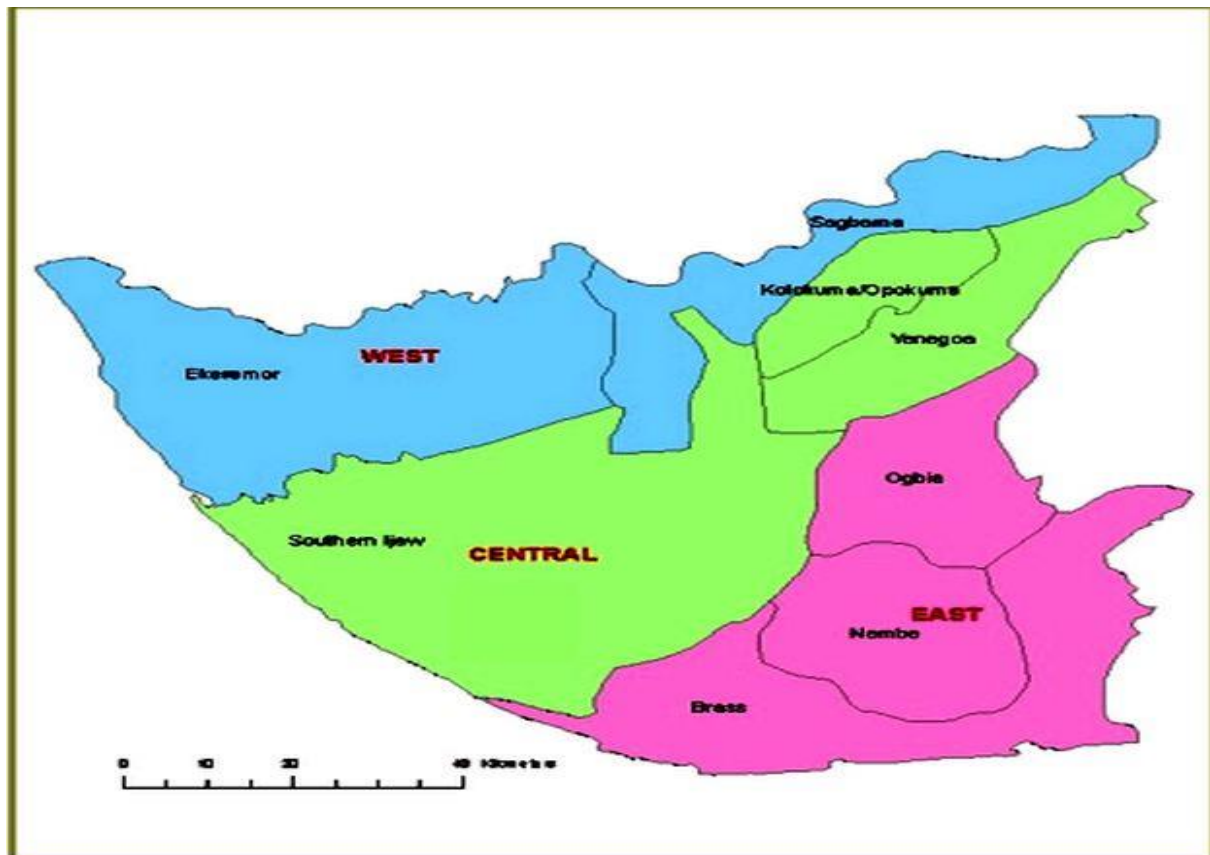


Fig 1.1c: Map of Bayelsa State showing Ekeremor LGA

Dodo-North NAG Wells Project is a component of the SSAGS+ Project which approval was given by the Federal Ministry of Environment in 2013.

1.2: EIA Objectives

The objectives of the EIA study are to:

- determine the baseline conditions of the environment (Biophysical, Social and Health);
- determine and evaluate the potential significant impacts of the proposed project activities on the biophysical, social (potential socio-economic effects of the project on the communities including impacts on cultural properties, social infrastructures, natural resources and lifestyles /values) and health environment of the area; and
- develop cost-effective mitigation measures and appropriate Environmental Management Plan (EMP).

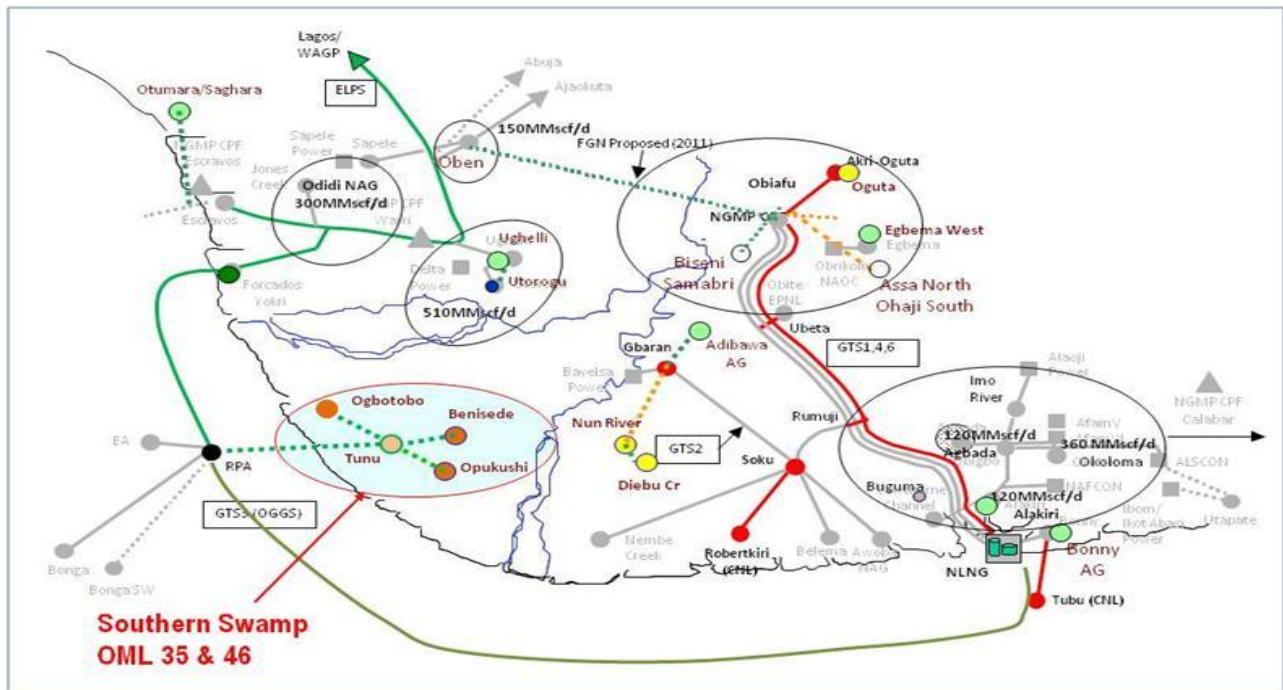


Fig. 1.2a: Southern Swamp Nodes within SPDC Gas Network

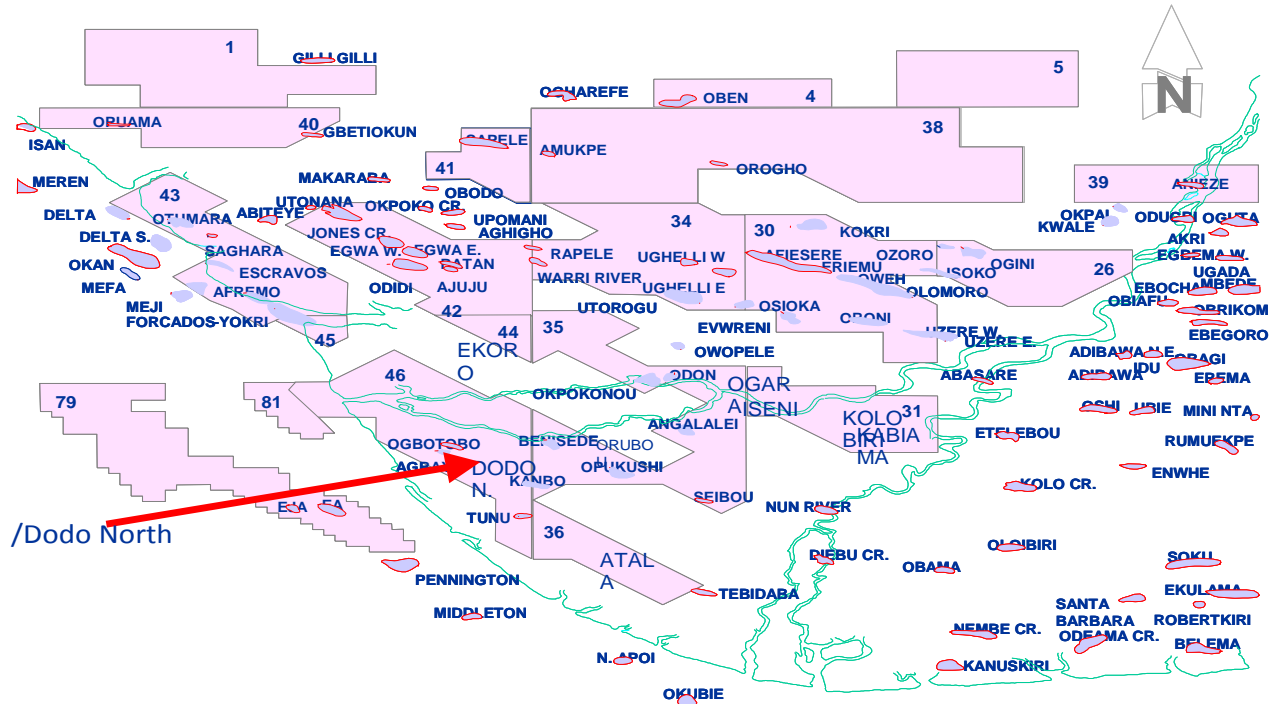


Fig. 1.2b: Dodo North in Southern Swamp Nodes within SPDC Gas Network

1.3: Project Location

The proposed project area is at the Dodo-North Field which is situated in the Southern boundary of OML 35, in the coastal swamp area, approximately Seventy kilometers (70km) West of Yenagoa. (Fig.1.2). It is located within Ekeremor LGA in Bayelsa State. Dodo River is the main water body draining the area. The proposed project is situated in N101394 and E362449.72 and N101352.44 and E362447.64. A land size of about 11 hectares will be utilized.

The inhabitants of the project area are mostly Ijaw speaking communities. The project area is located within the equatorial belt that experiences rainfall for most of the year. Past and present climatic data up to 2008 confirm that rainfall is recorded all year round. The average monthly rainfall as reported by NIMET is over 90% 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. However, available data from the Warri Meteorological Station, suggests a total annual rainfall in excess of 2,700 mm for the region. The peak rainfall period coincides with the period when the influence of south-westerly monsoon wind is at its peak. Temperatures are usually high and vary little year round which is typical of the equatorial belt. The mean temperature for the hottest months (February and March) is 34 °C while that of the coolest month (August) is 28°C. The average temperature difference between the hottest and coolest months is about 3°C while the mean daily temperature range is about ± 6.5 °C. The vegetation of the area is a mixture of mangroves, fresh water raffia swamp, and rainforest vegetation. The mangrove swamp forest is a homogenous population of mainly *Rhizophora racemosa*. and *Rhizophora mangle*.

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 labelling of dangerous and extremely hazardous wastes,
- Establish suitable and provide necessary requirements to facilitate the disposal of hazardous wastes;
- Research into possible re-use and recycling of hazardous wastes.

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.

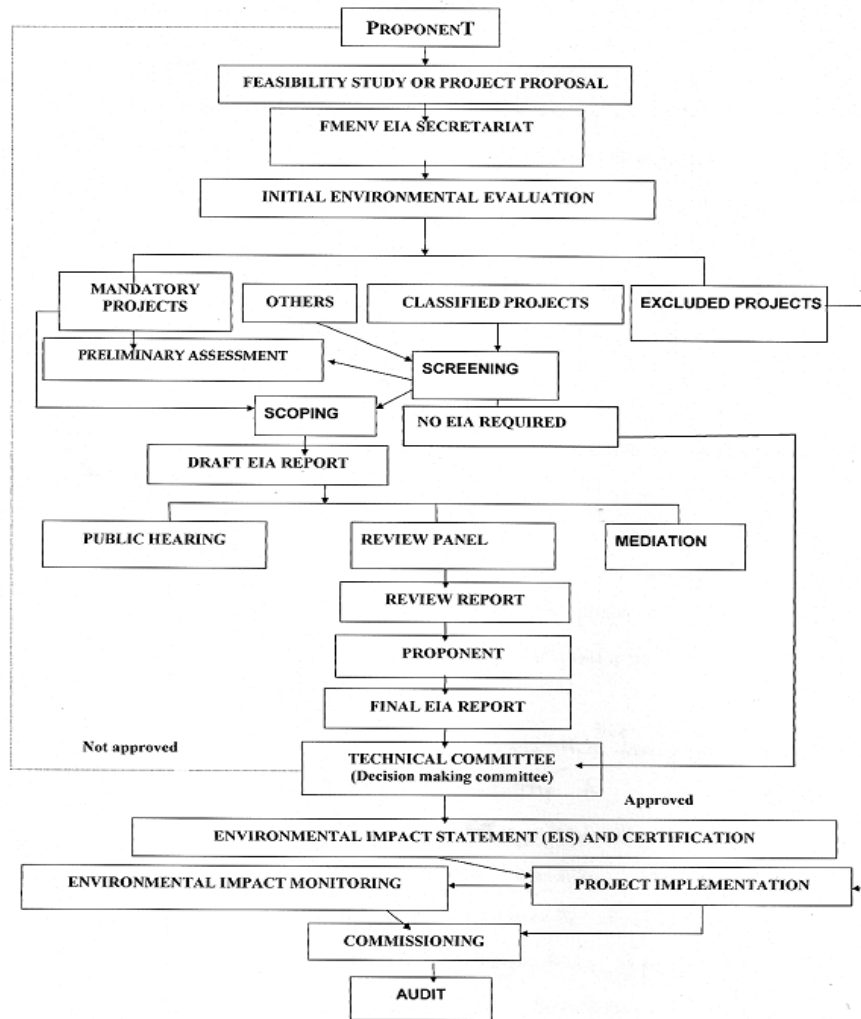


Figure 1.3: Flowchart of EIA Procedure in Nigeria

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.

Oil in Navigable Waters Act of 1968

It is an offence for any ship to discharge oil (including crude oil, fuel oil, lubricating oil and heavy diesel oil) or any mixture containing more than 100ppm oil residues into any part of the sea classified as a “prohibited sea area” and relates to the discharge of oil into any navigable waters of Nigeria. This act also empowers the Minister of Transport to make regulations requiring masters of Nigerian ships greater than 80 tons gross tonnage to maintain records of every oily discharge. In addition, every harbour Authority is empowered to provide oil reception facilities to allow vessels to discharge or deposit oil residues.

Harmful Waste Act of 1988

The Act prohibits the carrying, depositing and dumping of harmful waste on any land, territorial waters and matters relating thereto.

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 parastatal 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: Bayelsa State Regulations

- Bayelsa State Environment and Development Planning Authority Edict 1998
- Public Health Law – CAP 103 of the Laws of Eastern Nigeria 1963
- Bayelsa State Forestry Law 1998
- Bayelsa State Land Use (Environmental Degradation/Protection) Charge Law 2005

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 order to achieve continuous performance improvement. To this end, Shell companies manage these matters as critical business activities, set standards and targets for improvement, and measure, appraise and report performance externally.

(b) Governing Policies

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

(c) HSE Policy

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

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

The implications of implementing this policy are that,

- All activities shall be 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 recognize the importance of biodiversity.

Therefore, we are committed to:

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

(f) Waste Management Policy

It is the policy of SPDC to:

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

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).

Other considerations including:

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

These are based on SPDC Corporate Policies – 2008.

The development of an effective HSE Management Strategy is intended to ensure that throughout the life of 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).

SPDC has carried out this EIA in order to comply with all relevant statutory requirements as well as access its operations within the Dodo North NAG Project.

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 Dodo North NAG Wells Project. 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: Terms of Reference (ToR)

Shell Petroleum Development Company (SPDC) commissioned this EIA on Dodo-North NAG Wells Project area in order to comply with statutory requirements. The ToR was developed in an integrated manner to include the scope of work for biophysical, social and health impact assessments. It also aims at giving equal coverage to the biophysical, social and health aspects of the environment and further identify, for the public and the study executors, information required by government regulatory agencies for an impact assessment report for the proposed project. The ToR for this EIA was prepared to align with the standards required by the Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN) 2002 edition, SPDC HSSE policies, Shell Group Global Environmental Standards and other international standards.

1.7: Structure of the Report

The EIA report of the proposed project is presented in nine chapters i.e. in the format laid down by the Department of Petroleum Resources as outlined below:

- Title Page
- Table of Contents
- List of Tables
- List of Figures
- List of Maps
- List of Plates
- List of Acronyms and Abbreviations
- List of Preparers
- Acknowledgements
- Executive Summary

Chapter One – Introduction; - Background information, Administrative and Legal framework and Terms of reference

Chapter Two – Project Justification; - Project background, project objectives, need for the project, value of the project, envisaged sustainability, alternatives considered (including no project alternative), development options considered, site selection.

Chapter Three - Project Description, - Type of project, scope, location, material input/output and by-products, waste generation and management, technical layout, process, operation and maintenance, schedule.

Chapter Four – Description of the biophysical, socio-economic and health environment, - Study approach, literature review, baseline data acquisition method and QA/QC, geographical location, field data, climatic conditions, air quality, noise level, vegetation cover characteristics, land use and landscape pattern, ecologically sensitive areas, terrestrial fauna and wildlife, soil studies, aquatic studies including hydrobiology and fisheries, groundwater resources, social and health studies, prediction of changes in the baseline condition without the development in place.

Consultation - Identification of stakeholders, consultation with regulators, consultation with communities, community concerns and observations, and Participatory Rural Appraisal (PRA).

Chapter Five - Associated and Potential Environmental Impacts, - Scoping, impact prediction methodology, impacts of project activities (mobilisation of personnel and equipment, site preparation, vegetation clearing, drilling, construction of Flowlines/Bulklines and Hook-up phase, transportation, excavation, hydro testing of flowlines, tie-in and backfilling), impacts on resource utilisation, process impacts

(operation), short term/long term impacts, reversible/irreversible impacts, direct/indirect impacts, adverse/beneficial impacts, risk assessment, social impacts, health impacts.

Chapter Six - Mitigation Measures and Alternatives, - Control technology, compensation, alternative site, alternative route or location, compliance with health and safety hazards requirements.

Chapter Seven - Environmental Management and Community Development Plans, - Guidelines for specific project activities, emergency response procedures, mitigation plan, and monitoring programme (scope, parameters, frequency, location, methodology), auditing and inspection procedures, waste handling procedures, training program, roles and responsibilities.

Chapter Eight - Conclusions and Recommendations

CHAPTER TWO PROJECT JUSTIFICATION

2.1: Introduction

One of the objectives of the Nigeria Gas Master Plan is to generate enough gas into the Nigeria Domestic Gas market and SPDC is committed to this plan. Southern Swamp is one of the sources of SPDC's gas portfolio. To guarantee the sustenance of a minimum of 100 mmscf/d of Gas supply over a period of ten years from the Southern Swamp Associated Gas Solutions plus (SSAGS+) project to the Western Domestic Gas Market, it is planned that 2 NAG wells will be drilled from existing location at Dodo North to supplement the AG volumes from the Southern Swamp Node.

The Dodo North NAG Development (i.e. drilling of 2 NAG wells and laying of a Bulkline) is an integral and strategic component of the SSAGS+ Project. The SSAGS+ Project obtained EIA approval from FMEnv in 2003 but the project was stalled in 2006 due to a combination of security situation in the Niger Delta area and funding challenges. The previous SSAGS+ Project scope had 51 oil wells while the revised scope currently being progressed has only 18 but with the inclusion of 2 NAG wells from Dodo North. The EIA approval for the SSAGS+ project has been revalidated by FMEnv (ref. FMEnv/CDONF/EIA/123:208/Vol III/223) of 7th June 2013 upon completion of one season sampling and updating of the EIA Report by SPDC. However, this approval did not cover Dodo North NAG wells and hence the need to prepare a supplementary EIA Report to cover Dodo North.

The objectives of the Dodo North NAG project are:

- Align with government's aspirations by contributing to SPDC's plan to meet its assigned DOMGAS obligation by supplying about 100MMscf/day of gas from the Southern Swamp Area.
- To strategically manage the risk of long-term outages of the Southern Swamp AGG plant after commissioning by ensuring continuous gas supply to the domestic gas network.
- Be a key building block in implementing future gas development and operations in the Southern Swamp area.
- Develop this asset with minimum Total Cost of Ownership (TCO), meeting budget, and quality targets while ensuring that overall value to the Joint Venture, including Nigerian content, is maximized.
- Minimized 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.

In a nutshell, SSAGS+ project aims primarily to supply gas to the domestic market to support the Nigerian Government Energy aspiration and to eliminate gas flaring in the Southern Swamp Node. However, it is worth noting that the assigned domestic gas supply quota (100MMscf/d) cannot be met with AG volumes alone, hence the need to include the two (2) Dodo North NAG wells (Figure

2.1). The Southern Swamp area comprises fields within OMLs 35 and 46 in the coastal swamp area, 65km South of Warri and about 70km West of Yenagoa; this is shown in Figure 2.2.

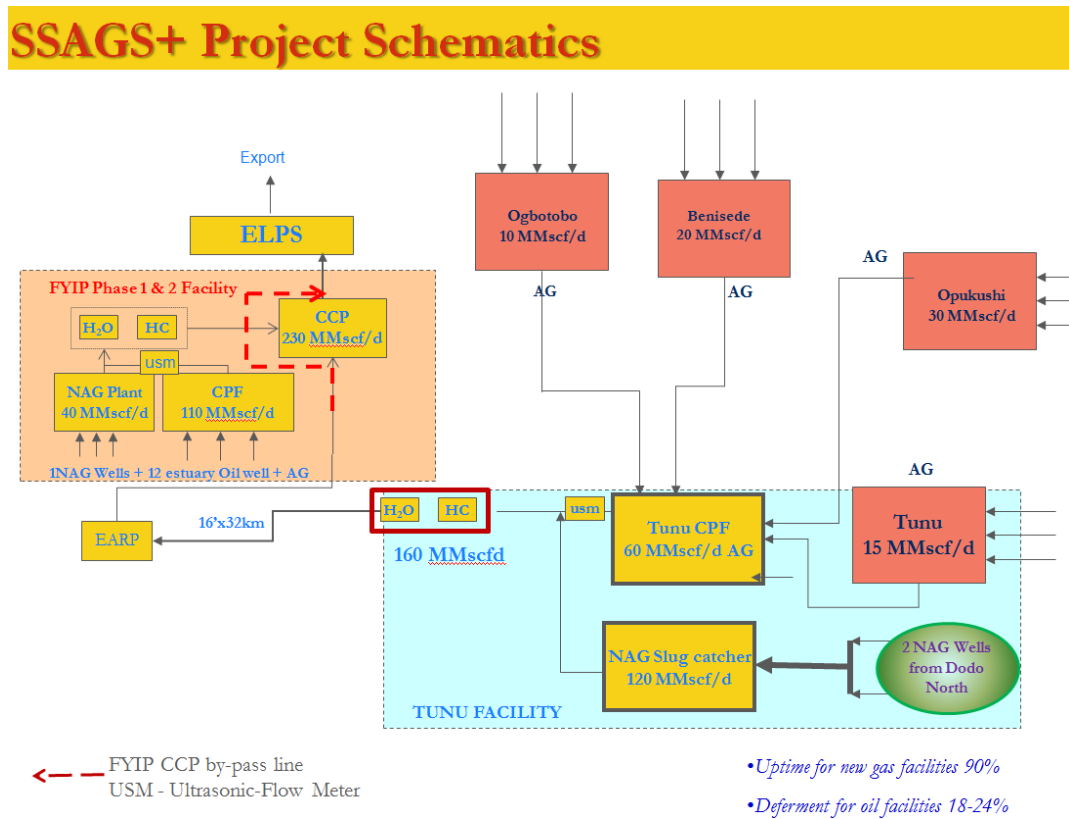


Fig. 2.1: SSAGS+ Project Schematics showing Dodo North Wells (in green sphere)

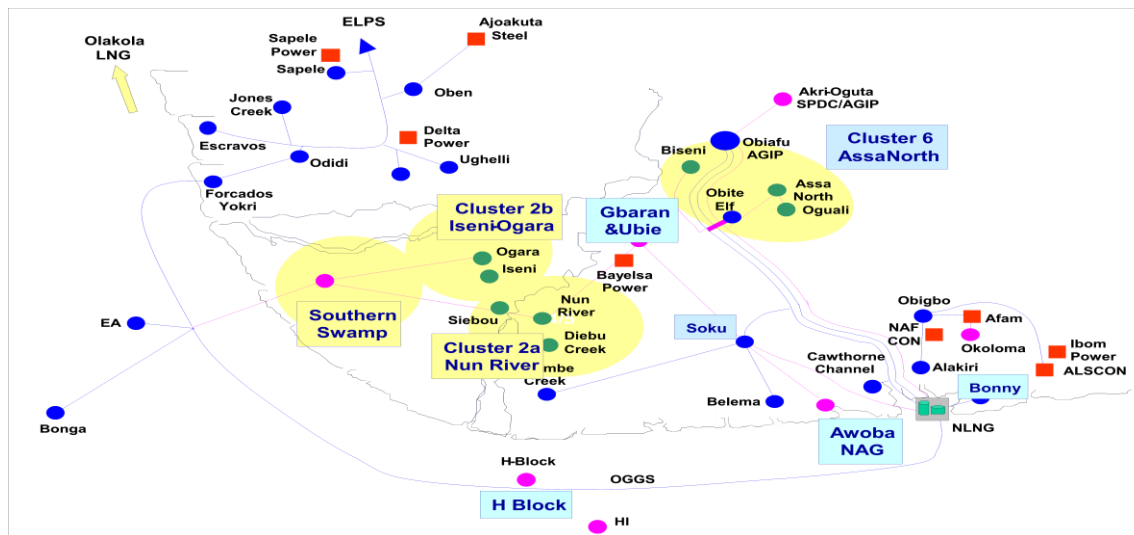


Fig. 2.2: SSAGS+ and other Gas Portfolio Projects

There are 10 fully, 10 partially appraised and 4 un-appraised fields within the Southern Swamp node, with expectation oil UR of 1,636 MMstb and 2,138 Bscf of associated gas (GIIP UR of 4 Tcf, 53% RF). All existing production in the area is gathered into 4 flow stations at Tunu, Ogbotobo, Benisede and Opukushi. The produced oil is evacuated via Trans Ramos pipeline to Forcados Terminal whilst the associated gas is currently flared. Upon completion of the SSAGS+ project, the AG from the four flow stations and NAG from the two Dodo North wells will be processed (water and hydrocarbon dew pointing) at the Gas Conditioning Plant at Tunu. This processed gas will be exported to ELPS via the existing 24"OGGS line from EA Riser Platform (RP-A) to Forcados Yokri (reverse flow) and the existing 16"line from FYIP CPF to Odidi. A new pipeline will be installed from Tunu to EA RP-A. In order to allow gas from Southern Swamp to reverse flow through OGGS to FYIP, a new manifold was installed on EA RP-A in Q1 2011.

The EPC contracts for the production facilities and gas-gathering lines (including Dodo North NAG line) have been awarded and detailed design is currently ongoing. The Dodo North Field Development Plan (FDP) has been approved by DPR and the 2 Dodo North wells have been included on SPDC's drilling sequence for 2014 to ensure that the target first gas delivery date is met.

2.2: Value of the Project

The total project cost is \$344.184million. This comprises of \$75.606 million for flowlines and manifold/bulkline and \$67.328million for wells, \$192.855million for NAG CPF at Tunu and \$8.395 for EIA studies and sustainable community development.

2.3: Stakeholders Engagement and Project Screening

A Concept Alignment Workshop for the Southern Swamp Associated Gas Solution (SSAGS+) Project was held on November 2nd, 2010 to ensure an optimized and robust concept. Further engagements were held including an EIA Scoping workshop (specific for Dodo North) in Yenagoa, Bayelsa State in May 2011 with all major stakeholders in attendance including FMEnv and DPR. In the workshop, issues associated with the option selected for the project were identified and ameliorative measures proffered.

2.4: Project Options

The project alternatives considered were;

- No Project Option
- Drill from new location
- Drill from existing location

The advantages and disadvantages of each alternative/options are summarized in Table 2.1.

Table 2.1: Project Options Considered

S/N	Options	Advantages	Disadvantages
1.	No Project Option	<ul style="list-style-type: none"> • No Capital Expenditure • No impact on the environment 	<ul style="list-style-type: none"> • No extra income for the immediate communities. • The ability of SPDC to meet up with domestic gas supply obligation will be seriously hampered. This will in turn impact negatively on the energy aspiration of the Nigerian Federal Government. • There will be a challenge in meeting the minimum gas volume required for the Tunu CPF to function effectively. This could lead to process upsets. • There will be difficulties in sustaining company obligation to supply gas to the domestic gas market needed for driving industry. • Loss of revenue to Government.
2.	Drill from new location	<ul style="list-style-type: none"> • Requires land acquisition and therefore this will create revenue to the land owners within the community. • Employment opportunities • Contract opportunities • Source of revenue to Federal Government 	<ul style="list-style-type: none"> • Requires extensive land take • There will be need to execute Capital dredging with the attendant environmental issues during the location preparation of the area. • Increased pressure on existing socio-economic facilities • Increased company footprint in the area • High Capital Expenditure • Delay in project execution
3.	Drill from existing location	<ul style="list-style-type: none"> • No land take • No additional Capital Expenditure • Employment opportunities • Contract opportunities • No negative impact on project schedule • Minimal vegetation clearing • Source of revenue to Federal Government 	<ul style="list-style-type: none"> • Increased pressure on existing facility • Dredging required for preparation of the location. But the volume/impacted area will be smaller compared to option 2.

After extensively analyzing the various options, Option 3 was chosen.

2.5: Project Alternatives

The Project alternatives for the proposed Dodo North NAG Wells Development Project spans from Drilling options, Route selection to Drilling options. The advantages and disadvantages of the project alternatives are presented in Table 2.2a to Table 2.2c.

Drilling options

In line with SPDC’s environmental policies, the drive is to minimize land-take for drilling, the same well slot location for the abandoned DN-001 appraisal well has been chosen for both wells. The following key considerations were made in siting the Dodo Wells:

Table 2.2a: Site Selection for Dodo North Wells

S/N	Drilling Options	Advantages	Disadvantages
01	Option 1: Reuse of existing well bores for DN-001 and DN-002 and sidetrack to target reservoirs	<ul style="list-style-type: none"> • Minimized environment impact 	<ul style="list-style-type: none"> • Integrity challenges from the wellbores abandoned for over 15 years • Two flowlines required with potentially higher cost and increased land take for two flowline right of ways
02	Option 2: Reuse same well slot for DN-001 and spud two new wells to target reservoirs	<ul style="list-style-type: none"> • Assured well integrity • Flexibility to bulk well production to the central processing facility • Reduced land take for the bulkline right of way • Optimized selection of materials • Overall shorter length of bulkline route 	<ul style="list-style-type: none"> • High drilling cost
	Option 3: Drill the well at new well site with dedicated onsite processing facility	<ul style="list-style-type: none"> • Assured well integrity • Improved pipeline integrity • Optimized selection of materials 	<ul style="list-style-type: none"> • Higher land take • Higher cost • Higher environment impact

Following the site selection review, a decision was reached not to reuse the abandoned well bores due to observed integrity challenges. Option 2 is selected to optimize use of existing processing facilities and minimize environmental impact.

Route Selection options

The design and construction of the high pressure / high temperature non associated gas flowlines shall be in accordance with applicable regulations, Shell (DEP31.40.00.10-Gen, version 33) and Industry standards (ASME B31.8-2010) Gas transmission and distribution piping systems. The following scenarios were evaluated in selection of the optimal flowline / bulking option for the Dodo North wells:

Table 2.2b: Route Selection options of the optimal flowline / bulking option for the Dodo North wells

S/N	Route Selection Options	Advantages	Disadvantages
1	Option 1: Two Duplex Stainless Steel Lines from Dodo North to Tunu CPF	<ul style="list-style-type: none"> • Lower operating cost as corrosion inhibition is not required • Increased potential for reuse of these flowlines to develop adjoining fields 	<ul style="list-style-type: none"> • High installation cost • Risk of chloride induced corrosion on the duplex stainless steel lines fluid composition analysis are not available from the Dodo North appraisal wells • Increased land take for two flowlines
2	Option 2: Bulking option using fully rate bulkline to close-in tubing head pressure	<ul style="list-style-type: none"> • Lower installation cost than option 1 • Potential for future reuse of bulkline to develop adjoining fields • Lower operating cost as corrosion inhibition is not required • Minimized environmental impact due to reduced land take 	<ul style="list-style-type: none"> • High Installation cost as Duplex bulkline will be required
3	Option 3: Bulking option using instrumented protection system to derate design pressure for the bulkline to the flowing	<ul style="list-style-type: none"> • Lowest installation cost for carbon steel flowline • Lowest total cost of ownership • Minimized environmental impact 	<ul style="list-style-type: none"> • Higher operating cost as corrosion inhibition will be required

S/N	Route Selection Options	Advantages	Disadvantages
	tubing head pressure	due to reduced land take • Low risk of chloride induced cracking	

The selected Option 3 will require short sections of duplex stainless steel flowlines to be installed from the wellheads to the Bulkheader platform.

Ditching / Excavation / Dredging options

Dredging is required for only major river crossing. The following considerations have been made with respect ditching and excavation along the bulkline right of ways:

Table 2.2c: Ditching / Excavation / Dredging options along the bulkline RoW

S/N	Dredging Options	Advantages	Disadvantages
1	Option 1: Open Cut trench backfilled with 1m top of pipe cover (<i>within the swamp terrain and shallow non navigable creeks</i>)	<ul style="list-style-type: none"> • On bottom stability • Reduced third party incursion • Use of back hoe excavators for controlled excavation and minimum ditch width • Minimized environmental disturbance as top soil will be reinstated at backfilling 	<ul style="list-style-type: none"> • High installation cost
2	Option 2: Installation of bulkline on surface along the swamp and shallow non navigable creeks	<ul style="list-style-type: none"> • Low installation cost • Minimized environmental disturbance 	<ul style="list-style-type: none"> • High risk of third party damage • Higher risk of environmental pollution
3	Option 3: Open cut dredging to depth of 4.5m below LLWS and minimum 3m top of pipe cover	<ul style="list-style-type: none"> • Minimize trawler/anchor interaction with buried line • Potential for self-burial of the lines in-situ due to current activities in the area • Minimize installation strain as the required pull tensions are low due to small line size and narrow creek widths. The widest river crossing is less than 250m width. 	<ul style="list-style-type: none"> • Increased turbidity due to suction dredger activities • Obstruction to third party use of navigable creeks during river crossing pull (<i>not more than six hour period</i>)
4	Option 4: thrust boring for river crossing sections	<ul style="list-style-type: none"> • Minimum obstruction to third party users 	<ul style="list-style-type: none"> • Operational and maintenance concerns

S/N	Dredging Options	Advantages	Disadvantages
		<ul style="list-style-type: none"> • No turbidity concerns • No trawler/anchor interaction with buried line 	<ul style="list-style-type: none"> relating to high pressure drops • Higher installation cost

Options 1 and 3 are selected for ditching, excavation and backfilling works required to install the Dodo North bulkline/flowlines across the predominantly swamp terrain with labyrinth of small creek and a few navigable creek crossings.

2.6: Envisaged sustainability

The envisaged sustainability of the proposed project is presented in this subsection.

2.6.1: Economic sustainability

Dodo North NAG Wells have large reserves of Non-Associated Gas and oil. There are therefore proven reserves of gas that can economically and commercially support the project. There is high demand for natural gas in the international and domestic market. The project will therefore contribute substantially to the revenue accruing to Nigeria and host communities. The host communities will benefit from the project through local contracting and employment opportunities, increased cash flow and stimulation of local economies within the communities and Stimulation of local economy and markets from increased demand for food, and other products in the local market.

2.6.2: Technical sustainability

Dodo North NAG Wells are technically sustainable because of SPDC's proven gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Proven technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project.

2.6.3: Environmental sustainability

Facilities and flowline (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.

2.6.4: Social sustainability

The proposed project will:

- Develop and maintain effective long term relationships with relevant stakeholders;
- Assure that the EIA process leads to development and implementation of social investment;
- Continuous consultation with stakeholder communities will further promote social sustainability of the project;
- Develop manpower skill to enterprising members of the communities.

CHAPTER THREE PROJECT AND/OR PROCESS DESCRIPTION

3.1: Introduction

Dodo North is a partially appraised field and yet to be produced. The field which is located in SPDC's OML 35 and about 70km West of Yenagoa, was discovered in 1981 and to date a total of 2 wells have been drilled in the field. Hydrocarbon has been discovered in 10 reservoirs. Out of the 10 reservoirs 9 are pure NAG reservoirs and one reservoir (U5000X) has 10ft of oil rim. Dodo North is surrounded by Opomoyo, Orubou and Opukushi fields. These fields are in the same structural setting with Dodo North, separated by saddles, and sharing the same stratigraphic elements.

Dodo North field development was strategically considered a quick win to produce swing gas essential to meet the domestic gas obligation of 100MMscfd agreed with the Federal Government due to its proximity to the Tunu CPF and the flexibility of drilling new wells on existing location with minimal land-takes. The Dodo North wells shall have a peak individual production capacity of 100MMscfd which shall be regulated to make up AG volumes, maintain domestic gas obligation of 100MMscfd over the next 10years and maintain effective reservoir management. Gas from Dodo North shall be processed at a new Central Gaps Processing facility (CPF) at Tunu design to export a maximum of 160MMscf/d to the domestic gas market and can process maximum Associate Gas (AG) volumes of 70MMscfd from the four Flowstations and maximum NAG volume of 120MMscfd from the two dodo North wells. These facilities shall be installed as part of a larger Southern Swamp Associated Gas Solutions Project for which EIA approvals have already been secured.

In line with this, an opportunity-reframing workshop was held in April 2010 for the Dodo North field NAG reservoirs development project. Following the workshop, an integrated subsurface review of the four largest gas bearing intervals in the Dodo North field (U1000X, U5000X, U6000X and U8000X reservoirs, ranked on the basis of Annual Review of Petroleum Resources (ARPR) reported volumes) was initiated to formulate an integrated reservoir development plan (RDP) for the 4 NAG reservoirs. The scope was expanded to encompass a Field Development Plan for Dodo North in line with the latest DPR regulation. Detailed property models for porosity, permeability, net-to-gross and saturation were further generated in PETREL using top and base horizon maps and reservoir properties for the U1000X, U5000X, U6000X and U8000X reservoirs. Average porosity is 26%, while average permeability ranges from 3000mD. Average Net to Gross is 0.98% while average Hydrocarbon saturation is 0.91%. Wells review of existing Dodo North 1 &2 wells indicated that the wells are not suitable for re-use in the U6000X reservoir. From evaluations, it was considered possible to re-use the Dodo North-2 well as a sidetrack for the U1000X, U5000X and U8000X reservoirs development.

Two new deviated wells EASN2 & EASN3 shall be drilled 55m apart utilizing the existing Dodo North 1 (DN001) acquisition slot to minimize land-take in line with SPDC's environmental policies. The well designs are based on the fact that the shallowest reservoir U1000 is at 8970 ftss. The

EASN-002 well will have a 13 3/8” surface casing, 9 5/8” intermediate casing and 7” production liner while EASN003 will have a 13-3/8” surface casing and 9-5/8” production casing. The casing size selection is based on 7” chrome production tubing for the two wells. Table 3.1 provides the casing and logging intervals for the Dodo North Wells.

EASN 002 well shall be drilled vertically to kick off point at 2500 ftah. Gradually build deviation angle at the rate of 0.35° /100ft to a maximum of 5.83 deg at 301 deg azimuth to surface casing setting depth at 6000 ftah. Drill along tangent in the same azimuth to 10700ftah and set production casing. Drill well to TD of 11740 ftah (11700 ftss) by gradually dropping angle to a final inclination of 3.94° along azimuth 300.17°. EASN 003 wells will be drilled vertically to kick off point at 2000 ftah. Gradually build deviation angle at the rate of 1.35° /100ft to a maximum of 12.77 deg at 2950 ftah (2942 ftss). Drill along tangent to 8985ftah (8828ftss) and to well TD of 9668 ftah (9500 ftss), gradually dropping angle to a final inclination of 8.84° along azimuth 243.00°.

Table 3.1: Dodo North Logging Plan for the Two Wells with Pilot Holes

Hole Size (in)	Casing / Completion Scheme	Logs required	Justification / Remarks
24"	24" (Stove Pipe)	Nil.	
17 1/2 "	13 3/8 " (Surface Casing)	MWD/GR. Mud log (pit volumes, gas volumes, pore pressure, hole condition, etc)	For deviation and stratigraphic correlation. For lithology identification, hydrocarbon detection and real-time pressure evaluation
12 1/4 "	9 5/8" (intermediate Casing)	MWD/GR. Mud log (pit volumes, gas volumes, pore pressure, hole condition, etc)	For stratigraphic and structural control. For lithology identification, hydrocarbon detection and real-time pressure evaluation
8 1/2"	7" (Production Tubing/Liner)	MWD/LWD:GR/RES/NEU/DEN/DIR/SONIC	For geo-steering and structural control. For Hydrocarbon detection and Fluid Typing Formation pressure measurement and PVT analysis
		EWL: GR/SBT/CCL EWL: GR/CCL/PERF	Cement Integrity. Depth correlation to Perforate target Sand
8 1/2"	Pilot Hole.	LWD/GR/RES/NEU/DEN.	For geo-steering and structural control.
Notes:	MWD - Measurement while drilling LWD - Logging While Drilling GR - Gamma Ray Log DEN – Formation Bulk Density RCI – Reservoir Characterization Instrument	FEWD EWL RES NEU SBT	Formation Evaluation While Drilling Electric Wire-line Logging Resistivity Log Compensated Neutron Segmented Bond Log

Locations have been selected to drill all the two wells. Short duplex stainless steel lines shall be laid to produce these wells to a Bulkheader platform to be located approximately 150m - 250m from each of the wells from which the NAG production will be bulked to a new NAG slug catcher to be installed at the Tunu CPF at an arrival pressure of 120barg as part of the Southern Swamp

Associated Gas Solutions Project. The Bulkheader platform shall be equipped with instrumented flow control valves, High Integrity Pressure Protection Systems to control flow allocation from each of the NAG wells and ensure that the bulkline is limited to a flowing tubing head pressure (FTHP) of 150barg.

3.2: Project Objectives

The strategic objectives of this project are:

- Align with government's aspirations by contributing about 100MMscf/day of gas from the Southern Swamp Area to the domestic gas network.
- 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.
- To develop additional new oil and gas in the node (90.4 MMbbl with 54.3 Bcf AG and ~268 Bcf NAG) based on 2P RES.
- Enhance Company reputation through execution of capital projects that has attendant benefits to host and impacted communities. Also demonstrating the company commitment to improving the environment.

3.3: Project Location

The Dodo North Field is in OML-35 approximately 70km West of Yenagoa. It is surrounded by Opomoyo, Orubou and Opukushi fields. The field is under the Tunu Node /Catchment area. The field was discovered in 1981. It is a Partially Appraised Field (PAF) and there is no production to date. Two wells have been drilled in the field and new wells will be drilled from exiting locations. Dodo North field is located in the Southern Swamp area. The field comprises of mainly Mangrove swamp forest dominated by *Rhizophora racemosa*. The evacuation of non associated gas from this field shall be via 1 Nos. 10'' bulk flowline to Tunu Central Processing Facility (CPF) which is about 11 km away for processing.

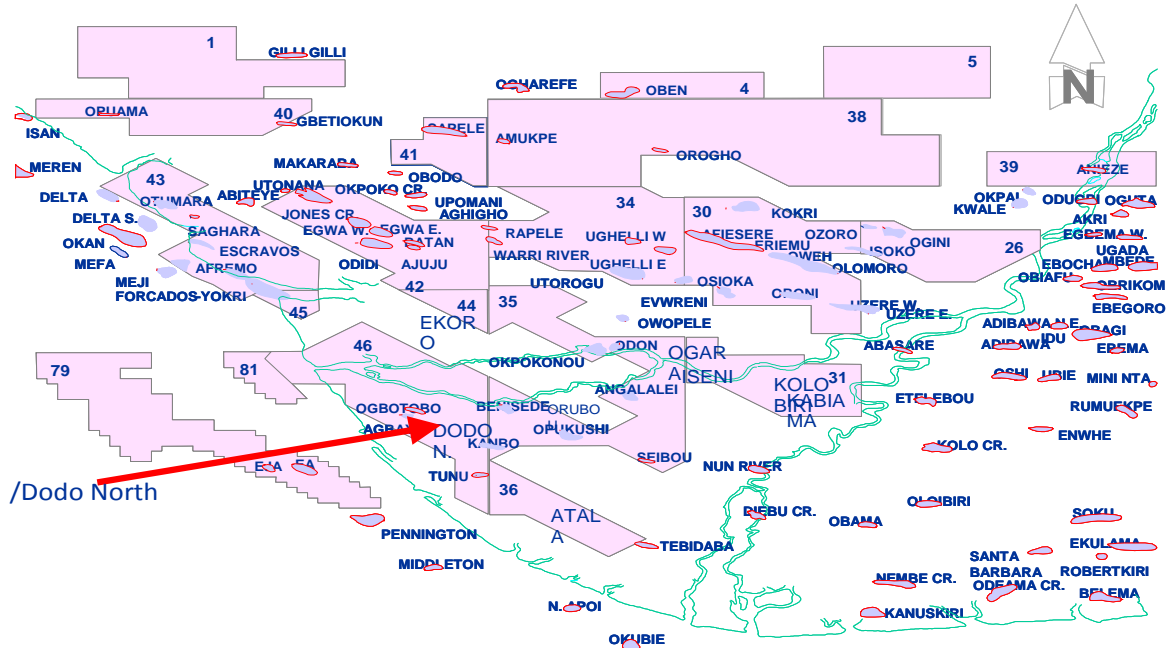


Fig. 3.1: OML Block Map showing location of Dodo North Field

3.4: Proposed Work Scope

The proposed Workscope for the Dodo North NAG Wells Project includes the following:

- Drill 2 Non Associated Gas (NAG) wells (DN 001 and DN 002) on existing well slots to minimize additional land take.
- Lay Gas Flow Line: 10” x 10km bulkline from Dodo North Well 1 and 2 (DN 001 and 002) to Tunu CPF
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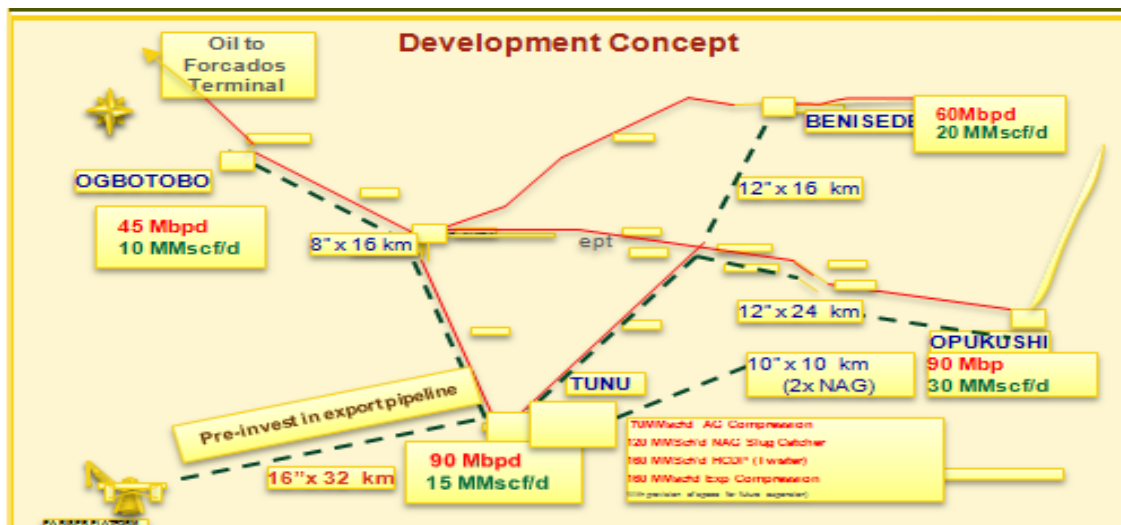


Fig. 3.2: SSAGS+ Development Concepts

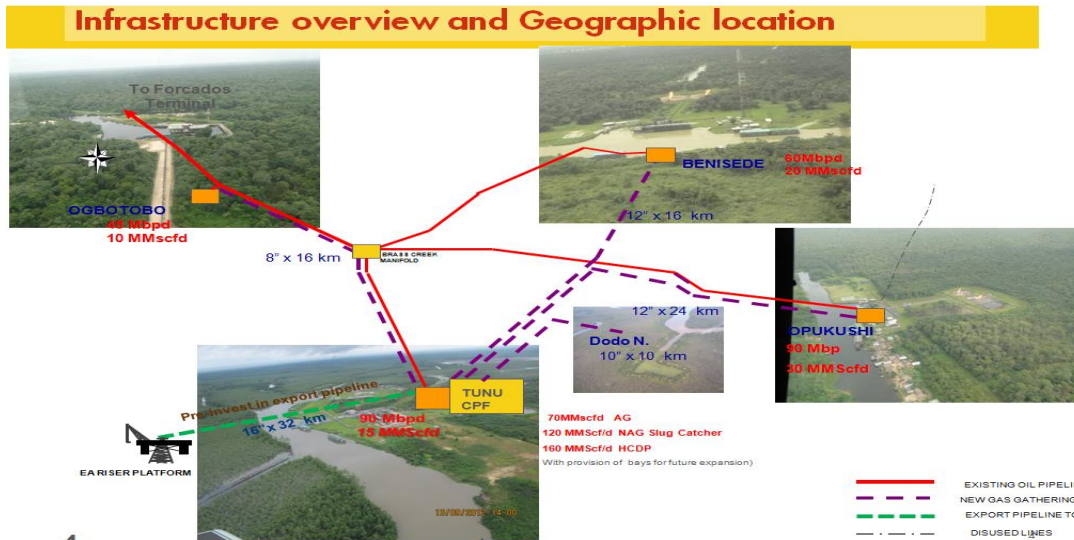


Fig. 3.3: SSAGS+ Infrastructure Overview

3.4: Summary of Main Project Activities

A summary of the main project activities shall be covered under the following headings;

3.4.1: Land Acquisition

The bulkline will be laid on existing Right of Way (RoW) as much as possible to minimize land take. However, an additional land acquisition (circa 11 hectares) will be required to adequately accommodate project activities.

3.4.2: Pre-Mobilization/Mobilization

Estimated population of workers at each site during mobilization and construction will be about 50, with a maximum of 150 at peak period. Logistics and accommodation shall be provided for personnel in camp sites around the well sites. These camp sites shall also serve as a field logistic base for storage of essential supplies as appropriate and shall be movable (barge mounted) to provide effective support as the flowline works transit along the RoW from Dodo North to Tunu CPF.

As much as it is reasonably practicable, mobilization for well drilling campaign and flowline installation activities shall be sequenced to maintain minimum site presence as well as exposure to personnel, equipment and resources. The site camp shall be mobile and can be moved as the crew transit the right of way to minimize intra field movement, security exposure and construction footprint.

3.4.3: Site Preparation Activities

Site clearing

All the land area within the NAG Bulkline RoW from Dodo North to Tunu F/S 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.

Location Preparation/Dredging

Location preparation shall be executed prior to the proposed drilling and completion scope of the Dodo North NAG Well project in September 2015. Two wells have been drilled within the Dodo North field, therefore there is an existing well slot. Maintenance dredging of the access and slot shall be executed to enable re-entry of the drill rig for drilling activities from these existing well slots.

3.4.4: Wells (Drilling and Completion)

EASN-002 and EASN-003 wells shall target (U1000X, U5000X and U6000X reservoirs) with EASN-002 producing U6000X sand at TVD of -11350.59ftss first and U5000X sand at -11161.8ftss to be perforated later. EASN-003 will produce only U1000X sand. Table 3.2 shows the surface location and the sub surface coordinate for the proposed wells (EASN-002 and EASN-003). In line with SPDC’s environmental policies, the drive is to minimize land-take for drilling, the same well slot location for the abandoned DN-001 appraisal well has been chosen for both wells.

Table 3.2: Dodo North Wells location and their coordinates

Planned Well	Existing Well Location	Surface Coordinates		Sub-surface Coordinates						Top of sands (ftss)	
		Northing (m)	Easting (m)	U1000		U5000		U6000		TVD ftss (+/- 50 ft)	MD ft ahbdf
				Northing (m)	Easting (m)	Northing (m)	Easting (m)	Northing (m)	Easting (m)		
EASN-002	DN-001 Appraisal Well	101394	362449.72			101518	362240	101520	362237	-11161.8	11200.85
EASN-003		101352.44	362447.64	101162	362040					-8993.49	9154.66

The actual along hole (ah) depths are approximate and dependent on the actual well path and DFE. The potential of encountering the reservoir +/- 30 ft from proposed depth exists. The +/- 30 ft uncertainty considers the maximum actual depth difference in DN-001 and DN-002 appraisal wells, proximity of the proposed well to DN-001 and DN-002 and the complexity and relative flatness of the structure. Proposed well trajectory and Completion design for the EASN-002 and EASN-003 is presented as Fig 3.4a and 3.4b.

The wells will be completed with sand control to forestall sand production based on reservoir modeling predictions. The gas composition from adjoining fields indicates that there is no hydrogen sulphide while the carbon dioxide content is 0.412 - 0.685%. To avoid chemical injection and corrosion problems, 13% chrome tubing will be used. All the wells will be equipped with permanent downhole gauge (PDHG) and v-monitors for data transmission. The installation of PDHG will

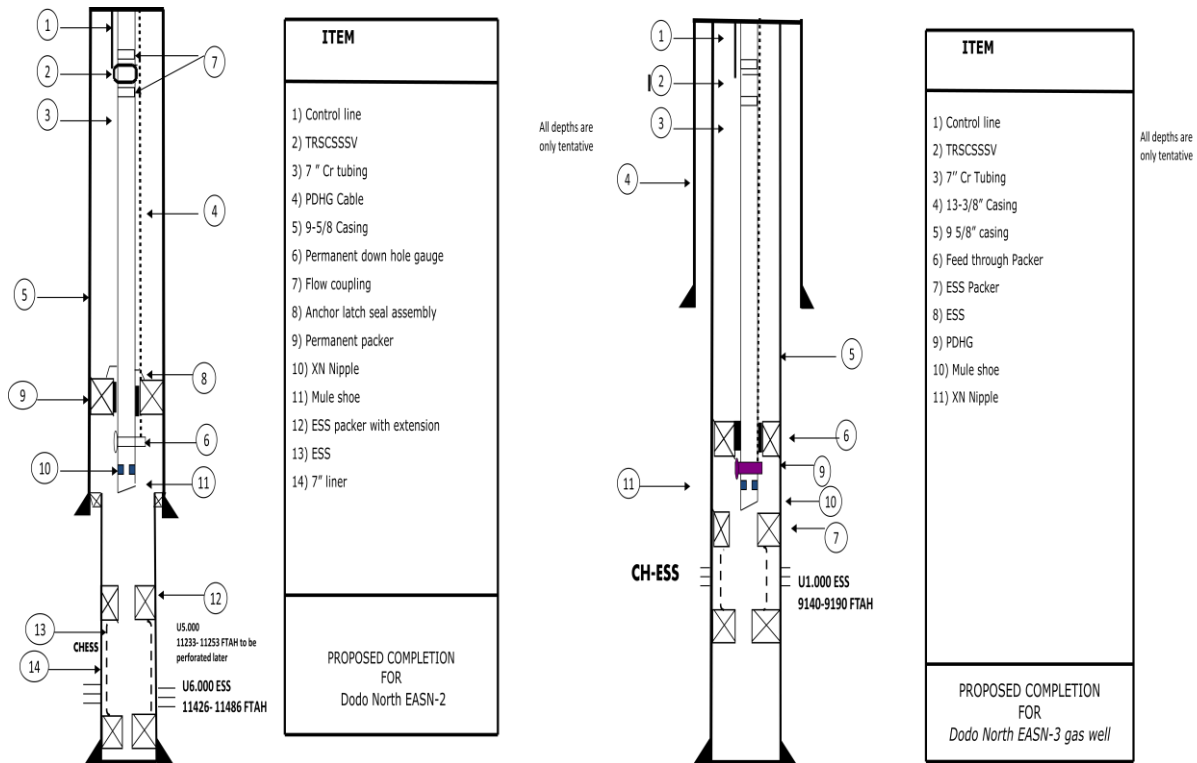


Fig. 3.4b: Proposed Completion Diagrams for wells EASN-002 and EASN-003

The Dodo North NAG wells are high pressure / high temperatures wells and design of these wells comply with all regulatory, international design codes and standards.

Drilling and Completion Risk

Two appraisal wells have been drilled in the Dodo North field. The history of these wells was studied to populate the risk register below for the mitigation of known drilling risks. The mitigation gives a guideline for the actions to be taken to ward off / minimize upon experiencing such risks, during the execution phase. The technical risks and drilling hazards have been identified for the Dodo North field. But the key hazards include Borehole instability, stuck pipe, well bore collision, well control incidents etc. Summary of the field review for the two wells are shown in Table 3.3.

Table 3.3: Drilling and completions risk register for Dodo North Wells

RISK	RISK DESCRIPTION	WHERE OCCURRED	MITIGATIONS
Stuck Pipe	Pipe Stuck Due to borehole instability as a result of heaving shale	Dodo North 1	Drilling practice, Better mud engineering, Lubricity
Well Control	Well kick due to overpressure or underbalanced condition.	Dodo North 1,2	Accurate pore-pressure prediction, Use functional BOP.
Drilling Tool	Loss of drilling tools (drilling assy, evaluation tools) as a result of twist off	Dodo North 2	Smooth well trajectory design. Ensure PMS is carried out as at when due. Inspection certificates of tools are sighted before use in the rig. Effective hole cleaning. Use of Rotary steerable technology. Good mud
Borehole Instability	Bore hole instability due to swelling shales, sloughing shales, poorly consolidated formations, poor drilling fluid rheology and interaction. Drilling fluid losses.	Dodo North 1,2	STABOR Modeling, Pseudo OBM and Drilling practice
Collision			Top hole drilling deviation data to be monitored rigorously, Anti collision plot to be made and frequently checked during drilling, If required the hole to be nudged off early to further reduce risk, Gyro survey shall be taken at the end of each phase and at the stove pipe shoe.

3.4.5: Flowline and bulkline Design and Installation

The design and construction of the high pressure / high temperature non associated gas flowlines shall be in accordance with applicable regulations, Shell (DEP31.40.00.10-Gen, version 33) and Industry standards (ASME B31.8-2010) Gas transmission and distribution piping systems. The shut duplex stainless steel flowlines from the wells to the Bulkheader platform shall be designed to withstand the closed-in tubing head pressure (CITHP) of 263barg at closed-in tubing temperature of 110⁰C and maximum flowrate of 100MMscfd. The bulkline however shall be designed to handle a bulk flow rate of 120MMscf/d of wet gas at the flowing tubing head pressure (FTHP) of 150barg and maximum process temperature of 110⁰C as this line will be protected upstream by a high pressure protection system. Due to uncertainties in the compositions of the Dodo North well composition, known composition of NAG wells close to Dodo North has been used for detailed engineering on this line with a specified wall thickness of 17.85mm using 10”, API 5L Grade X65 line pipes over a design life of ten years.

The Dodo North Bulkline shall transverse predominantly swamp terrain within the Niger Delta Swamps and a total of 21 creek crossings of which only 3 are navigable (see figure 3.8 below). The Project Team has secured Permit to Survey (PTS 2723) and Oil Pipeline License (OPL 1504) and has acquired a 15m right of way stripe with total length of 10km. Activities involved in Installation of the one number Dodo NAG bulkline shall include the following:

- Site Mobilization
- Right of Way Survey

- Ditching / excavation / Dredging
- Bevelling, Fitting and Welding
- Field Joint Coating
- Non Destructive Weld Inspection / Testing
- Laying, Backfilling and Site Restoration
- Hydrotest
- Facilities hook up at Tunu CPF and Dodo North Wells.

A 2” Corrosion Inhibition line and a Submarine Composite Fiber Optic Cable will be installed alongside the NAG Bulkline. The 10” bulkline and the 2” corrosion inhibition line shall be laid in the same trench of swamp/shallow water Lay Barge. Relevant regulatory permits for installation of the 10” Dodo North Bulkline has been secured including Permit to Survey Pipeline Right of Way Route and Oil Pipeline License. As part of this process, a 15m wide pipeline right of way has been acquired from the original land owners. The new lines shall be coated with 2.7mm of polypropylene coating and 70mm of high density (3040kg/m³) concrete wall coating and shall be buried with consolidated top of pipe backfill of 1m.

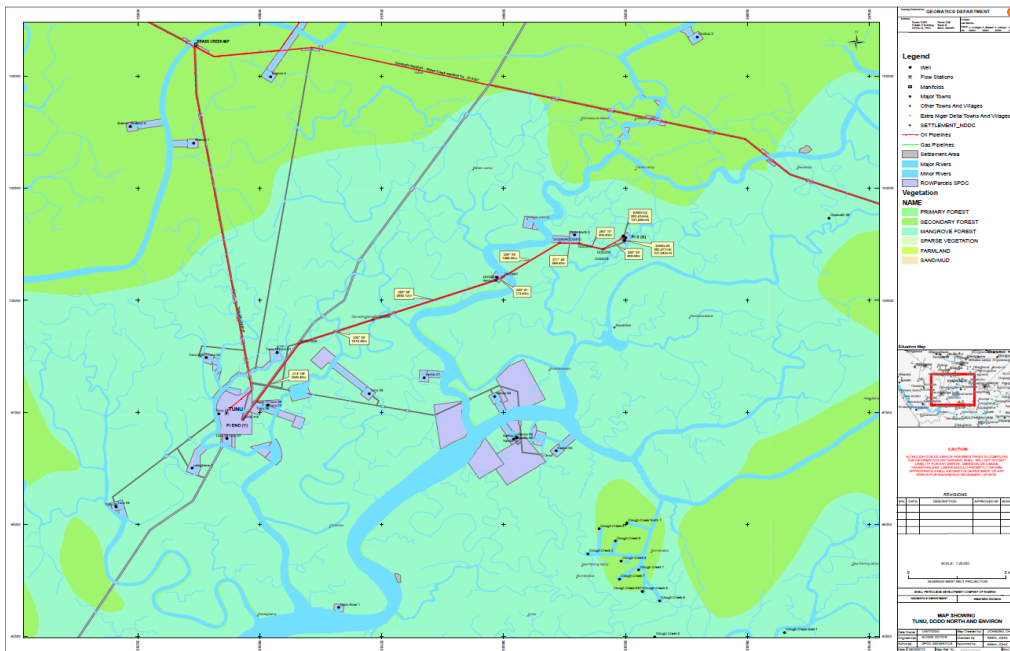


Fig. 3.5: Proposed Route for the Dodo North Bulkline

3.4.5.1 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 river crossings and one major river crossing shall be performed as part of the Dodo North bulkline 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 crossing.

3.4.5.2 Welding, NDT and Laying

This activity shall involve welding the 10" x 11km bulkline using the floatation method where the pipeline is laid from a single laybarge moving through a channel (burial trench) cut along the RoW. The line pipes shall be procured with capped bevel ends, however, any bevel end damages shall be restored prior to fitting and welding. A Pipe storage barge shall be moored next to the laybarge. The Pipelines shall be coated with three-layer polyethylene coating to provide external corrosion protection. Field joints shall be coated with shrinkable sleeves.

Visual inspection and 100% radiography (NDT) 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.

3.4.5.3 Backfilling and Site Restoration

The pipe shall be inspected to confirm that it has been laid to the correct profile Lowering and backfilling. The Pipeline trench will be backfilled using the previously excavated materials and the top soil shall be reinstated where possible. Plant species nursed during the site preparation stage shall be replanted on the cleared sections of the right of way. All spoil dumps winned during dredging of river crossings shall be utilized to backfill the river crossing trenches.

3.4.5.4 Cleaning and Hydrostatic Testing

The flowlines shall be cleaned with inhibited brackish water which shall be evacuated through our Tunu Flowstation. The cleaned lines shall then be subjected to hydrostatic test using pressurized water columns to a pressure 1.25 times the flowline design pressures to provide assurance on the pipeline integrity. The flowlines shall then be depressurized and dried to the proper specification. The Hydrotest water shall be sourced from fresh water creeks in close proximity to Tunu Central Processing Facility (CPF) treated through a scheme consisting of a hold tank, a filtration tank and high pressure pumps. Effluent from the lines shall be received in a break tank at the Dodo North end where it will be pumped out into an effluent disposal barge.

3.4.5.5 Hook up, Start up and Site Demobilization

This involves all the activities necessary to connect the welded and tested flowlines to the completed wells as well as facilities at Tunu CPF. Produced Non Associated Gas (NAG) shall be evacuated to Tunu CPF for processing and dew pointing.

After start up of the wells and all site reinstatement activities are successfully completed, all equipment, personnel and resources mobilized to support drilling, completion, construction and commissioning works shall be completely demobilized including site logistic bases.

3.5 Waste Generation and Management

Drilling and Other Programme

Table 3.4 Potential waste expected from the Proposed Dodo North NAG Wells Project

Waste Type	Control /Management Measures
Mud	<ul style="list-style-type: none"> - Used pseudo oil based mud (POBM) will be re-used in the drilling of other wells. (Standard toxicity test will be conducted in DPR approved laboratories on the POBM before they are used) - Spent POBM would be incinerated at the Thermal Desorption Unit (TDU) provided at Onne.
Cuttings	<ul style="list-style-type: none"> - Bottom hole cuttings drilled with POBM and contaminated with POBM will be transported and incinerated at the TDU at Onne port - POBM cuttings can also be processed by separating the cutting into solid and liquid phases using shaker. The liquid shall be passed through active carbon and filters (carbon & silica) to remove contaminants. The resultant clean water is discharged or re-used. For the solids, they shall be mixed with cement and silicates and used for road tar or as land fill material. -The percentage mud on cuttings shall be kept below 10% before incineration through the use of installed high gravity shakers/dryers.
Cement	<ul style="list-style-type: none"> - Cement residues and returns (spud mud and cement – contaminated water) generated during the top hole cementation stage will be collected and re-injected.
Brine (NaCl) Discharge	<ul style="list-style-type: none"> - Solids free, lightweight, non-toxic completion brine will be used. - Excess brines shall be re-injected
Acids	<ul style="list-style-type: none"> -Used or spent acids will be diluted and neutralized through the addition of dilute caustic soda. Thereafter it will be disposed off through re-injection.
Sand Consolidation Fluid	<ul style="list-style-type: none"> -Used sand consolidation fluids (well fix etc.) will be collected in drums and sent for incineration or re-injected
Sewage	<ul style="list-style-type: none"> -It is envisaged that the maximum number of personnel at drilling site at any one time will be about 150 persons. Sanitary sewage produced at site will be treated on the rig sewage treatment plant as per DPR standard. The water can be re-used for flushing the system or disposed in rivers. Regular monitoring will be carried out.
Industrial and domestic wastes	<ul style="list-style-type: none"> -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.
Rig bilge	<ul style="list-style-type: none"> -Oily water discharges shall be controlled to less than 20ppm oil in water by the rig oil/water separation system.

Spudding and drilling of wells, well completion and hook up are some of the major activities in addition to site preparation/dredging and flow lines and bulk lines installation. The drilling and completion operations shall be managed at the project sites. Drilling operation requires the use of drilling fluid (mud) at different depths.

Drainage Discharges

Drainage discharges upon the drilling rig will occur from a number of sources including:

- Clean area floor drains;
- Deluge drains;
- Machine area floor drains;
- 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 overboard without any treatment. The other discharges may contain oil or chemicals and would be routed to the oily water drainage and treatment system at the terminals. The expected waste from the drilling activities and their management strategies are tabulated in Table 3.3.

3.6 Execution Strategy and Cost

SPDC has existing contracts covering the wide variety of well engineering flowline installations and commissioning services that will be required for the drilling and completion of these wells. The total project cost is \$147.329million. This comprises of \$75.606 million for flowlines and manifold/bulkline and \$67.328million for wells, \$1.158million for EIA studies and \$4.395million for sustainable community development. Associated cost for the Gas Processing facilities are carried as part of the Southern Swamp Associated Gas Solutions Project for which EIA approval was conveyed in letter referenced FMEnv/CONF/EIA/123:208/Vol. III/223 and dated 07th July 2013.

Table 3.5: Detailed Cost Breakdown

Description	Total CAPEX (\$mln)
EIA Cost	1,158
NAG Location Preparation	2,993
NAG Development Drilling	40,077
NAG Development Completion	23,100
NAG Flow lines and Hookup	75,606
NAG Facilities	192,855
NAG SCD	8,395
Total Project CAPEX	344,184

Preliminary schedule for drilling, completion, production testing and hook-up of the Dodo North NAG wells to the new processing facilities is presented in Figure 3.6. Actual drilling and hook up sequence shall be subject to availability of drilling rig and approval of this EIA.

S/N	Activities	Start Date	End Date	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16		
01	Secure EIA Approval for Dodo North Wells		Jul-15	█																							
02	Slot sweeping	Aug-15	Nov-15								█																
03	Rig Move (including personnel, equipment and supplies logistics)	Aug-15	Aug-15											█													
04	Drilling and Completion of EASN-002 Well	Sep-15	Nov-15													█											
05	Drilling and Completion of EASN-003 Well	Oct-15	Dec-15														█										
06	Well testing on EASN-002 Well	Dec-15	Jan-16															█									
07	Well testing on EASN-003 Well	Jan-16	Feb-16																█								
08	Hook Up of EASN-002 Well	Feb-16	Apr-16																	█							
09	Hook Up of EASN-003 Well	Mar-16	May-16																		█						
10	Site Demobilisation	May-16	Jun-16																						█		

Fig. 3.6: Proposed Drilling, Completion and Hook-up Schedule for wells EASN-002 and EASN-003

3.7: Operation and Maintenance Activities

The Dodo North Wellheads are remote, unmanned facilities which shall be operated and monitored remotely from the Tunu Central Control Room. The wells are also equipped with remote shutdown capability but will require operator intervention for startup. The Wellhead shall 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 HSSE policy and guidelines. The NAG wells fluid composition data was based on a PVT laboratory study report for the adjoining Orubou F3 field. The well stream contains 0.00678 mole fractions of CO₂, 0.00039 mole fraction of N₂ and zero content of H₂S, Mercury and sulphur. Material selection of for the production tubing, flowlines, bulkline and processing facilities has accounted for the CO₂ content of this well stream.

Reservoir completion intervals are designed to reduce coning/cusping of formation water. Length of the perforated interval will be optimized after the wells are logged to prevent early water production from coning/cusping effect and maximize gas recovery. All liquids from the Tunu CPF will be pumped to the Forcados Terminal where the water will be separated from the condensate. Effluent water treatment and disposal will be handled in line with approved procedures at Forcados Terminal.

A Wet-Gas Flow Meter is provided for each of the flow lines from wells EASN-002 and EASN-003 at the Dodo North Bulkheader Platform to provide continuous measurement of the production volumes from each well which will be monitored from the Tunu Central Processing Facility (CPF). This will be done by using conventional gas metering equipment such as venturi meters, with the meter readings then corrected to compensate for the over-reading caused by the liquids in the flow. To carry out this compensation calculation, it is necessary to determine the Liquid to Gas Ratio (LGR) of each well by installing gas and liquid meters on the NAG inlet separator outlets, together with a water cut meter. Gas from the NAG wells in addition to the Associated Gas from the four Flowstations will be produced to Tunu CPF where it will be processed using Twister technology.

Production from the two NAG wells (EASN-002 and EASN-003) be conveyed to a Bulkheader platform 150m – 250m from each of the wellheads with short duplex stainless steel flowlines sized to hand a maximum production of 100MMscf/d from each of the wells. Bulk production from the wells shall arrive at a dedicated high pressure NAG slug catcher for slug volume handling upstream the Twister inlet. This slug catcher design adequately accounts for anticipated liquid volume for ramp-up from 10MMscfd to 100MMscfd of gas at about 25MMscfd per hour for each of the wells. The twister is designed to achieve water and hydrocarbon dew pointing up to the export gas quality specifications. Condensate from the NAG inlet separator will pass under level control to the condensate header at Tunu CPF. There, it will be combined with liquids from the Tunu CPF associated Gas slug catcher and routed to the condensate flash vessel in the Flowstation for flash stabilization. See Figure 3.7 for the Operations schematics.

An operation and maintenance manual will be developed before handover of this line for operation. Provision of spares for the initial two years operations and maintenance is included in this contract scope. Waste and effluent management during pigging at the Dodo North Bulkheader Platform and workover activities at the wellhead shall be handled using special purpose effluent disposal barge.

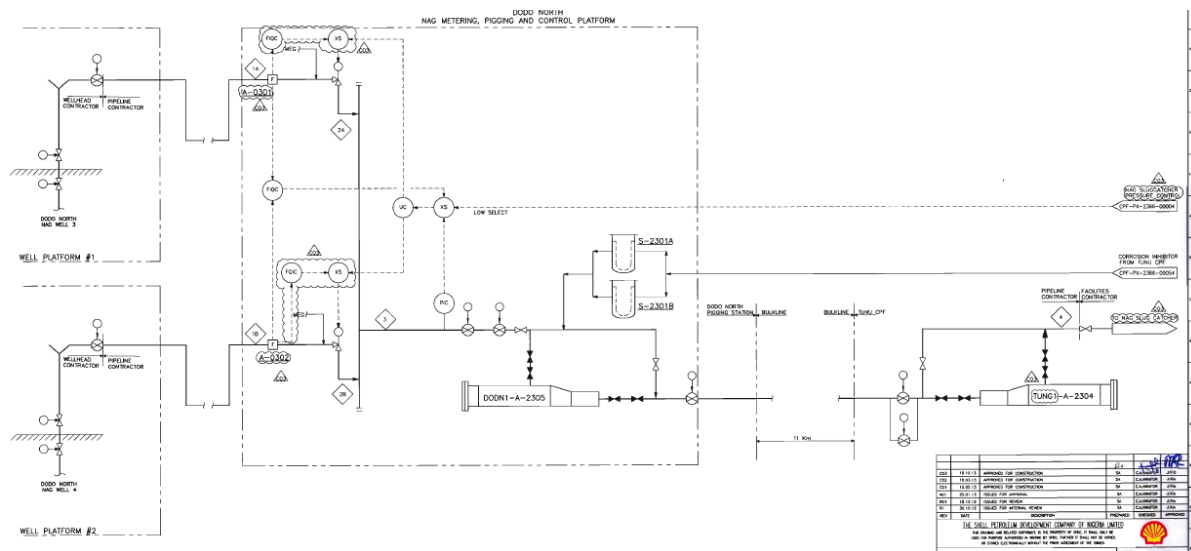


Fig. 3.7: Process Flow Schematics for Dodo North Wells

Operations

The wells shall be remotely monitored and operated from the Tunu Central Processing Facility and no accommodation or helipad facilities will be required. Routine pigging, valve maintenance and instrumentation calibration activities performed by Operations and maintenance staffs at the Dodo North Bulkheader/ Pig Launcher Platform and Tunu Pig receiver Platform shall be supported using existing company logistics at the Tunu Logistics base which operates and maintain all company assets within the Tunu catchment area. The Dodo North wells and Bulkheader platforms shall however be provided with boat landing platforms and access stairways/ladders to ensure access during these routine and operations site visit. The Wellhead will be maintained and safeguarded in accordance with SPDC’s HSSE policy and guidelines. As-built technical integrity will be

safeguarded through maintenance (monitoring, inspection, testing and servicing) activities. These will be carried out at regular intervals throughout the facilities lifetime to sustain adherence to specifications, codes of practice, standards and conformance to relevant laws and policies. Competent personnel will maintain as-built technical integrity by undertaking maintenance activities in accordance with approved plans and procedures and by supervision of the maintenance activities. A programme of internal and external reviews and audits will further verify it. Responsibility for safeguarding the technical integrity of the wells and associated facilities shall rest with the Tunu CPF Asset Superintendent. The system shall be standardised on the levels of executive actions: Process Shutdown Levels 1, 2 and 3 and Emergency Shutdown (ESD) viz:

- Level 1 ESD Emergency Shutdown(With depressurisation)
- Level 2 PSD 1 Plant Process Shutdown(Without depressurisation)
- Level 3 PSD 2 Train Shutdown (Without depressurisation)
- Level 4 PSD 3 Equipment Shutdown(Without depressurisation)

All ESD and Fire & Gas systems shall be centralised at the respective control room or equipment room with information on safety and shutdown status repeated at CCR. ESD & PSD manual push buttons will be provided at CCR for operator interface on all facilities. High integrity detection systems and/or voting systems shall be applied and alarms shall be screened and rationalised to minimise manual intervention of Control Room Operators.

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 conditions. 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.

3.8 Decommissioning/Abandonment

The Wellhead and their ancillary installations have a life expectancy of about 25 years. The operation and maintenance procedure shall provide for monitoring the performance and the integrity of the system components. When the performance of the system scales to diminishing returns, SPDC standard procedures for decommissioning shall be invoked. A decommissioning team shall be set up to plan and implement laid down guidelines on decommissioning. The following activities are involved in decommissioning/abandonment:

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

The demolition exercise shall be carried out with skill and diligence to avoid spill of hazardous liquids and damage to the environment. At the end of demolition, various solid wastes shall be segregated according to their types and then disposed of according to SPDC waste disposal guidelines.

3.9 Contingency Plan

During drilling of the well, there are several uncertainties associated with lack of core data from the appraisal wells, actual depth of target sands and management of formation of fluids. Most of these will normally be addressed by the drilling procedures and site specific contingency plan. However, a containment bund wall is planned at the Dodo North to help contain any run offs during extended production testing of the wells. An effluent handling tank sized to handle three days condensate volume will also be deployed at site during this period. It is unlikely to have any uncontrolled gas release during drilling and completion of these wells. However, continuous gas testing shall be maintained at this site and the well is designed to have fully rated blow out prevent during drilling and wellhead at completions. The well shall be immediately controlled and/or isolated to avoid risk of explosion, asset damage or harm to people. In the event of borehole instability or related drilling problem, the contingency that will meet the well objective will be to sidetrack. If Tops and Bases come in deeper the TD, the well perforation or final depth will be adjusted accordingly, with final well TD confirmed by Geologist. Overall contingencies are to be firmed by the Petroleum Geophysicist based on the actual nature of the challenges.

CHAPTER FOUR

ENVIRONMENTAL BASELINE CONDITION

4.1 Introduction

The purpose of the baseline data acquisition is to establish, before the execution of the project, the status of the various environmental components that are likely to be affected by the proposed Dodo North NAG Wells project. Dodo North NAG is located within OML 35 in Bayelsa State. The environmental components evaluated comprised biophysical, social and health. The status and sensitivities of the various ecological components of the Dodo North NAG Wells project area were assessed from review of existing reports on baseline and EIA studies conducted in recent times by SPDC for other projects in the area, published literature, detailed questionnaires, interviews maps, field sampling surveys, laboratory and data analyses.

The baseline was produced based on a one-season (wet season) field exercise carried out between 1st and 11th August, 2012 as approved by the regulators (See Appendix VII). The EIA of SSAGG 2003 served as second season (Dry Season) for biophysical parameters, while the EIA of Benisede catchment Area Phase 1 2004 was used for aquatic microbiological results for dry season.

4.2: Study Approach

This chapter documents the environmental (biophysical, health and social) setting of the Dodo North NAG Wells Project area, as it is presently constituted. The approach adopted includes the following:

- Assessment of the issues identified in a stakeholders' workshop (SPDC, 2011).
- Review of existing literature on Dodo North NAG Wells project area:
 - Environmental Impact Assessment (EIA) of SSAGS+ Project, 2013;
 - Environmental Impact Assessment (EIA) of SSAGG Project, 2003;
 - Environmental Impact Assessment of Benisede Catchment Area Phase1 2004; and
 - Various In-house maps/charts on the area (remote sensing, satellite imagery and land use)

4.3: Baseline Data Acquisition Methods

Prior to commencing baseline studies, known issues and impacts identified from some of the EIA projects reviewed above were used in further developing the scope of this study.

4.3.1: Consultation

It is the policy of SPDC to consult with stakeholders and relevant authorities in all its activities to show management commitment. The New SPDC EIA Process Manual requires that such consultation should take place. A one season data gathering was approved by the regulators (FMEnv and DPR) owing to the fact that there is an approved EIA which was conducted earlier in 2003 (EIA of SSAGG, 2003) and was never utilized as a result of security concerns within the project area.

A scoping workshop was organized for Dodo North NAG project (within the project area) which was a modification of the project in 2003 and a major component of the present project was conducted between 24th to 25th May 2011 at Ayalla Hotels, Yenagoa Bayelsa State (Appendix VIII) to produce the terms of reference and context of the EIA. Of particular note was the presence, at this workshop of:

- Representatives of each of the five (5) communities involved;
- Representatives from the Federal and State Government regulators: Federal Ministry of Environment (FMEEnv); Department of Petroleum Resources (DPR); Bayelsa State Ministry of Environment;
- Representatives of Ekeremor LGA in Bayelsa State within which the project is located;
- Key project staff from SPDC; and
- Non Governmental Organizations (NGOs) – representatives from the Niger Delta Peoples Coalition (NDPC).

This scoping workshop formed a key component of this study. The broad objectives were:

- Education and enlightenment of identified stakeholders (communities, Government agencies, NGOs, CBOs etc., on the need for their involvement in the conduct of the study and to assist the project team in articulating the concerns of the communities as well as those of their immediate environment;
- Building trust and confidence that would enhance the capacities of the identified stakeholders through participation in the project.
- Forming and promoting partnership with identified stakeholders through networking, information sharing and participation in consultation exercises.

The identified community stakeholders were visited by the proponents before commencement of fieldwork to inform them of the purpose of the project and the need for their cooperation and participation. At the field locations, the study team met with the Chief/Paramount Ruler, the Chairman of the Community Development Committee (CDC), the Women leader and the youth leader and discussed the objectives of the study. This helped in securing the social license to conduct baseline studies in these communities. Consultation with other stakeholders is ongoing and shall be sustained throughout the duration of the project.

4.3.2: Study Locations

The map showing the study area is given in Figure 4.1. The sampling points were geo-referenced using Global Positioning System (GPS). The coordinates of the sampling locations are presented in **Appendix I**. 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 (**Appendix 1**).

4.3.3: Fieldwork/Laboratory Analyses

A one-season fieldwork was embarked upon for the biophysical study, while a cross-sectional study was undertaken in the case of social and health studies. The samples collected were analysed in FMEnv and DPR approved laboratories in Warri. Table 4.1 summarizes the methods used in collecting the samples from the field. Methodology for field studies and laboratory analysis are presented in Appendix I. The laboratory analysis was carried out by Thermosteel Nigeria Limited, Warri, Delta State.

Table 4.1: Methods Used in Collecting the Environmental Samples

Environmental components	Methods*
Geographical Positioning	Platinum Meridien (Magellan) GPS Receiver with built-in map and 3-Axis Electronic Compass and Barometer
Meteorology	Literature survey, field studies with rain gauge, Thermograph, Wind vane, EXTECH INSTRUMENTS-Hygro-Thermometer + Infra Red Thermometer, Model No. RH 101 and KESTREL 3000 Pocket Weather Meter
Air Quality	Impinger trains for gases, USEPA High-Volume sampler
Noise	EXTECH INSTRUMENTS –Digital Sound Level Meter, Model No. 407750 after calibration with EXTECH INSTRUMENTS Model 407744 Sound Level Calibrator
Vegetation	Transects, Quadrants, keyInformant 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 Statistical analysis for hydrobiology	Collection with Ekman grab Collection with 55 micron plankton net Collection with 55 micron two plankton net Direct observations, structured and unstructured interviews and laboratory analyses Margalef index (D) of taxa richness; Shannon – Wiener index of general diversity (H)
Social Environment	Key Informant Interviews, Focus Group Discussion (FGD), Direct Observation, Administration of structured questionnaires and Collection of secondary data.
Health Studies	Key InformantInterviews, FGD, Administration of structured questionnaire and interviews, Physical examination of volunteers, Walk-through survey and Collection of secondary data.
Waste Management	Physical examination, inventorisation and walk-through survey

4.4 Baseline Environmental Conditions

4.4.1 Climate, Meteorology, Ambient Air Quality and Noise

Climate

The climatic information is based on data collected from the study area during the field work and analysis of long term historical data for Warri meteorological station, obtained from the Federal Meteorological Services Department, Oshodi. Other meteorological data were also obtained from the University of Benin, Edo State and Niger Delta University, Wilberforce Island, Bayelsa State. These stations are closest to the project area. The data covered the period from 1998 to 2007. Microclimatic records were then measured for respective outdoor locations for ten days around the project area. Monitoring stations include meteorological/microclimatic data at 60 m, 200 m, 500 m and 1000 m from the proposed project site. Air Quality data and noise levels were simultaneously measured at the same locations for meteorology measurements. Data were gathered on each day starting from about 8.00 am through 5.00 pm. The summary of the results of the two season microclimate, noise and air quality is presented in Table 4.2a, while the detailed result is presented in the Appendix II.

Table 4.2a: Summary of microclimatic conditions, noise and air quality of Dodo North and Tunu area

PARAMETER	Tunu		Dodo North	
	Dry Season	Wet Season	Dry Season	Wet Season
Wind Speed, m/s	1.88	1.46	1.33	0.97
Temp. °C	30.53	27.44	32.27	26.85
Rel. Humidity, %	75.65	84.42	71.27	86.33
Noise, dB(A)	71.4	43.21	75.05	38.73
SO ₂ , ppm	<0.01	<0.01	<0.01	<0.01
NO ₂ , ppm	<0.01	<0.01	<0.01	<0.01
NO, ppm	<0.01	<0.01	<0.01	<0.01
CO, ppm	1.31	<0.01	1.88	<0.01
NH ₃ , ppm	-	<0.01	-	<0.01
H ₂ S, ppm	0.91	<0.01	0.21	<0.01
SPM, µgm ³	45.53	0.97	18.23	1.65
VOC, µgm ³	-	0.02	-	0.24

Wind

The sampled areas are located about 70km West of Yenagoa, an area which is under the Tropical Wet climate zone. Analysis of climatic data obtained from Port Harcourt and Warri synoptic stations show the prevailing wind directions as presented in Figure 4.1a. The wind rose shows that South Westerly is predominant between March and October which roughly coincides with the rainy season. On the other hand, Figure 4.1b shows that North Easterly are rather frequent between November and February during the dry season. The South Easterlies and North Westerly are more evenly distributed throughout the year as shown in Figures 4.1c. Statistically, the surface wind speed measured during field studies range from 0.1 to 0.5 m/s for 64 % of the time, 0.6 to 1.0 m/s

for 28 % of the time and greater than 1.0 m/s for 8 % of the time. Average wind speeds measured at the sampling sites are presented in Appendix II. Average wind speed was 1.88 m/s during the dry season and 1.46 m/s during the wet season at Tunu, whereas at Dodo North they were 1.33 m/s and 0.97 m/s respectively. The microclimate in the project area is largely determined by these trade winds in a complex manner in the course of the year. The diurnal variation of wind speed determines to a very large extent what is recorded during field studies. A study of two year record of 5 minute records with Davis Instruments microstation located at the University of Benin yielded the diurnal variation of wind speed in Figure 4.1c. The diurnal pattern was closely examined by taking hourly averages of the reading. Both the hourly aggregated peak and average wind speed for every 5 minute period were considered. Clearly the peak and 5 minute average show the same pattern over a given daily cycle giving averages of 3.2 m/s and 1.9 m/s respectively. Observations with another micro weather station in Niger Delta University, Yenagoa gave very similar variation.

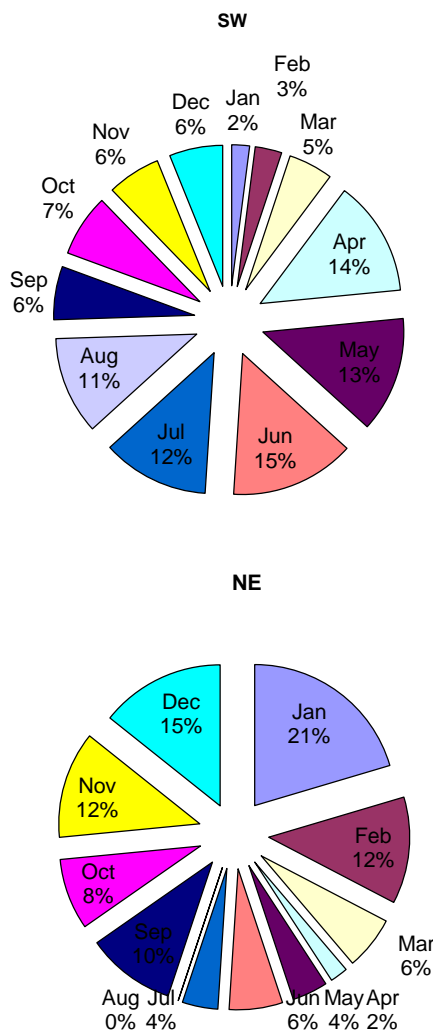


Fig. 4.1a: Wind Rose of prevailing wind directions in the project area (1998 -2007)
 Source: National Meteorological, Centre Oshodi (2005)

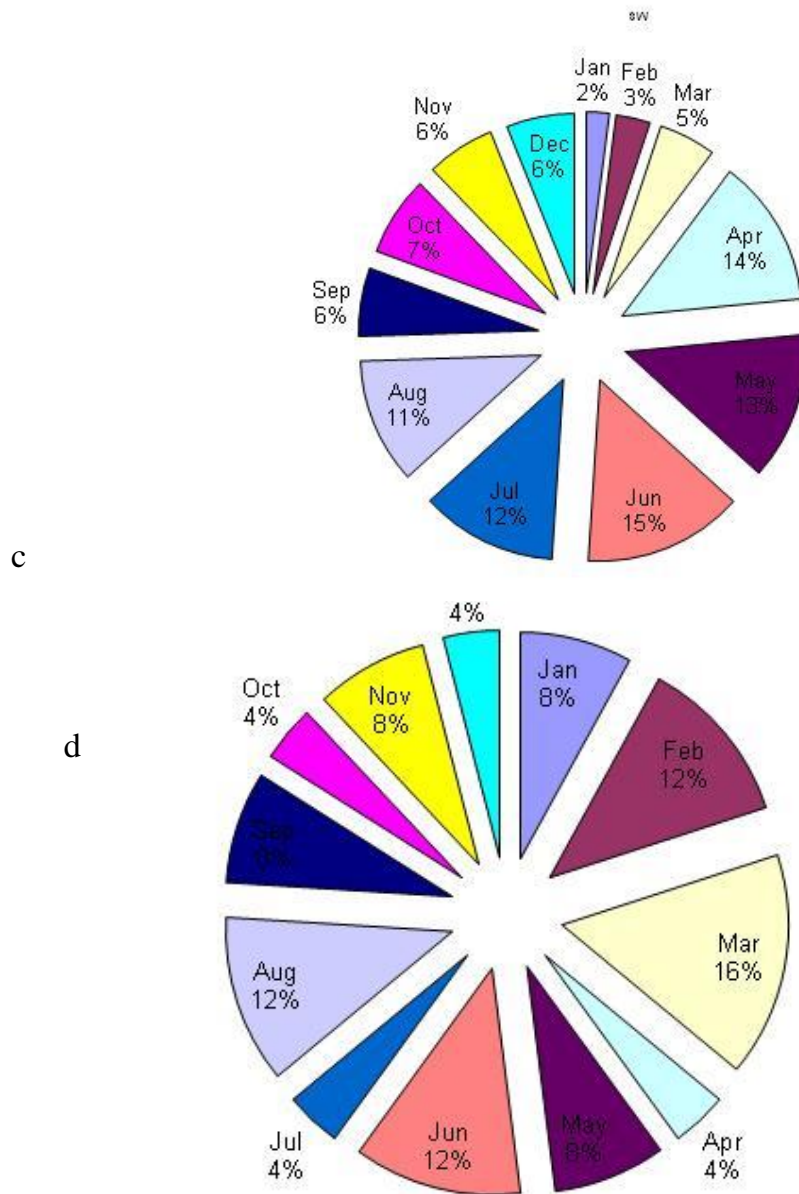


Fig. 4.1b: Wind Rose of prevailing wind directions in the project area (1998 -2007)
 Source: National Meteorological Centre, Oshodi (2005)

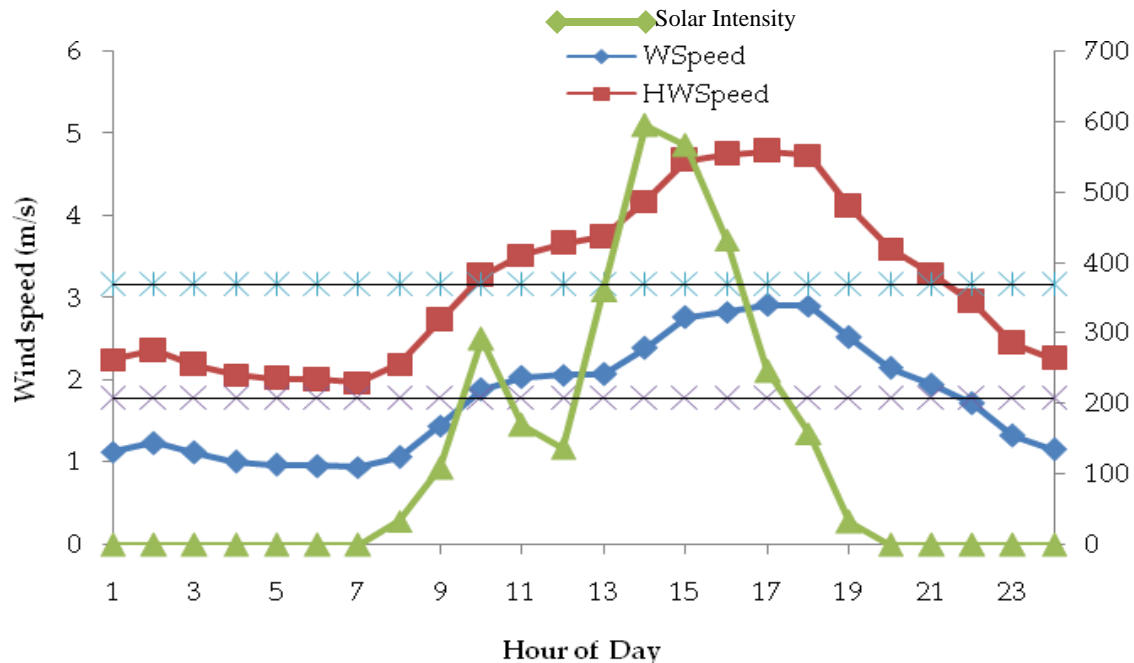


Fig. 4.1c: Diurnal variations of 5-minute data from the Davis Instrument located at NCEE, Benin City.

Table 4.2b: Monthly average wind speeds for Benin City in meters/sec.

	August	September	October
NCEE	1.97	1.98	1.77 ^a
	3.43	3.46	3.15 ^b
NIMET	5.37	4.34	3.69 ^c
NASA SSE	3.68	3.22	2.64 ^d

- a. 5 minute average data
- b. Peak value of 5 minute average data
- c. Twelve year daily average data (1993-2004)
- d. 21-year daily average data (1983 - 2005)

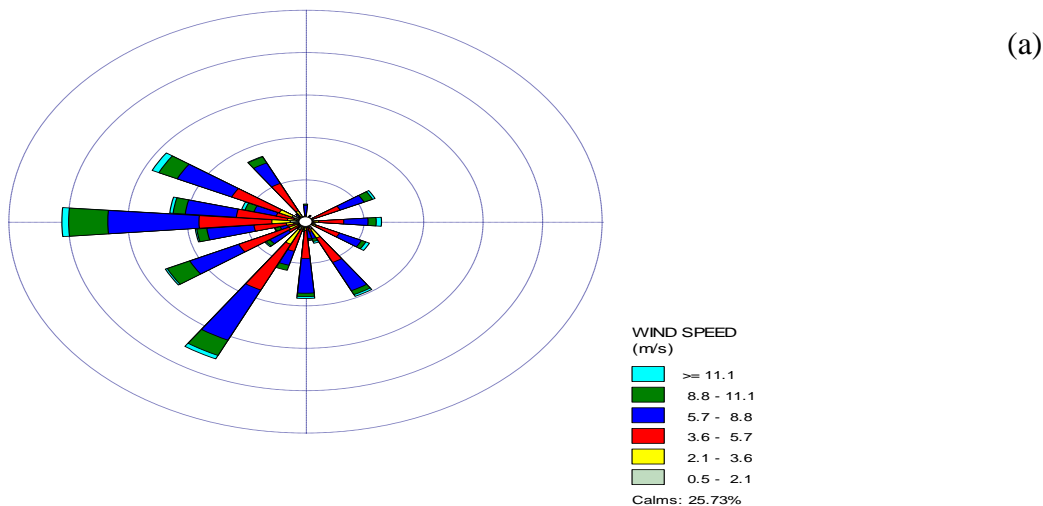
It is also observed that daily and monthly averages from this 5-minute data set are consistently lower than that of the historical records from NIMET at 10 m height. These results agree more with those from National Aeronautic Space Agency (NASA SSE) at 50 m height.

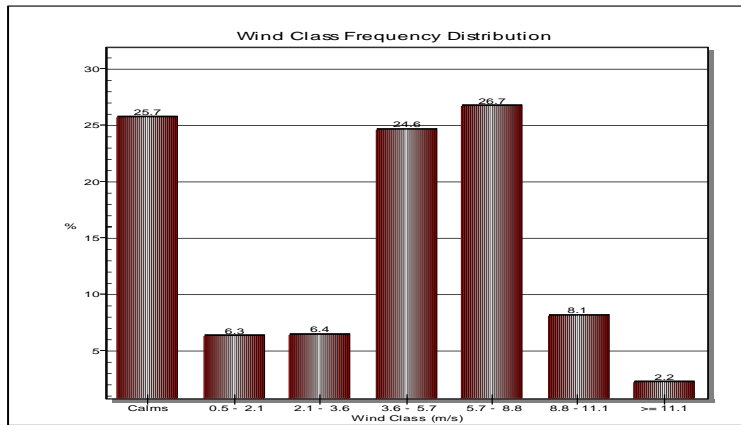
Thus, daily averages can lead to over estimation of observed wind speed if the readings are taken just every hour rather than on a very short time scale of minutes or lower. That these results appear to agree more with NASA SSE underscores the importance of accurate and detailed observation and analysis of any variable meteorological parameter for proper assessment. It is important to note that the measured wind speed in the field ranged from 0.1 m/s to 3.5 m/s. The wind speed as recorded in the previous study showed maximum wind speed in the area to be about 2.5 m/s. The previous Table of values (Table 4.1b) showed no major variation from the present study.

Other meteorological parameters are the prevailing wind speeds and directions which were compiled from both NASA Atmospheric Data Centre and NIMET, Oshodi, Lagos. On a regional scale, the 22-year data from NASA SSE presented in Figure 4.1c shows the general meteorology of Edo, Delta and Bayelsa States. Humidity remains high at about 84.5% and only drops in Dec/Jan to about 65%. The normal bimodal distribution of rainfall is clearly noted in the precipitation curve with a peak of about 8 mm/day during the months of Jun/Jul/Sept. Insolation of the atmosphere averages at about 10 kW/m²/day which just doubles the value at the earth's surface of about 5 kW/m²/day. The daily maximum and minimum temperature are also depicted in the Figure. The minimum temperature average is about 21.5°C.

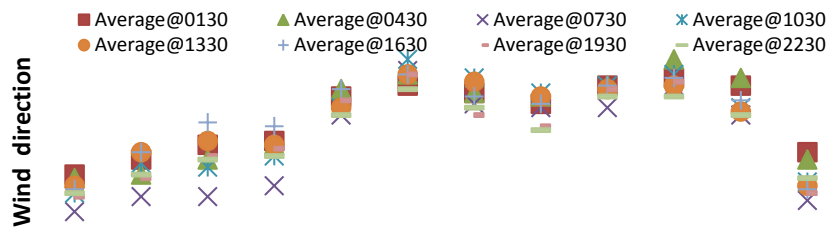
Rainfall

The project area is located within the equatorial belt that experiences rainfall for most of the year. Ten year historical climatic data covering 1997 to 2008 confirms that rainfall is recorded all year round. The average monthly rainfall is presented in Figure 4.1d showing 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. However, available data from the Warri Meteorological Station, suggests a total annual rainfall in excess of 2,700 mm for the region.





(b)



(c)

(a) wind rose, (b) wind class frequency distribution and (c) monthly variation in wind direction. NASA Atmosphere Data Centre and NMET, Oshodi, Lagos.

Fig. 4.1d: Prevailing wind speed and direction in Benin City and environs

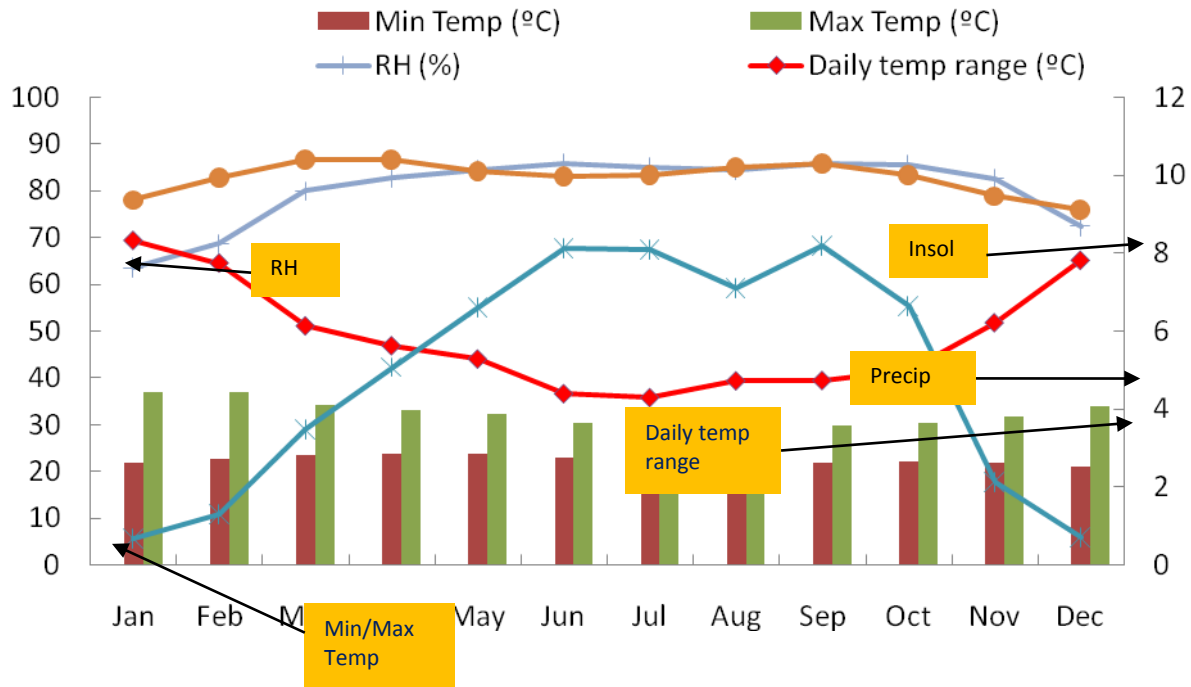


Fig. 4.1e: General meteorological parameters of Benin City from 1983 – 2005 (NASA SSE)

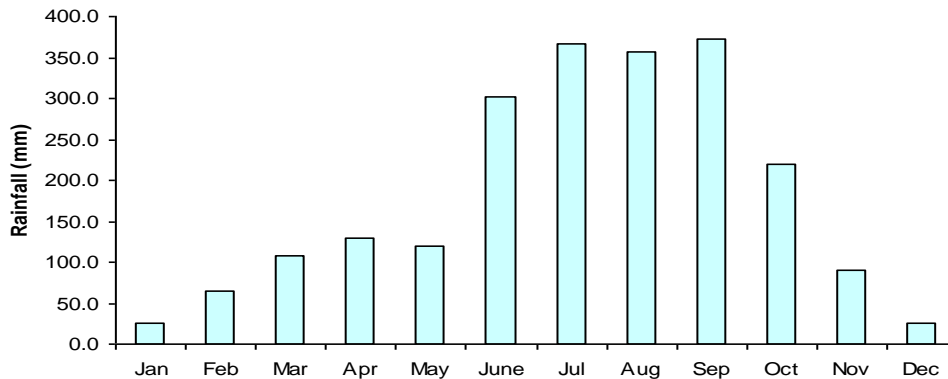


Fig. 4.1f: Average Monthly Rainfall Distribution for Warri Synoptic Station

Relative Humidity

The historical average Relative Humidity (RH) for the project area is presented in Figure 4.1g. The data show that relative humidity values are high all year round at an average of 78.5%, which is typical of equatorial climate. Humidity values naturally exceed 85% during the rainy season under the influence of the moisture laden South Westerly. The daily variation of relative humidity is intricate. Usually it is highest in the morning and drops to a low value just before dusk. Relative humidity measured during the field work ranged from 72.9 to 97.50 % as presented in Appendix II. During the dry season, RH was 75.65% at Tunu and 71.27 at Dodo North, whereas during the wet season, it was 84.42 and 86.33% respectively.

The complex interplay between pressure and other meteorological parameters does not easily yield to straightforward analysis. Recorded pressures are typical of the area which is often between 745 and 757 mmHg. There is no significant difference between indoor and outdoor atmospheric pressure as expected.

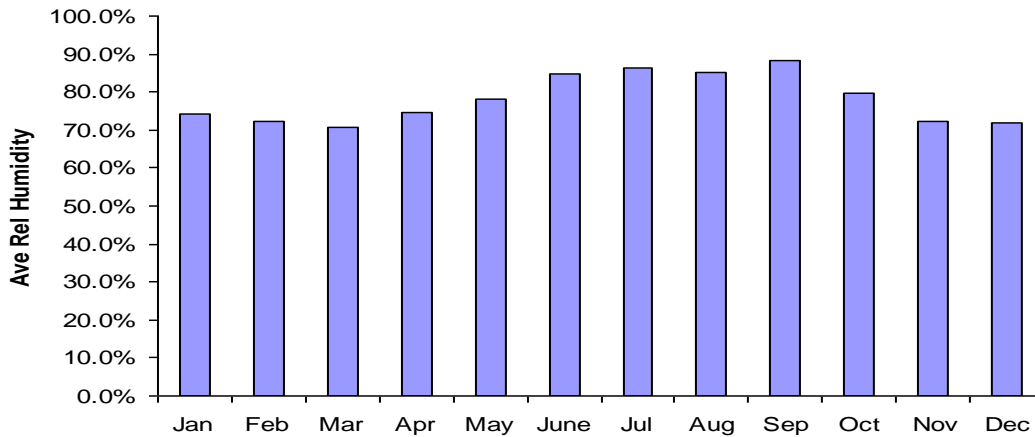


Fig. 4.1g: Average Relative Humidity for Warri Synoptic Station

Temperature

Figure 4.1h shows the 10-year average maximum, minimum and the mean monthly temperatures for the project area. The study area experiences uniformly high temperatures throughout the year because of high insolation (Oguntoyibo 1982). The highest mean monthly maximum temperature of 33.6 °C occurs in February while the lowest value of 27.3 °C is experienced in July, during the peak period of the wet season. Due to the depletion of incoming solar radiation by greater cloud cover, temperature values are slightly lower during the wet season (Oguntoyibo, 1982). The spatial temperature variations recorded within the project area during the study may likely be accounted for by the transient cloud cover and time of day rather than as a result of effects of the plant operations. The ambient temperatures recorded during the field survey ranged from moderate to high i.e. 25.30 to 31.0 °C with an average of 28.15 °C as presented in Appendix II. Average temperature was generally higher during the dry season than wet season. Average temperature was 30.5 °C at Tunu during the dry season and 27.44 °C during the wet season, whereas, it was 32.27 °C at Dodo North during the dry season and 26.85 °C during the wet season.

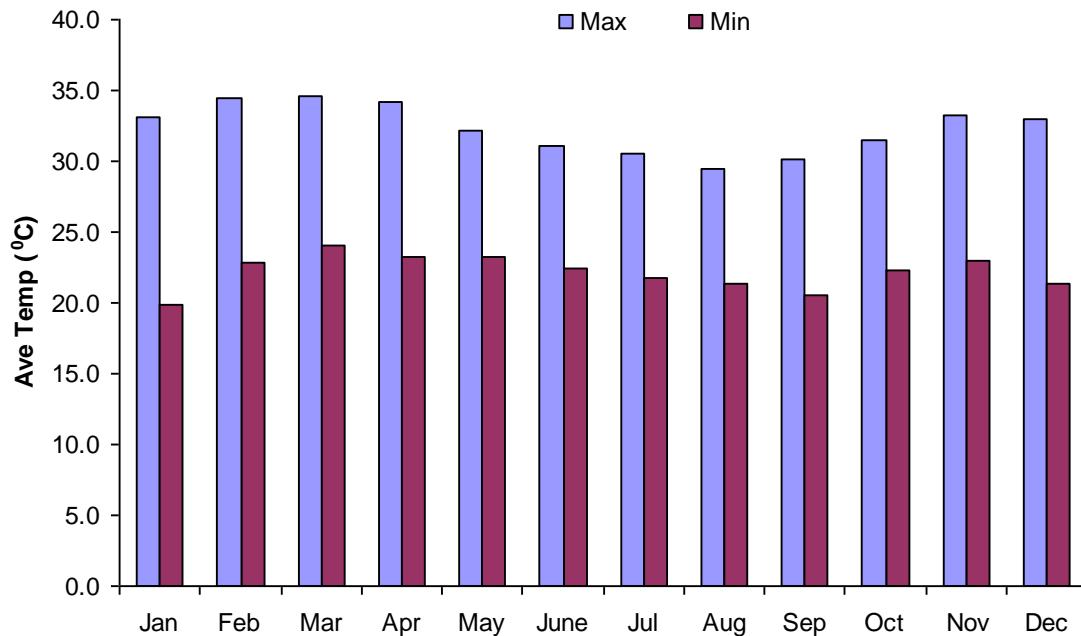


Fig. 4.1h: Average Monthly Temperatures for Warri Synoptic Station

Noise and Vibration

Noise has since been considered an occupational health hazard the oil industry is not exempt from being an environmental noise contributor; with flowstation operations contributing to intense noise and vibrations. Noise and vibrations from flowstation operations typically emanate from electric power generators, compressors, separators and gas scrubbers, crude transfer pumps powered by gas driven engines, inlet manifolds, gas flaring, flowstations alarm systems, surge vessels and separators. Before establishment of oil facilities, site investigation and preparation, construction, and normal activities are often noise and vibration intensive. There are small private electric power generators within the communities, but these are used mainly at night. The psychological and physiological effects of working in a noisy environment for prolonged periods have been documented (Passcluer-Vermeer, 1971; Starck *et al* 1987; Willingham 1976).

The Noise Exposure Limits for Nigeria is presented in Table 4.2c. The details of noise measurement at each of the sampling points are presented in Appendix II. On the average, noise was 71.4 dB(A) at Tunu during the dry season and was significantly lower, being 43.21 dB(A) during the wet season. A similar pattern was observed at Dodo North, noise being 75.05 dB(A) during the dry season and 38.73 dB(A) during the wet season. However, all the measurements taken fell below FMEEnv/DPR permissible limit of 90 dB(A) for 8 h exposure limits and are all within acceptable limit.

Table 4.2c: Noise Exposure Limits for Nigeria

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

Source: FMEnv, 1991

Air Quality

In this aspect of the study, some air pollutants were monitored, including Suspended Particulate Matter (SPM), Nitrogen dioxides (NO₂, NO), sulfur dioxide (SO₂), and carbon monoxide (CO), ammonia (NH₃), hydrogen sulphide (H₂S) and VOC to evaluate the state of air quality in the project area. Air pollutants concentration observed during the field work at the selected sites are presented in Table 4.2a and Appendix II.

Air Quality Assessment

A summary of the air quality measurement in Dodo North and Tunu fields covering the adjoining pipeline RoW is presented in Table 4.2a while the detailed results are presented in Appendix II. The regulatory limits for these parameters are presented in Table 4.2d for FMEnv, and Tables 4.2e and 4.2f for DPR and WHO respectively. During both seasons, NH₃, SO₂, NO₂ and NO were not detected (<0.01 ppm). Carbon monoxide was not detected during the wet season in both stations, but low concentration was recorded during the dry season being 1.31 ppm at Tunu and 1.88 at Dodo North. The CO therefore fell within the DPR/FMEnv regulatory limits of 10 – 20ppm. Similarly, H₂S was not detected in the wet season whereas in the dry season H₂S was 0.91 ppm at Tunu but was significantly lower at Dodo North being 0.21 ppm. During the dry season, SPM was higher in Tunu than Dodo North, but lower during the wet season. At Tunu, SPM was 45.53 µg/m³ during the dry season and 0.97 µg/m³ during the wet season, whereas at Dodo North, SPM was 18.23 µg/m³ during the dry season and 1.65 µg/m³ during the wet season. These values were several factors lower than the permissible DPR/FMEnv limits of 250 µg/m³ and World bank limit of 150 - 230 µg/m³. Volatile organic compounds were 0.02 µg/m³ in Tunu and 0.24 µg/m³ in Dodo North.

Table 4.2d: Nigerian Ambient Air Quality Standards

Pollutants	Time of Average	Limit
Particulate	Daily average of daily values 1 hr.	250 $\mu\text{g}/\text{m}^3$ 600* $\mu\text{g}/\text{m}_3$
SO _x as SO ₂	Daily average of hourly values 1 hour.	0.01ppm (26 $\mu\text{g}/\text{m}^3$) 0.1 ppm (260 $\mu\text{g}/\text{m}^3$)
NO _x as NO ₂	Daily average of hourly values (range)	0.04- 0.06 ppm (75- 113 $\mu\text{g}/\text{m}^3$)
Carbon Monoxide	Daily average of hourly values 8-hourly average	10-20ppm (11.4-22.8 $\mu\text{g}/\text{m}^3$)
Photo Chemical Oxidant	Hourly values	0.06ppm
Non methane Hydrocarbon	Daily average of 3 – hourly values	160 $\mu\text{g}/\text{m}^3$

* Concentration not to be exceeded for more than once a year

Source: FEPA 1991 (Guideline and Standards for Environmental Pollution Control in Nigeria)

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

Pollutant	1-Hour Mean (μgm^{-3})	Daily Mean (μgm^{-3})	Annual (μgm^{-3})
Total Suspended Particulates (TSP)	150 - 230	60 - 90	
Carbon monoxide(CO)	30	10	
Sulphur dioxide (SO _x)	350	100 - 150	40 - 60
Nitrogen Dioxide (NO _x)	400	150	
Lead			0.5 – 1.0

⁽¹⁾ Not to be exceeded more than once per year.

⁽²⁾ Final rule signed October 15, 2008.

⁽³⁾ Not to be exceeded more than once per year on average over 3 years.

Table 4.2f: World Health Organisation (WHO) Guidelines for Maximum Exposure to the major pollutants

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 $\mu\text{g}/\text{m}^3$ (annual mean); 100-150 $\mu\text{g}/\text{m}^3$ (Daily average)
Suspended Particulate Matter (SPM)	Pulmonary effects are associated with the combined exposure to SPM and SO ₂	Black: 40-60 $\mu\text{g}/\text{m}^3$ (Annual mean). 100-150 $\mu\text{g}/\text{m}^3$ (Daily average)

Pollutant	Possible Effects	WHO Guidelines
		Total SPM: 60-150 $\mu\text{g}/\text{m}^3$ (Annual mean); 150-230 $\mu\text{g}/\text{m}^3$ (Daily average)
Nitrogen dioxide (NO ₂)	Effects on lung function in persons suffering from asthma from short-term exposures	150 $\mu\text{g}/\text{m}^3$ for 24 hr mean; 400 $\mu\text{g}/\text{m}^3$: Not to be exceeded
Carbon Monoxide (CO)	Reduced oxygen - carrying capacity of blood	10 $\mu\text{g}/\text{m}^3$ (for 8 hr); not to be exceeded.

Source: WHO Air Quality Guidelines for Europe

4.4.2: Soil Studies

Mean values of the soil physicochemical properties are shown in Table 4.3a and the detailed results given in Appendix III. However, physicochemical and microbiological parameters of the subsurface soils of the 2003 studies are not available.

Soil Texture

Texture determined *in-situ* showed that the soils were mainly hydromorphic, with very poor drainage conditions (aquic moisture regime) in both seasons. Soil texture in both dry and wet seasons was mainly sand. However, pockets of silty clay were observed beyond the coastlines, while loam and sandy clay loam was found around Tamogbene. In some cases, soils were neither sticky nor slightly sticky, structureless to very weak blocky structure. These properties made the soils very porous, leading to high permeability and low organic matter content.

Soil Reaction (pH)

Mean pH of the Dodo North surface soil was 3.60 and 4.24 in the dry and wet seasons respectively. That of the control soil was 4.41; this indicates extreme acidic status. Soil pH of the controls ranged from 3.80 to 5.15 i.e. extreme acidic to slightly acidic. The extreme pH value is detrimental to exchangeable cations and organic matter release and availability to plants. The extreme acidic pH is typical of mangrove swamp vegetation. Application of lime and organic matter build up should be encouraged for enhanced soil condition for plant growth and improvement of soil fertility.

Exchangeable Cations

Mean exchangeable calcium content of Dodo North surface soils was 107.44 mg/kg in the wet season and was comparably higher than 3.86 mg/kg in the dry season and 64.73 mg/kg of the control. Mean potassium content was highest in the wet season at both depths; the mean value was also high in the control. The value was rather very low in the dry season. The soils of Dodo North has sufficient calcium content in the wet season but deficient in the dry season when compared to critical level of 761.52 mg/kg. Mean sodium content of the surface and subsurface depths was high in the control and wet season but was very low in the dry season. Poor soil texture and low water retention are due to high Na content; it encourages clay dispersion and leaching losses of nutrients. Higher CEC in the wet season and the control is attributed to higher calcium content.

Heavy Metals

Heavy metal concentrations in the soils of Dodo North were generally low with the exception of iron. Mean Cadmium, chromium, nickel, copper, zinc and lead contents in the wet season were 4.82 mg/kg, 21.47 mg/kg, 22.04 mg/kg, 28.36 mg/kg, 23.26 mg/kg and 20.86 mg/kg respectively. That of the dry season which was lower in concentrations, were 0.03, 0.07, 0.49, 0.14, 5.71 and 2.46 mg/kg, respectively. Heavy metal concentrations in the soils of the control were similar to that of the wet season. Higher concentrations of heavy metals in the wet season are due mainly to solute recharge and extreme acidic pH of the soil. Mean iron content of the soil in the wet and dry seasons was very high; it was relatively higher compared to critical iron content of 200 mg/kg. Adefemi *et al.* (2007) had earlier reported the occurrence of iron in high concentrations in soils within the Niger Delta regions of Nigeria.

Total Organic Carbon

Mean total organic carbon (TOC) of the wet and dry seasons was 11.10 and 90.77 g/kg while the control was 11.42 g/kg. The soils had low organic carbon in the wet season and high content in the dry season. The extreme pH may lead to breakdown of organic matter by soil fungi that thrive best under such condition.

Total Petroleum Hydrocarbon

Total petroleum hydrocarbon occurred in very low content in both season, poses no problem to plant growth and invasion of the soils by unfavourable microorganism.

Microbiology

The microbial counts of surface and sub-surface soil are presented in Table 4.3b. The Total Heterotrophic Bacteria (THB) and Total Fungi (TF) counts are normal for soils within the Niger Delta. Bacterial and fungi counts vary slightly in both seasons. A percentage hydrocarbon population of greater than 10 % especially % HUB is suggestive of hydrocarbon pollution of the soil due to exposure of microorganisms to hydrocarbons. A percentage HUB population of between 1.0 and 10% is suggestive of hydrocarbon contamination. Current percentage HUB (0.83 to 0.88 %) levels in both seasons are suggestive of low hydrocarbon levels in the soils within the study area.

Table 4.3a: Mean Chemical properties of surface and subsurface soils

PARAMETERS	Dodo North (Wet season)		Control Wet Season		Dodo North (Dry season)	DPR Intervention Level mg/kg	Soil Critical Level
	0-15cm	15-30cm	0-15 cm	15-30cm	0-15cm		
	Mean	Mean	Mean	Mean	Mean		
pH	4.24	4.19	4.41	4.48	3.60	5.5-6.5	
Temperature, °C	27.08	26.68	27.30	27.60			
Cation Exchange Capacity cmol/kg	1425.82	1004.49	29.37	20.89	12.2		
Sodium, mg/kg	673.03	491.66	956.17	582.78	2.93		50
Calcium, mg/kg	107.44	63.94	64.73	46.96	3.86		761.52
Potassium, mg/kg	491.66	332.24	261.28	229.24	0.33		98.84
Cadmium, mg/kg	4.82	2.71	5.41	3.26	0.03	12	50
Zinc, mg/kg	23.26	16.30	20.90	15.28	5.71	720	250
Iron, mg/kg	1078.53	797.33	973.85	881.66	1292.79		200
Magnesium, mg/kg	153.69	116.65	97.03	73.37	5.08		238.40
Copper, mg/kg	28.36	17.97	29.17	19.22	0.14		
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001		
Chromium, mg/kg	21.47	15.19	19.26	13.78	0.07	380	50
Nickel, mg/kg	22.04	18.61	18.56	10.00	0.49		50
Lead, mg/kg	20.86	15.80	16.12	8.79	2.46	530	100
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	0.06		
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	0.002		
Organic							
TPH, mg/kg	6.14	1.88	3.30	1.06	3.16	5000	50
Total Organic Carbon, g/kg	11.10	13.00	11.42	6.90	90.72		10
Microbiology							
Total Heterotrophic Bacteria (THB), cfu/g x10 ⁵	2.99	2.83	3.14	3.10			
Total Fungi count (TFC), cfu/g x10 ⁴	3.37	3.14	3.57	2.78			

PARAMETERS	Dodo North (Wet season)		Control Wet Season		Dodo North (Dry season)	DPR Intervention Level mg/kg	Soil Critical Level
	0-15cm	15-30cm	0-15 cm	15-30cm	0-15cm		
	Mean	Mean	Mean	Mean	Mean		
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.62	2.34	2.87	2.45			
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ²	1.97	1.78	2.11	1.99			

Note: Subsurface soils in 2003 studies were not sampled

Table 4.3b: Microbial Population of the surface and sub-surface soil

Parameters	Dodo North (Wet season)		Dodo North (Dry season)		Control Wet Season	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15 cm	15-30cm
Total Heterotrophic Bacteria (THB), cfu/g x10 ⁵	2.99	2.83	NA	NA	3.14	3.10
Total Fungi count (TFC), cfu/g x10 ⁴	3.37	3.14	NA	NA	3.57	2.78
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.62	2.34	NA	NA	2.87	2.45
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ²	1.97	1.78	NA	NA	2.11	1.99
Mean % HUB	0.88	0.83	NA	NA	0.91	0.79
Mean % HUF	0.58	0.57	NA	NA	0.59	0.72

NA-not available

Note: Subsurface soils in 2003 studies were not sampled

4.4.3: Vegetation Cover Characteristics

Dodo North area is drained by the tidal Dodo creek, and Dodo River which also supply the area. The brackish vegetation is influenced by the inflow from the Dodo River in both dry and wet season. The type of vegetation cover found within the study area in both seasons consists mainly of mangrove swamp forest and slight pockets of raffia swamp forest). The mangrove swamp forest occurs at the fringe of high mangrove, and the back swamp low mangrove vegetation. A check list of plant species common in the area is given in Table 4.4.

The high mangrove fringe was found along the Dodo river brackish estuary; the vegetation is in near pristine condition with minimal logging occurring. It is a homogenous population of *Rhizophora racemosa*. Vegetation is dense with touching crowns and few gaps in the canopy. Most of the trees in the area are of timber size with girth of up to 100 cm at breast height. In some areas tree heights reach 25 to 30 m, with species density of 625 trees per ha. The low mangrove / scrub-shrub vegetation consists of *Rhizophora mangle* and is the dominant vegetation cover in Dodo North and neighboring Tunu locations (Plate 4.1a). Average height of the vegetation is 2 m, with some areas reaching 3.5 m. Vegetation cover is up to 60 percent and density is ca. 3500 plants per hectare.

The vegetation is mostly homogenous and critical to the stabilization of the area. However, opportunistic species were found in some areas indicating disturbance of vegetation; *Dalbergia ecastaphyllum* formed dense thickets in disturbed patches (apparently due to line cutting), while *Elaeis guineensis* (oil palm) was also seen competing with *R. mangle* in some areas. Invasive species *Pandanus candelabrum* was found having a density of over 2500 plants per hectare. These invasive and opportunistic species usually out-do native species creating gaps in the well suited vegetation structure that guarantees soil stabilisation in this sensitive wetland system. Mats of *Eichhornea crassipes* were observed. These have the potential to clog up the area and compete for the DO required by other aquatic organisms.



(SSAGG, 2002)

(Current study, 2012)

Plate 4.1: Typical profile of the low mangrove in Dodo North

Table 4.4a: Some Plant Species in Dodo North

Mangrove Swamp Forest	Name	Family	Common Names	Economic Value
Trees	<i>Rhizophora mangle</i>	Rhizophoraceae	Red mangrove	Timber
	<i>Rhizophora racemosa</i>	Rhizophoraceae	Red mangrove	Timber
	<i>Panadanus candelbrum</i>	Pandanaceae	Chandelier tree	Timber
	<i>Panadanus odoratissimus</i>	Pandanaceae	Screw pines	Timber
	<i>Elaeis guineensis</i>	Arecaceae/Palm ae	Oil palm	Edible fruit
Ferns/Epiphytes	<i>Acrostichum aureum</i>	Pteridaceae	Swamp fern	For roof/ antidote for snakes
	<i>Bulbophyllum oreonastes</i>	Orchidaceae	Mountain living <i>Bulbophyllum</i>	For stomach ailment
Hydrophytes	<i>Eichhornia crassipes</i>	Pontederiaceae	Water hyacinth	In environmental control and as fertilizer.
	<i>Nymphaea lotus</i>	Nymphaeaceae		

In the dry season the field was predominantly covered by mangrove plants. Plants with the highest frequency of occurrence were the red mangrove *Rhizophora racemosa* and *R. mangle*. This was however not different from that observed in the wet season. In both seasons, growth of the two plant species was luxuriant. A small population of the tall red mangrove, *Rhizophora racemosa*, was confined to the edges of creeks and rivers. Light demanding species such as *Acrostichum aureum*, *Paspalum vaginatum* and *Fimbristylis* spp. occurred between the mangrove canopies. Epiphytes were abundant on the tree trunks. Typical dominant species was *Bulbophyllum oreonastes*.

In the dry season, the dwarf red mangrove dominated the vegetation top layer. The vegetation has an open canopy in areas dominated by the dwarf red mangrove which was also typical of the wet season. The average canopy height was 3 metres. Primary vegetation dominated the

mangrove swamp while secondary types were prevalent in areas where spoil heaps were dumped.

Plant Pathology

The overall health condition of the plants was normal. Observation of the vegetation in the study area easily showed that the vegetation is generally luxuriant. The plants did not show any signs of poor growing conditions.

Agriculture and Land Use

Generally, within the study area, it was observed that agriculture is clearly a major occupation. Farming is seen along water ways and swamp clearings, and close to major communities. Common crops cultivated include sugar cane (*Saccharum officinarum*), plantain (*Musa paradisiaca*), cassava (*Manihot* sp), yam (*Dioscorea* sp) and cocoyam (*Colocasia esculenta*) especially in Tamogbene (Table 4.4b). Crops such as yam, cassava, and cocoyam thrive best during the dry season due to low water level compared to the wet season with its high water level. In Table 4.4c, the land use in the area is presented. The land use types includes, Farming, Industry, Housing, Infrastructures and Others (Fallow lands, Shrines).

Table 4.4b: Percentage composition of Crops grown in the study area

Crops Grown	Percent Spread (%)
Cassava (<i>Manihot</i> sp)	20
Cocoyam (<i>Colocasia esculenta</i>)	10
Yam (<i>Dioscorea</i> sp)	5
Plantain (<i>Musa paradisiaca</i>)	15
Sugarcane (<i>Saccharum officinarum</i>)	20

Table 4.4c: Percentage composition of Land use in the study area

Land Use	Percent Spread (%)
Farming	20
Housing	10
Industry (Oil and Gas)	20
Infrastructures (Schools)	5
Others	45

Forest Resources

Economic species commonly observed in the wild within the study area include *Elaeis guineensis* (Oil Palm), other medicinal plants also exist, which have commercial benefit to the indigenes.

Phytochemistry

The means and ranges of the plant phytochemistry in wet season are shown in Table 4.4d and Appendix III. The uptake of heavy metals generally by mangrove plants is determined by several factors which include salinity and redox potential of the growth environment: this is not only dependent on seasonal variation but proximity to sea water influx and supply of land

surface water runoffs. Metals such as vanadium, cobalt, mercury, arsenic and aluminium concentrations in the plant tissue were in trace quantities (<0.001 mg/kg) that are not toxic to the plants in wet season. Copper, Mn and Zn are among plants nutrients essential for plant growth. Mean Cu, Mn, Zn and Fe contents in plant tissues in Dodo North were 17.54, 559.27, 30.42 and 209.69 mg/kg respectively but for the controls, the mean contents were 19.01, 859.80, 17.66 and 305.72 mg/kg respectively. Plants in the control area in wet season had higher Mn, Cu and Fe concentrations compared to plants in the study area. This is an indication that activities within Dodo North have no adverse effects on plants growth. Concentrations of Mn, Cu, Fe and Zn in plants tissue in Dodo North and control areas were below toxic levels of 2000, 30, 600, 1000 mg/kg in the wet season, heavy metals such as Cr, Cd and Pb mean contents in plant tissues in Dodo North were 18.89, 2.33 and 20.80 mg/kg respectively, while that of the control were 20.15, 2.23 and 15.78 mg/kg respectively. Mean concentrations of Cr, Cd and Pb were below toxic limits that could be harmful to plants and therefore occur in favourable concentrations. Activities within the area have not increased heavy metal concentrations in plant tissues when compared to the control mean values.

Table 4.4d: Ranges and means of elements concentrations in plant tissues

Parameters	Dodo North Range (wet season)	Dodo North Mean (Wet season)	Control Range (Wet season)	Control Mean (Wet season)	Maximum tolerable limits Mg/kg
Calcium, mg/kg	149.07-2470.00	1166.29	2226.00-2303.00	2264.50	
Sodium, mg/kg	531.12-3187.00	2296.23	1304.00-2979.00	2141.50	
Magnesium, mg/kg	174.73-1146.00	655.99	816.42-816.77	816.60	
Potassium, mg/kg	526.12-1313.00	1010.90	817.55-1099.00	958.28	
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001	
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	5 ^a
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	20 ^b
Copper, mg/kg	10.42-23.18	17.54	18.60-19.42	19.01	30 ^b
Cobalt, mg/kg	<0.001	<0.001	<0.001	<0.001	50 ^c
Aluminium, mg/kg	<0.001	<0.001	<0.001	<0.001	
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	
Nickel, mg/kg	8.97-37.28	20.03	13.67-43.51	28.59	100 ^b
Lead, mg/kg	12.97-33.73	20.80	13.31-18.24	15.78	100 ^b
Chromium, mg/kg	9.56-28.22	18.89	18.60-21.70	20.15	52-92 ^d
Zinc, mg/kg	11.34-83.93	30.42	14.09-21.23	17.66	1000 ^b
Cadmium, mg/kg	0.25-7.00	2.33	2.04-2.42	2.23	100 ^b
Iron, mg/kg	119.60-332.88	209.69	210.88-400.56	305.72	600 ^a
manganese, mg/kg	12.98-1251.00	559.27	793.00-926.59	859.80	2000 ^b

a= Tatjana and Bojka (2013), b = Manicol and Beckett (1985) and Kabata-Peendias and Pendias (2001), c = Dragoja *et al.* (2007)

4.4.4: Aquatic Studies

4.4.4.1: Surface Water Physicochemistry

A summary of the water quality of the study area is presented in Table 4.5a and Appendix IV for both wet and dry seasons. The pH ranged from slightly acidic to slightly alkaline in the wet season (6.1-7.7) and dry season (5.5-7.9). The pH of the control stations was also slightly acidic. These pH values were generally within the DPR/FMEnv limits of 6.0 – 9.0 except in the dry season, where a pH of 5.5 was recorded. Being a mangrove environment, low pH is common (Ohimain *et al.*, 2004). Temperatures were generally higher in the dry season (29.1-32.6°C) than in the wet season (23.87 - 28.50 °C). Temperatures recorded during both seasons were generally lower than the DPR/FMEnv limits of <40 °C.

Three turbidity related parameters (colour, TSS and turbidity) were measured. The colour of the water was several factors lower in the wet season (4.9-15.0 pt-Co) than dry season (0-133 pt-Co). A similar pattern was observed for turbidity. Turbidity values of 2.15-8.65 NTU and 0-20 NTU were recorded during the wet and dry seasons respectively. This is not unusual because of the diluting effect of rainfall on turbidity, though surface runoff can also increase turbidity during the wet season. It is therefore suspected that flooding might have been responsible for the higher TSS in the wet season (15 - 16997 mg/l) than the dry season (125-600 mg/l). These values are several factors higher than the DPR/FMEnv limits of 30 mg/l.

Oxygen related parameters studied include DO, BOD₅ and COD. The DO was higher in the dry season (5.5-9.8 mg/l) than wet season (3.20-8.25 mg/l), due to increased primary productivity and within the DPR/ FMEnv limits of 30 mg/l. The BOD₅ was lower during the wet season (1.99-7.20 mg/l) than dry season (2.6-7.7 mg/l), but lower than the DPR/FMEnv limits of 10 mg/l. Chemical Oxygen Demand (COD) was lower in the wet season (5.0-8.9 mg/l) than dry season (2.4-43.2 mg/l), though lower than the DPR/ FMEnv limits of 40 mg/l. All the hydrocarbon related parameters were low (<0.1) in both seasons including THC, TPH, PAH and phenols except for the dry season where THC ranged from 0.7 – 4.7 mg/l, but was still lower than the DPR/FMEnv limits of 7 mg/l.

Salinity related parameters measured during the study include TDS, electrical conductivity, chloride, sulphate and other anions. The results of the salinity related parameters showed high variability, possibly indicating that the water draining the study area is a mix of freshwater and brackish water. The electric conductivity during the wet season (20-32070 µS/cm) was slightly higher than the dry season (1761-26000 µS/cm). Total Dissolved Solids (TDS) being directly correlated with conductivity exhibited the same pattern being slightly higher in the wet season. Sulphate was similarly higher during the wet season (0.320-103.34 mg/l) than the dry season (6-18.7 mg/l). Chloride was higher during the dry season (562-12116 mg/l) than wet season (5-7100 mg/l), due to dilution effect, but was significantly lower than the DPR/FMEnv limits of 2000 mg/l. Other anions occurred in traces (<0.1 mg/l) such as carbonate, phosphate, hydrogen sulphide, cyanide, nitrite and ammonia whereas nitrate was <2 mg/l in both seasons.

The major metals in the study area are sodium and calcium followed by magnesium, while potassium occurred in low concentration (23.4 - 28.2 mg/l) during the dry season. Sodium was higher during the dry season (223-7091 mg/l) than the wet season (1 - 4176 mg/l). Calcium was higher during the wet season (3-2819mg/l) than the dry season (12.8-280.8 mg/l). Similarly, magnesium was higher during the wet season (1-1689 mg/l) than the dry season (0.5-371.8 mg/l). Some metals occurred in the order of 1 – 10 mg/l (Cd, Pb, Fe), some metals occurred in the range of 11-20 mg/l (Zn) and others from 21 – 30 mg/l (Cu, Cr, Ni). All the other heavy metals (V, Hg, As, Ba) occurred mostly in trace concentrations below equipment detection limits (0.001mg/l) and <0.6 mg/l (Mn) in both seasons. Heavy metal concentrations were mostly recorded during the wet season, but occurred in traces during the dry season.

Table 4.5a: Summary of water quality data for wet and dry season

Parameter	Wet season				Dry season	DPR/FMEnv Limit
	Control 1	Control 2	Mean	Range	Range	
pH	6.50	6.51	6.596±0.400	6.120-7.700	5.53-7.95	6.0 – 9.0
Temperature, °C	25.0	28.00	26.570±1.430	23.87-28.5	29.1-32.6	<40
EC, µS/cm	57.1	34.00	5123±10898	20-32070	1761-26000	
Colour, pt-Co	4.99	10.00	7.765±3.029	4.9-15.0	0-133	
DO, mg/l	3.55	4.33	4.752±1.695	3.20-8.25	5.5-9.8	5
COD, mg/l	8.20	8.44	7.196±1.022	5.0-8.9	2.4-43.2	40
TDS, mg/l	34.10	18.60	5181±7259	15-16997	870-13000	2000
TSS, mg/l	8.10	10.00	7.902±3.162	3.0-16.0	125-600	30
Turbidity, NTU	5.85	7.25	5.186±2.040	2.15-8.65	0-20	10
Alkalinity, mg/l	8.59	1.99	4.537±2.717	1.99-7.990		
Hardness, mg/l	11.00	8.00	1160±1645	10-4200		
BOD ₅ , mg/l	6.65	6.70	4.791±1.796	1.990-7.200	2.6-7.7	10
Chloride, mg/l	11.64	7.09	1775±2900	5-7100	562-12116	2000
Salinity,‰					0.73-14.44	
Nitrate, mg/l	0.67	1.71	1.043±0.523	0.017-1.760	0.01-0.15	20
Sulphate, mg/l	2.64	0.16	33.476±43.529	0.320-103.340	6-18.7	200 – 400
Carbonate, mg/l	<0.001	<0.01	<0.01	<0.001		
HCO ₃ , mg/l					38-140	
Phosphate, mg/l	0.12	0.20	0.160±0.146	0.023-0.580	0.05-0.17	
Sodium, mg/l	5.006	3.314	1050±1683	1-4176	223-7091	
Calcium, mg/l	5.470	1.60	503±1000	3-2819	12.8-280.8	
Magnesium, mg/l	2.326	0.970	410±659	1-1689	0.5-371.8	30 - 150
Potassium, mg/l					23.4-28.2	75 – 200

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Parameter	Wet season				Dry season	DPR/FMEnv Limit
	Control 1	Control 2	Mean	Range	Range	
Phenol, mg/l	<0.001	<0.001	<0.001	<0.001		
Nitrite, mg/l	<0.001	<0.001	<0.001	<0.001	0.01-0.15	20
Ammonia, mg/l	0.43	2.096	0.774±0.784	0.030-2.500	0.02-0.35	0.2
Hydrogen Sulphide, mg/l	<0.001	<0.001	<0.001	<0.001		
Cyanide, mg/l	<0.001	<0.001	<0.001	<0.001		
Cadmium, mg/l	0.007	0.005	<0.001	<0.001-1.701	0.004-0.017	0.05
Vanadium, mg/l	<0.001	<0.001	<0.001	<0.001	0.005-0.02	
Zinc, mg/l	0.303	0.144	0.990±3.163	0.067-12.420	0.12-0.25	5 – 15
Lead, mg/l	0.010	0.008	0.751±1.800	0.007-6.680	0.05-0.4	0.01 – 1.0
Iron, mg/l	0.711	0.905	1.130±0.407	0.589-2.140	0.26-1.37	20
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	0.001-0.61	0.05
Manganese, mg/l	0.122	0.157	0.165±0.079	0.018-0.385	0.53-0.81	0.05– 0.5
Asernic, mg/l	<0.001	<0.001	<0.001	<0.001		
Copper, mg/l	0.298	0.108	1.005±3.700	0.006-15.360	0.001-0.008	0.05 – 1.5
Chromium, mg/l	0.024	0.043	1.815±6.923	0.013-28.670	0.001-0.05	0.05
Nickel, mg/l	0.002	0.002	5.100±10.812	0.145-24.440	0.009-0.02	< 1
Barium, mg/l	<0.001	<0.001	<0.001	<0.001		
Aluminum, mg/l					0.01-0.08	
Oil & grease, mg/l	0.66	0.47	0.488±0.332	0.030-1.120		
TPH, mg/l	0.63	0.33	0.398±0.334	0.003-1.130		
PAH, mg/l	<0.001	<0.001	<0.001			
THC, mg/l	0.80	0.47	0.464±0.319	0.023-1.150	0.7-4.7	7
THB, cfu/ml x 10 ⁴	3.9	4.5	4.2±1.0	1.9-6.1		
THF, cfu/ml x 10 ³	3.6	3.3	2.6±0.6	1.4-3.7		
HUB, cfu/ml x 10 ²	2.1	1.3	1.6±0.51	1.0-2.6		
HUF, cfu/ml x 10 ²	1.1	1.0	1.0±0.4	0.4-1.9		

4.4.4.2: Surface Water Microbiology

During the wet season, the population of Total Heterotrophic Bacteria (THB) in the water samples ranged from $1.9 - 6.1 \times 10^4$ cfu/ml with an average of $4.2 \pm 1.0 \times 10^4$ cfu/ml (Table 4.5a), which is in the range found in river waters in the Niger Delta region (Odokuma and Okpokwasili 1993). The population of Hydrocarbon Utilizing Bacteria (HUB) is in the range of $1.4 - 3.7 \times 10^2$ cfu/ml with a mean of $2.6 \pm 0.6 \times 10^2$ cfu/ml, thus accounting for almost 50% of the heterotrophic population. This high proportion of HUB indicate that the area have been exposed to petroleum hydrocarbons despite the fact that the concentration of organics (THC, TPH, PAH, phenols) in the water is currently low. Isolated bacteria from the surface waters include *Bacillus* sp, *Pseudomonas* sp, *Staphylococcus* sp and *Escherichia* sp. The order of predominance is as follows- *Bacillus* sp > *Pseudomonas* sp > *Staphylococcus* sp > *Escherichia* sp.

The Total Fungi (TF) count in the water sample was at least one order lower than their bacteria counterparts. The TF ranged from $1.4 - 3.7 \times 10^3$ cfu/ml with a mean of $2.6 \pm 0.6 \times 10^3$ cfu/ml. The population of Hydrocarbon Utilizing Fungi (HUF) ranged from $0.4 - 1.9 \times 10^3$ cfu/ml with a mean of $1.0 \pm 0.4 \times 10^3$ cfu/ml, thus accounting for nearly 100% of the total heterotrophic population. Again, such high proportion of hydrocarbon utilizers suggests that the area have been exposed to hydrocarbons either of petroleum or vegetative origin. Fungi isolated from the surface waters include *Penicillium* sp, *Mucor* sp, *Cladosporium* sp and *Candida* sp. The predominance is in the order *Mucor* sp > *Penicillium* sp > *Candida* sp > *Cladosporium* sp > *Aspergillus* sp.

4.4.4.3: Sediment Physicochemical Characteristics

The summary of physicochemical and microbiological properties of sediments collected from the study area is presented in Table 4.5b, while the detailed results are presented in Appendix IV. The pH of the sediment was acidic both in the wet (4.83 ± 0.59) and dry (4.56) seasons. This is not unusual in mangrove ecosystems of the Niger Delta (Ohimain, 2004; Ohimain *et al.*, 2004). Exchangable acidity was 1.09 ± 0.16 cmol/kg in the wet season and 1.65 cmol/kg in the dry season. Cation Exchange Capacity was 1.49 ± 0.21 cmol/kg in the wet season. Temperature was 26.89 ± 0.18 °C in the wet season. Electrical Conductivity was several factors higher in the dry season (3925.74 µS/cm) than wet season (176.04 ± 159.86 µS/cm). This is expected because of the dilution effect of the flood water during the wet season. Total nitrogen was several factors higher in the wet season (8.77 ± 5.73 g/kg) than dry season (0.50 g/kg). Phosphate was 3.22 ± 2.75 mg/kg, which was within the DPR intervention levels of 0.3-5.2 mg/kg.

Sodium concentration in the sediment was higher than calcium, potassium and magnesium. Sodium was several factors higher in the wet season (80.76 ± 60.53 mg/kg) than in the dry season (4.17 mg/kg). Potassium was also several factors higher in the wet season (15.83 ± 22.97 mg/kg) than dry season (0.92 mg/kg). Calcium and magnesium occurred at almost the same levels in the sediments. Calcium was slightly higher in the dry season (7.57 mg/kg) than wet season (7.47 ± 2.49 mg/kg). Magnesium was higher in the dry season (8.27 mg/kg) twice that of wet season (4.33 ± 1.44 mg/kg). In both seasons, many of the metals

occurred in traces (i.e. ranging from <0.001 to 0.1 mg/kg) such as Ba, Hg, V and Cd in that order. Cadmium was reported in the wet season in the range of 2.55-8.64 mg/kg with a mean of 4.88±0.64 mg/kg. This level of cadmium is within the DPR target/intervention value of 0.8-12 mg/kg. The concentration of nickel, chromium, lead and copper were in the range of 16 – 20 mg/kg in the wet season, whereas these parameters were several factors lower in the dry season. All these parameters were within the intervention values. Zinc was several factors higher in the wet season (93.81±167.03 mg/kg) than in the dry season (5.59 mg/kg), though lower than the intervention values of 140-720mg/kg. Among the heavy metals, iron had the highest concentration; being 322.32±201.72 mg/kg in the wet season and 1418.30 mg/kg in the dry season. The high level of iron is not unusual in the Niger Delta. Total Organic Carbon (TOC) was within the DPR intervention levels of 0.3-10 mg/kg in both seasons, being 4.47±1.95 mg/kg in the wet season and 6.19 mg/kg in the dry season. The TPH in the wet season (6.27±2.07 mg/kg) was twice that of the dry season (3.56 mg/kg).

4.4.4.4: Sediment Microbiology

In the wet season, THB population ranged from 1.2-5.5 x10⁵ cfu/g with a mean of 3.2±1.2 x10⁵ cfu/g. Hydrocarbon Utilizing Bacteria (HUB) population ranged from 1.3-2.9 x10³ cfu/g with a mean of 2.3±0.43 x 10³ cfu/g hence, the percentage of hydrocarbon utilizers is about 50 % of the heterotrophic species indicating that the area have been exposed to hydrocarbons either of petroleum or vegetable origin. Bacteria species isolated from the sediments include *Staphylococcus* sp, *Bacillus* sp., *Pseudomonas* sp, and *Escherichia* sp. Likewise, TF ranged from 1.7-3.7 x10⁴ cfu/g with a mean of 3.1±0.6 x10⁴ cfu/g. Hydrocarbon Utilizing Fungi (HUF) ranged from 1.0-2.0 x10² cfu/g with a mean of 1.6±0.23 x10² cfu/g. Thus, HUF accounted for about 50 % of the total heterotrophic population. Species of fungi isolated from the study area include *Mucor* sp. *Penicillium* sp, *Cladosporum* sp.

Table 4.5b: Sediment physicochemical and microbiological characteristics of Dodo North

Parameter	Wet season				Dry season	DPR Target - Intervention values
	Control 1	Control 2	Mean	Range	Mean	
pH	5.21	6.12	4.83±0.59	3.62-5.83	4.56	
Temperature, °C	27.04	27	26.89±0.18	26.50-27.12		
EC, µS/cm	113.93	20.6	176.04±159.86	28.43-630.00	3925.74	109-200
Total Nitrogen, g/kg	3.87	10.41	8.77±5.73	2.08-17.12	0.50	
Phosphate, mg/kg	2.13	0.92	3.22±2.75	0.84-8.88		0.3-5.2
Sodium, mg/kg	93.87	13.43	80.76±60.53	14.33-217.20	4.17	
Exchangeable Acidity, cmol/kg	1.29	0.98	1.09±0.16	0.76-1.28	1.65	
Calcium, mg/kg	4.28	8.32	7.47±2.49	4.29-12.34	7.57	
Cation Exchange Capacity, cmol/kg	1.52	1.61	1.49±0.21	1.11-1.88		
Potassium, mg/kg	7.11	8.18	15.83±22.97	3.18-73.40	0.92	
Cadmium, mg/kg	3.422	4.001	4.88±0.64	2.55-8.64		0.8-12
Zinc, mg/kg	17.42	27.47	93.81±167.03	16.46-527.16	5.59	140-720
Iron, mg/kg	530.23	438.212	322.32±201.72	20.32-530.24	1418.30	
Magnesium,	6.21	4.84	4.33±1.44	2.00-6.20	8.27	

Parameter	Wet season				Dry season Mean	DPR Target - Intervention values
	Control 1	Control 2	Mean	Range		
mg/kg						
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001		
Copper, mg/kg	21.67	21.13	17.14±3.13	13.72-23.13	1.35	
Chromium, mg/kg	26.12	27.41	18.91±7.83	4.89-30.57	0.06	100-380
Nickel, mg/kg	19.81	26	16.13±3.57	10.60-25.00	0.37	35-210
Lead, mg/kg	15.58	18.82	16.21±4.56	8.26-22.92	3.07	
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	0.05	
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	0.002	
TPH, mg/kg	6.31	4.22	6.27±2.07	2.13-9.41	3.56	1.0
Total Organic compounds, g/kg	4.92	4.9	4.47±1.95	1.80-8.83	6.19	0.3-10
THB, cfu/g x10 ⁵	3.83	5.26	3.22±1.23	1.22-5.50		
TF, cfu/g x10 ⁴	3.63	3.26	3.07±0.64	1.67-3.68		
HUB, cfu/g x10 ³	2.79	2	2.25±0.43	1.32-2.90		
HUF, cfu/g x10 ²	1.57	1.65	1.58±0.23	1.02-2.01		

4.4.4.5: Phytoplankton

These are microscopic chlorophyll containing plants in the water column called algae. They are of great ecological significance as primary producers, being able to manufacture their own food through photosynthesis. They form a steady supply of food for the zooplankton, macrobenthic invertebrates and fish. The wet season phytoplankton comprised of 17 species belonging to the divisions Cyanophyta (blue green algae) with 7 species, Chlorophyta (green algae) with 5 species, Euglenophyta (euglenoids) with only 1 species, and Bacillariophyta (diatoms) with 4 species (Appendix IV). The division Cyanophyta contributed the highest percentage to the total phytoplankton density, followed by Chlorophyta (Fig. 4.2a).

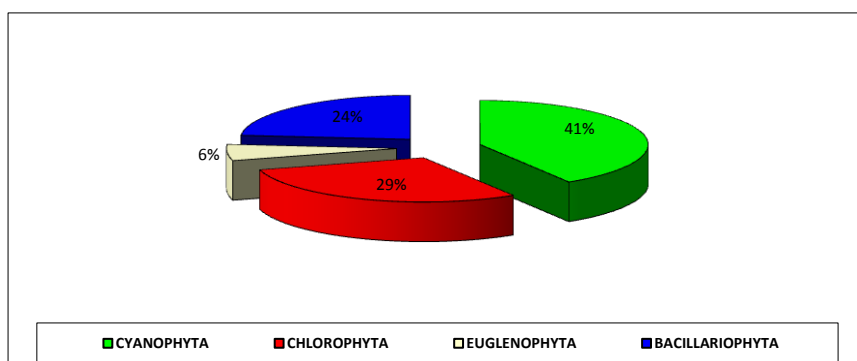


Fig. 4.2a: Contributions of phytoplankton divisions to the total density (Wet season)

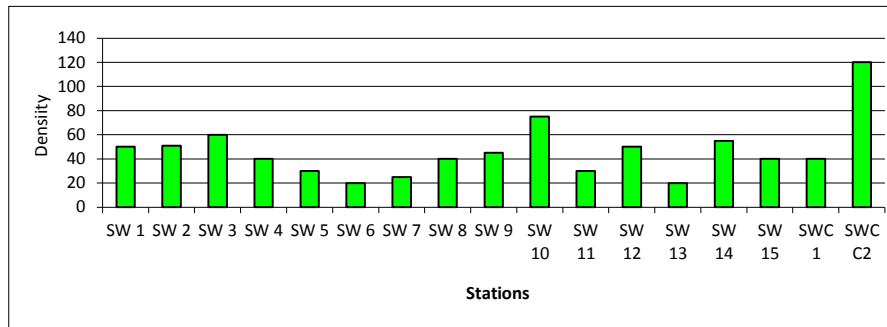


Fig. 4.2b: Spatial Variation in the Density of Phytoplankton in the Study Area

The density of phytoplankton was low, varying from 20 cells/m³ (SW 6 and SW 13) to 120 cells/m³ in the control station (SWC 2). The overall diversity of phytoplankton in the study area was also low, with Shannon diversity values less than 2.0 (Fig. 4.2c), indicating an unstable and perturbed environment.

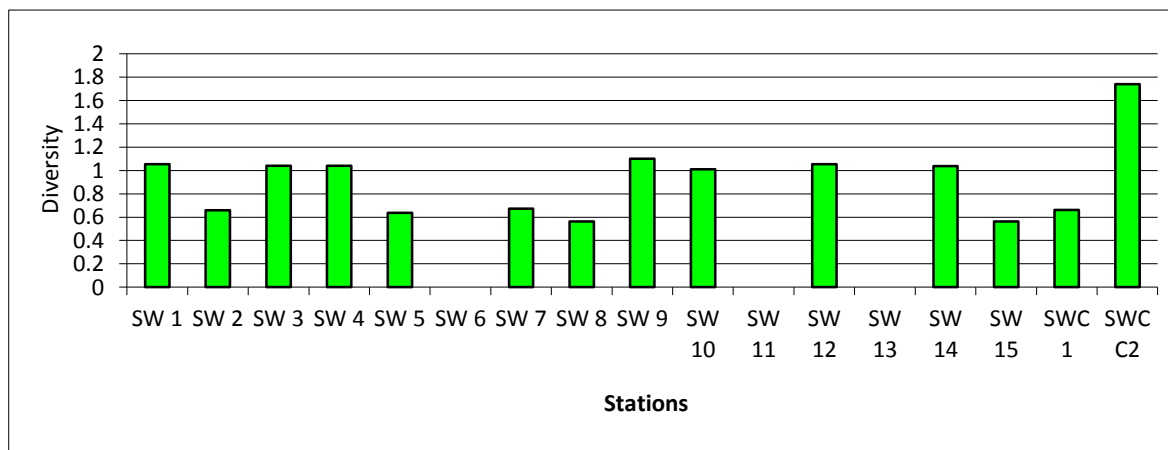


Fig. 4.2c: Spatial variation in the diversity of phytoplankton in the study area

The dry season phytoplankton comprised 16 species made up of the divisions Bacillariophyta, Cyanophyta and Euglenophyta, with Bacillariophyta dominating the population (Fig. 4.2d).

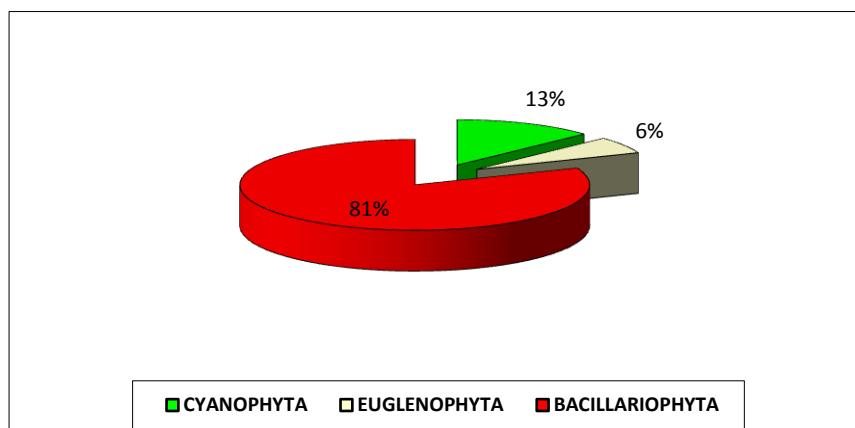


Fig. 4.2d: Contributions of Phytoplankton Divisions to the Total Density (Dry Season).

Majority of the dominant diatoms belong to Centrales (centric forms), constituting 69% of the diatom flora, while the remaining 31% were pennate forms. Members of the family Coscinodiscoceae represented the centric forms while the pennate forms were members of Naviculaceae and Surirellaceae.

4.4.4.6: Zooplankton

These are minute free-floating or weakly swimming animals within the pelagic zone of the water column. They consist of the Rotifera, Copepoda, Cladocera, and larval forms. The zooplankton community is subdivided according to its life history patterns as follows:

- Holoplankton: These are organisms whose entire life cycle is as zooplankton, e.g., calanoid copepods.
- Meroplankton: Those organisms that spend only part of their life cycle as plankton, e.g., eggs and larvae of fish, shrimp, crabs, molluscs and polychaete worms.

The wet season zooplankton community comprised 30 species made up of 8 protozoans, 7 rotifers, 3 ostracods, 6 cladocerans and 6 copepods (Appendix IV). The cladocerans dominated the zooplankton community, contributing 40 % of the total population, followed by the ostracods (22 %) and copepods (17 %). The rotifers (11 %) and protozoans (10 %) were the least represented (Fig. 4.2e).

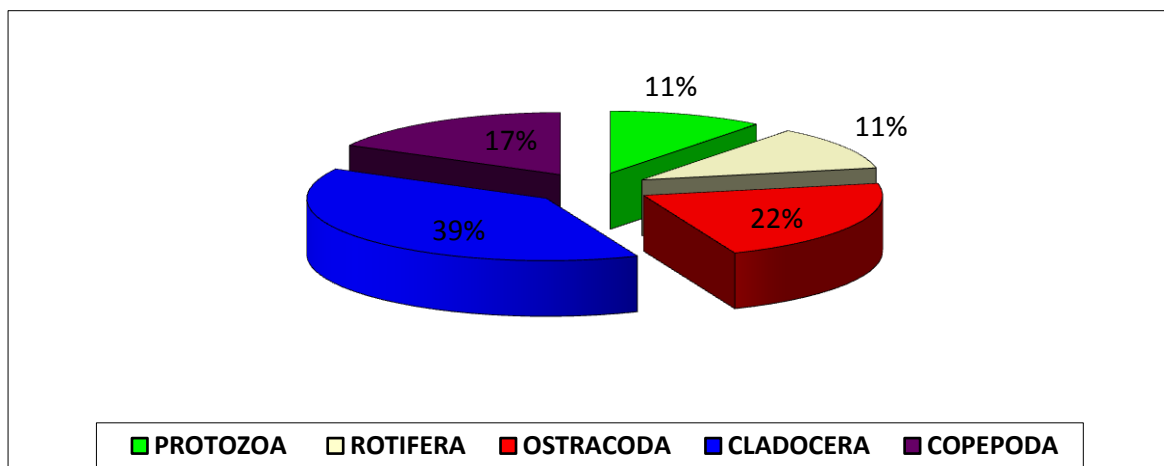


Fig. 4.2e: Contributions of Zooplankton Taxonomic Groups to the Total Density (Wet season)

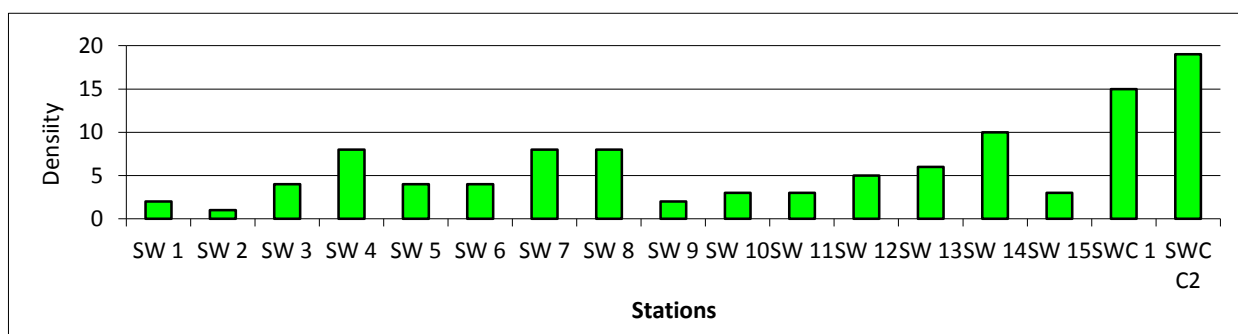


Fig. 4.2f: Spatial Variation in the Density Zooplankton in the Study Area (Wet Season)

The density of zooplankton in the study area was low, with the highest values occurring in the control locations SWC 1 and SWC 2 (Fig. 4.2f). Similarly, the overall diversity which measures community stability was low, ranging from 0 to a maximum of 2.11 in SWC 1 (Fig. 4.2g).

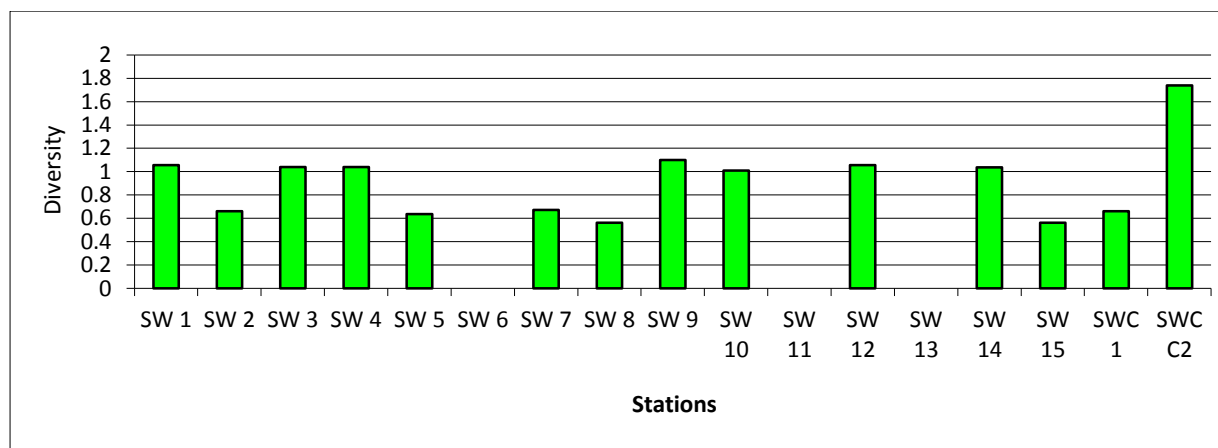


Fig. 4.2g: Spatial Variation in the Diversity of Zooplankton in the Study Area (Wet Season)

During the dry season, only ten (10) species belonging to Cladocera (2) and Copepoda (8) were recorded. The Rotifera, Protozoa and Ostracoda were not recorded during this season. The Cladoceran group was poorly represented, with only two species, *Bosminopsis deitersi* (Bosminidae) and *Moina micrura* (Moinidae). Cladocera constituted only 0.03% of the total zooplankton density recorded. The Copepoda was virtually the only taxonomic group, which occurred in this location during the dry season, making up 99.97% of the total zooplankton density. The Calanoida comprised *Thermodiaptomus yabensis* and *Arcatia tonsi* (Diaptomidae), making up 5.1% of the Copepoda. The Cyclopoida comprised *Thermocyclops crassus*, *Cryptocyclops bicolor*, *Halicyclops korodiensis* and *Tropocyclops* sp which made up 4.9% of the Copepoda density. The Harpacticoida represented by *Bryocamptus birsteini* were insignificant. Nauplius larvae made up the highest proportion (89.2%) of Copepoda. In this location, planktonic heteropod larvae of mollusc were recorded.

4.4.4.7: Macrobenthic Fauna

These are those organisms which are over 1.0 mm in size, living on or in the substrate. They may be infauna (living wholly or partially buried in soft or hard substrates e.g. bottom dwelling annelids, chironomids and bivalve molluscs) or epifauna (living on the surface, either, crawling as mobile benthic inhabitants or attached to different types of substrates e.g. crabs, littorinids, barnacles and oysters attached to the roots of *Rhizophora*).

The bottom dwelling macrobenthic invertebrates recorded during the wet season were represented by 12 species of Mollusca made up of 3 species of Bivalvia and 9 species of Gastropoda as presented in Appendix IV. The bivalves were dominated by *Egeria paradoxa* and *Sphaerium occidentale*, while *Thais haematobium* and *Tympanotonus fuscatus* dominated the gastropod molluscs. These are typical brackish water inhabitants.

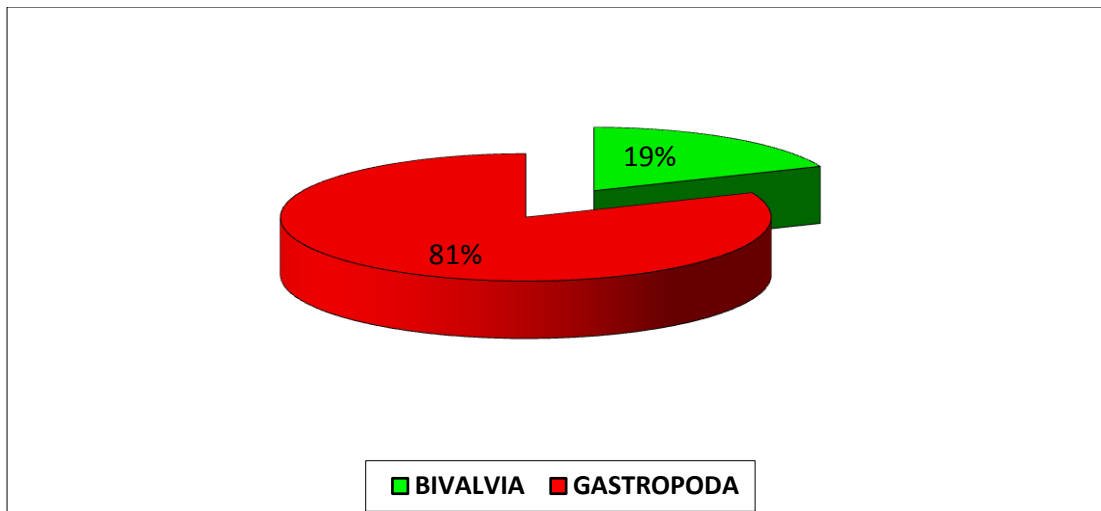


Fig. 4.2h: Contributions of Benthic Macroinvertebrate taxonomic groups to the total density (Wet season)

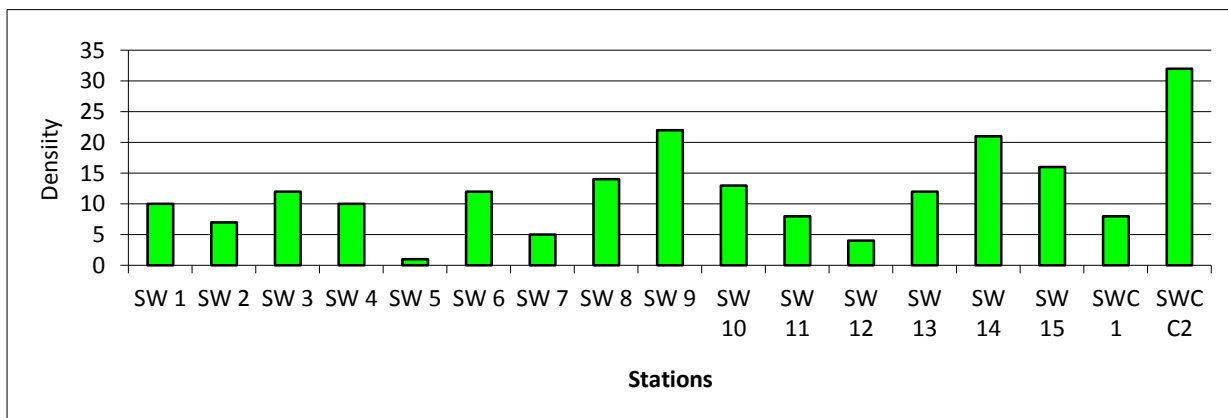


Fig. 4.2i: Spatial Variation in the Density of Benthic Macroinvertebrates in the Study Area

The density of benthic fauna was low in all the stations, with the highest value occurring in the control station SWC 2. The overall diversity was also low, with zero Shannon diversity index (H') in most of the stations as shown in Figure 4.2j. This is evidently a reflection of substrate instability.

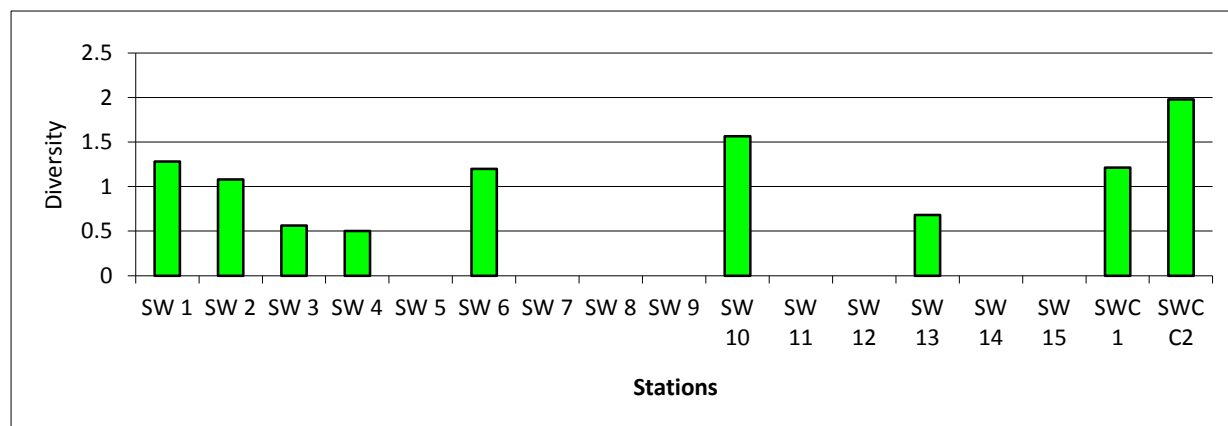


Fig. 4.2j: Spatial Variation in the Diversity of Benthic Macroinvertebrates in the Study Area

Low numbers of individuals and large numbers of species always characterize the macrobenthic community in tropical waters (Victor and Ogbeibu, 1985, 1986; Ogbeibu and Victor 1989 Ogbeibu and Egborge 1995; Ogbeibu and Oribhabor 2002, 2009; Omoigberale and Ogbeibu 2010). The dry season benthic macroinvertebrate composition was more robust, made up of fifteen (15) macrobenthic invertebrate taxa comprising 3 Oligochaeta, 8 Polychaeta, 1 Decapoda and 3 Gastropoda. Of these macrofaunal groups, Polychaeta was dominant, contributing 68% to the total benthic density. The Oligochaete group comprised of three families, Enchytraeidae, Naididae and Tubificidae each represented by a single species. *Enchytraeus* sp. was dominant.

Polychaeta, the most abundant taxonomic group was represented by five families, Glyceridae, Nereidae, Nephtyidae, Pilargidae and Capitellidae. *Nephtys dibranchis* (Nephtyidae) was the most widespread and abundant species recorded. The only decapod species encountered was *Potamalpheops monodi* (Alpheidae) which occurred in very low density. The gastropod molluscs were represented by three species, *Neritina glabrata*, *Tympanotonus fuscatus* and *Pachymelania bryonensis*. The obvious paucity of fauna in the wet season may be the result of seasonal phenomenon and disparity in sampling effort.

4.4.4.8: Fisheries

Fisheries involve the utilization of harvestable aquatic organisms and represent complex interactions between the population of organisms being harvested, the population of fishermen, and environmental conditions. Fishing is the most common occupation in the area, although crop farming, lumbering and other occupations are available. Fishes studied were those caught by the local fishermen and fisherwomen during the study period.

Local paddle boats or dugout types are mainly used during fishing activities; the most commonly used fishing gears are gill nets, filter nets, cast nets, and encircling nets in near and distant waters. Long lines, traps and the use of hand nets are common in all the locations studied. Those engaged in fishing include women, men and seldom children. Fishing is done generally in the communities early in the morning in the open rivers and creeks and cool evenings in small rivers around the neighborhood. No modern fish pond was found in the whole of the areas visited, but local fish ponds created by constructing barriers in creeks and water inlets are common.

Fish Catch Assessment

The catch per unit area is generally low as reported by the fishermen in the localities due to very high amount of rainfall causing migration of fishes. But in some locations in Tunu it was found to be high, especially with cat fish. This low catch per unit area has led to high prices in the whole of the communities. Only crayfish and prawn were found to be relatively cheap as compared to fishes. Assessment was made by engaging fishermen with the use of surface set gill nets, the catch per unit area was low, and this corroborated the assertion of the fishermen earlier interviewed in the different communities.

Species Composition

Fishes bought from fisherfolks and those observed in their natural environment in the different locations are shown in Table 4.5c. Fisheries resources in the area are of diverse and multi-species due to fresh and brackish water conditions. Eleven fish species in fifteen families were identified. The Cichlidae is the most dominant family and had four different species while the Mochockidae had two species and other families were represented by single species. Shellfishes common in nearly all the locations include prawn and/or crayfish Atyidae and Palaemonidae. The prevailing condition factors showed that the fishes have favourable conditions to thrive. Some of the fishes within the study areas are seasonal migratory species, with some being dominant during a particular season.

Table 4.5c: Check list of Fishes Identified in the study area

Families	Species
CICHLIDAE	<i>Tilapia macrocephaly</i>
	<i>Tilapia Melanopleura</i>
	<i>Tilapia sarotherodon</i>
	<i>Tilapia zilli</i>
MALAPTERIDAE	<i>Malapteruridae electricus</i>
MOCHOCKIDAE	<i>Syndontis clarias</i>
	<i>Syndontis filamentosus</i>
CLARIDAE	<i>Clarias gariepinus</i>
LEPIDOSIRENIDAE	<i>Properus annectens</i>
CYPRINDAE	<i>Barbus batersii</i>
OSTEOGLOSSIDAE	<i>Heterotis niloticus</i>
SCHILBEIDAE	<i>Physailia pellucid</i>
GYMNARCHIDIAE	<i>Gymnarchus niloticus</i>
BAGRIDAE	<i>Chrysichthys auratus</i>
HEPSEPTIDAE	<i>Hepseptidae odoe</i>

Tissue Analysis

The tissues of selected fish species (Table 4.5d) were analysed to ascertain the concentration of heavy metals, and possible bioaccumulation to toxic levels. The concentrations of heavy metals in all the fish tissues analysed complied with FAO (1983) limit for safe consumption. There is therefore no evidence of heavy metal contamination in the fish tissues, and the fishes are fit for human consumption.

Table 4.5d: Heavy metal concentrations in fish tissue

PARAMETER S	TAMOGBENE												
	Cr	Cd	Cu	Pb	Fe	Ni	V	Zn	As	Hg	Mn	Se	Ag
<i>Polynemus quadrifillius</i>	0.005	<0.01	5.17	<0.02	22.34	<0.001	<0.001	10.23	<0.001	<0.001	9.66	<0.001	<0.001
<i>Tilapia zillii</i>	<0.001	<0.01	6.45	0.23	8.11	<0.001	<0.001	12.89	<0.001	<0.001	12.66	<0.001	<0.001
<i>Ethmalosa fimbriata</i>	<0.001	0.04	7.23	0.98	16.13	<0.001	<0.001	6.11	<0.001	<0.001	11.21	<0.001	<0.001
<i>Chrysichthys nigrodigitatus</i>	<0.001	<0.01	7.11	0.17	20.13	<0.001	<0.001	4.12	<0.001	<0.001	8.78	<0.001	<0.001
Mean concentration in fishes sampled	0.005	0.040	6.490	0.460	16.678	0.000	0.000	8.338	0.000	0.000	10.578	0.000	0.000
Mean concentration in water	0.02	0	0.29	0.03	0.65	0	0	0.26	0	0	0.11	0	0
FAO(1983) standards		0.5	30	0.5				30					

4.4.5: Geology and Hydrogeology

4.4.5.1: Geology

The thick wedge of the Niger Delta sediments can be considered to consist of three units (Short and Stauble, 1967). The topmost, the Benin Formation is made of very friable sands with minor intercalations of clay. The sands are mostly coarse-grained, pebbly, poorly sorted and contain pods and lenses of fine-grained sands. Petrographic study on several thin sections shows that quartz makes 95% of all grains. The general thickness of the Benin Formation is variable and ranges from less than 200m at the northern limit to about 2000 m in the central area of the Delta.

Underlying the Benin Formation is ‘deltaic’ Agbada Formation, which consists of interbedded sands and shales. It has a thickness of 300m to about 4,500m. The basal unit, primarily composed of marine shales is the Akata Formation. This unit also comprises some sand beds. The thickness ranges from 600m to possibly 6,000 metres. The project area is part of the geologic sequence of the Quaternary 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 project area are generally composed of sands, gravel and clays.

A total of 6 vertical electric sounding (VES) stations were sited and studied in the field (Appendix V). The VES points were sited close to the boreholes. The VES points consist of bowl type curves, characterized by a left – most descent and a right – most rise. All flanks showed relatively high resistivity values in the range of 100 to 150 Ω m in the top geo-electric layer and the substratum signifying an all sandy soil that is also moist.

4.4.5.2: Hydrogeology

Stratigraphy

Previous sedimentological, biostratigraphical and sequence-stratigraphic studies (Reijers *et al.*, 1997) revealed the combined influence of eustatic cyclicity and local tectonics. Depositional sequences as defined by Vail (1987) and consisting of strata bounded by unconformities and their lateral equivalents are only recognised in specific sectors of the delta. In contrast, delta-wide genetic sequences as defined by Galloway (1989) and consisting of strata bounded by maximum flooding surfaces within transgressive shales are more readily identifiable in the Niger Delta. Interferences of cycles with different periods result in mega sequences that are chronostratigraphically confined and sedimentologically characterised.

A total of six boreholes were drilled; the stratigraphies are uniform in all the boreholes (Fig. 4.3a). This comprises of a muddy clayey sand top soil, a saturated silt and sand melange that grade into silty sand substratum. This made the aquifer phreatic (pores and fractures are saturated with water). Also, the texture and structure implication is that the aquifer has a moderate to high permeability rate.

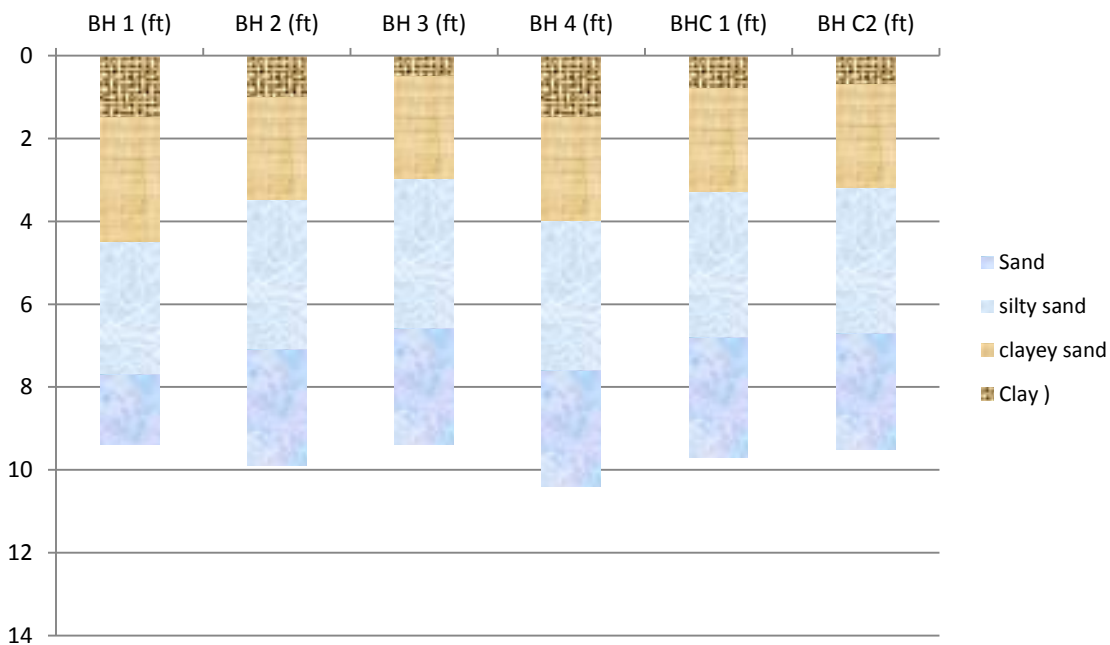


Fig. 4.3a: The Stratigraphy of the Boreholes in the Study Area

4.4.5.3: Groundwater Flow Direction

All static water levels derived were mostly at the surface (in the range of 0 to 0.5 m). Thus the direction of flow is consistent with the surface water flow which is in the south of southwest direction i.e. towards the Dodo creek and Dodo River in both wet and dry seasons. During rainy season, when the water table elevation is expected to be high, groundwater will be discharged into the channels of the river.

Since the environment is subject to tidal flow, the groundwater flow direction will be reversed when the tide is up resulting into a north of north east directional flow. This type of flow during high tide results in deposition of materials in the swampy terrain that gives rise to muddy top soil. With time growth faults begin to develop due to the unstable nature of the underlying unconsolidated sand medium.

4.4.5.4: Groundwater Quality

The results of the physicochemical and biological properties of ground water in the wet season study are presented in Appendix V, the range and mean values are shown in Table 4.6. Ground water in the area and the control points were slightly acidic with mean pH values of 5.95 and 6.34 respectively. In the dry season (EIA of SSAGG, 2003) mean pH was 6.60; the differences is attributed to rising groundwater in the wet season that usually initiate tidal flow of water southward. Mean groundwater temperature of 26.44 and 26.50 °C was recorded for the area and the control points in the wet season. Groundwater temperature in the dry season (45 °C) was higher than that recorded in the wet season. The pH level observed is in line with Ohimain (2004) and Ohimain *et al.* (2004). They reported high acidity levels in mangrove swamp forest in the Niger Delta. Electrical conductivity (EC) is a direct indication of total dissolved solids and salinity; mean salinity of the area and that of the control were below the threshold of 5000 µS/cm. In the wet season, concentrations of Hg, V, Ni, As, Pb, Cd and phenol occurred in trace amount in the area and control groundwater. Similarly, mean Fe, Cu, Cr, Zn, Mn and Ni contents of the area groundwater in the dry season were below WHO limits. But Mn and Cr contents of the control groundwater were slightly higher than the safe limits. Concentrations of nitrate, sulphate, carbonate, nitrate and ammonium were low. Consequently the likelihood of groundwater pollution is rare in the area.

Microbiological activities were very slight in the waters; mean THB and TF counts in the wet season were 3.95×10^4 and 3.73×10^3 cfu/ml while the controls were 4.10×10^4 and 3.79×10^3 cfu/ml respectively. Mean HUB and fungal counts in the wet season were 1.9×10^4 and 1.2×10^3 cfu/ml while the controls were 1.67×10^4 and 1.1×10^3 cfu/ml respectively.

Table 4.6: Ranges and Means of Groundwater Parameters in the Study Area

Parameters	Dodo North Range (wet season)	Dodo North Mean (Wet season)	Control Range (Wet season)	Control Mean (Wet season)	WHO Tolerable limits mg/kg
pH	4.20-6.70	5.95	6.14-6.54	6.34	6.5-9.2
Temperature, °C	26.00-	26.44	26.00-27.00	26.50	-
Electrical Conductivity, µS/cm	12.00-30.00	195.11	173.10-200.00	186.55	5000
Colour, pt-Co	5.00-10.00	6.25	5.00-5.00	5.00	20
Dissolved Oxygen (DO), mg/l	2.00-6.42	3.79	2.00-6.38	4.19	-
Chemical Oxygen Demand (COD), mg/l	7.24-27.85	12.81	7.24-8.20	7.72	40
Total Dissolved Solids (TDS), mg/l	9.33-295.74	106.79	91.74-125.00	108.37	200-500
Total Suspended Solids (TSS), mg/l	1.00-9.10	5.88	4.00-9.00	6.50	-
Biochemical Oxygen Demand (BOD), mg/l	5.65-6.75	6.19	5.66-6.60	6.13	40
Turbidity, NTU	5.20-6.58	6.02	6.00-6.58	6.29	25
Alkalinity, mg/l	1.99-9.99	4.85	5.99-9.99	7.99	-
Hardness, mg/l	8.00-	62.00	12.00-48.00	30.00	-
Salinity, mg/l	3.33-35.45	14.35	10.64-35.45	23.05	-
Nitrate, mg/l	0.09-2.73	1.30	0.32-2.16	1.24	10
Sulphate, mg/l	0.93-27.72	13.09	27.72-27.72	27.72	400
Carbonate, mg/l	<0.001	<0.001	<0.001	<0.001	-
Phosphate, mg/l	0.04-2.13	0.82	0.19-1.39	0.79	<5.0
Calcium, mg/l	7.87-42.59	22.75	7.87-12.83	10.35	-
Magnesium, mg/l	2.06-11.58	6.67	3.08-3.87	3.47	50
Hydrogen Sulphide, mg/l	0.98-4.95	3.32	<0.001	<0.001	-
Phenol, mg/l	<0.001	<0.001	<0.001	<0.001	0.2
Nitrite, (NO ₂ ⁻), mg/l	<0.001	<0.001	<0.001	<0.001	-
Cyanide, mg/l	<0.001	<0.001	<0.001	<0.001	5-10
Ammonia, mg/l	0.31-4.04	1.95	4.04-4.04	4.04	-
Cadmium, mg/l	<0.001	<0.001	<0.001	<0.001	0.01
Zinc, mg/l	0.14-0.22	0.19	0.22-0.22	0.18	24
Iron, mg/l	0.31-3.52	1.64	2.06-2.24	0.22	3.0
Manganese, mg/l	0.02-1.37	0.40	0.11-0.24	2.15	0.5
Copper, mg/l	0.02-0.13	0.10	0.10-0.13	0.13	1.3
Chromium, mg/l	0.03-0.16	0.09	0.07-0.07	0.12	0.1
Nickel, mg/l	0.15-0.15	0.15	<0.001	0.07	0.1
Lead, mg/l	0.01-0.01	0.01	<0.001	<0.001	1.6
Vanadium, mg/l	0.01-0.01	0.01	<0.001	0.01	1.2
Arsenic, mg/l	<0.001	<0.001	<0.001	<0.001	7
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	0.01
THB, cfu/ ml x 10 ⁴	2.60-5.13	3.95	3.04-5.13	4.09	-
TF, cfu/ml x 10 ³	3.01-4.44	3.73	3.14-4.44	3.79	-
HUB, cfu/ml x 10 ²	1.22-2.66	1.92	1.55-1.80	1.68	-
HUF, cfu/ml x 10 ²	1.00-1.45	1.22	1.00-1.22	1.11	-

4.4.6 Wildlife/Invertebrate Fauna

The wildlife of the Dodo North NAG Wells project area is typical of the mangrove swamp. Wildlife hunting is of low scale in the study area. The dominant wildlife species observed in the study area were birds. Few species of Arthropoda, Crustacea and Mollusca were observed in the area. A checklist of the species collected is shown in Table 4.8. The phylum Arthropoda dominates the invertebrate community and is represented by the Order Diptera which include the tse-tse fly (*Glossina* sp), butterflies (*Acrae terpicore*), mosquito (*Anopheles* sp) and bees (*Apis mellifera*). Other invertebrates include periwinkles, oysters and crabs-the common decapod crustaceans marsh crab (*Sesarma huzardi*), and purple mangrove crab (*Goniopsis pelii*). The population density of the crabs varies from 10 - 20 per m² depending on their sizes and the substrate. These organisms were common and are not threatened by any human activity. The avifauna was represented by egrets, ducks, kingfishers, hammerkop, weaver birds, and kites. Majority of the bird species were observed in the area in the mornings and evenings. Mammals recorded include few species of rodents (squirrels, rats, antelope, bush-tailed porcupine, bush pig and grasscutters).

Table 4.8: Wildlife Inventory and Conservation Status in the Study Area

Class	Family	Species	Abundance Index (AI)	Conservation status		
				Local	IUCN	WCMC
Mammalia	Cricetidae	<i>Cricetomys emini</i> (Giant Rat)	XXX	S	-	-
"	"	<i>Epixerus ebii</i> (Palm Squirrel)	XXX	S	-	-
"	"	<i>Helioscirus rufobrachium</i> (Red-legged Sun Squirrel)	XX	S	-	-
"	Thryonomidae	<i>Thryonomys swinderianus</i> (Cane Rat or Grasscutter)	XXX	S	-	-
"	"	<i>Atherurus africanus</i> (Brush-tailed Porcupine)	XX	S	-	I
"	Mustelidae	<i>Aonyx capensis</i> (Cape clawless otter)	X	V		
"	Cercopithecidae	<i>Cercopithecus mona</i> (Mona Monkey)	XX	V	-	-
Aves	Accipitridae	<i>Milvus migrans</i> (Black Kite)	XXX	S	Afm/B, PM	-
"	"	<i>Kaupifalco monogramicus</i> (Lizard Buzzard)	XXX	S	RB, ?Afm	-
"	"	<i>Accipiter erythropus</i> (Chicken Hawk)	XXX	S	R(B)	-
"	Bucerotidae	<i>Tokus fasciatus</i> (African Pied Hornbill)	XXX	S	RB	-
"	"	<i>Ceratogymna fistulator</i> (Piping Hornbill)	XX	V	RB	-

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Class	Family	Species	Abundance Index (AI)	Conservation status		
				Local	IUCN	WCMC
"	Ardeidae	<i>Egretta alba</i> (Cattle Egret)	XXX	S	RB	-
"	"	<i>Egretta garzetta</i> (Little Egret)	XX	S	RB	-
"	Covidae	<i>Corvus albus</i> (Pied Crow)	XXX	S	RB	-
"	Alcedinidae	<i>Halcyon malimbica</i> (Blue-crested Kingfisher)	X	S	RB	
"	"	<i>Halcyon senegalense</i> (Woodland Kingfisher)	XX	S	RB	
"	Apodidae	<i>Apus affinis</i> (Little Swift)	XXX	S	RB, PM	
"	"	<i>Cypsiurus parvus</i> (African Palm Swift)	XXX	S	RB	
"	Ploceidae	<i>Ploceus cucullatus</i> (Village Weaver)	XXX	S	RB	
"	"	<i>Ploceus ocularis</i> (Spectacled Weaver)	XXX	S	RB	
"	Pycnonotidae	<i>Pycnonotus barbatus</i> (Common Bulbul)	XXX	S	RB	
"	Cuculidae	<i>Centropus senegalensis</i> (Senegal Coucal)	XXX	V	RB	
"	Columbidae	<i>Streptopelia semitorquata</i> (Red-eyed Dove)	XXX	S	RB	
Reptilia	Agamidae	<i>Agama agama</i> (Rainbow Lizard)	XXX	S	-	
"	Scincidae	<i>Mabuya affinis</i> (Blanding's snake)	XXX	S	-	
"	"	<i>Lygosoma fernandi</i> (Red/Fire Skink)	X	V	-	
"	Varanidae	<i>Varanus niloticus</i> (Nile Monitor)	X	V	-	
"	"	<i>Osteolaemus tetrapis</i> (Short-nosed Crocodile)	XX	V	VU	
"	Chamaeleonidae	<i>Chameleo sp</i> (Chameleon)	XX	V	-	
"	Boidae	<i>Python sebae</i> (African Rock Python)	X	V	-	
"	"	<i>Python regius</i> (Royal Python)	X	V	-	
"	"	<i>Calabaria reinhardtii</i> (Calabar Python)	X	V	-	
"	Viperidae	<i>Causus maculates</i> (Night Adder)	XX	V	-	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Class	Family	Species	Abundance Index (AI)	Conservation status		
				Local	IUCN	WCMC
"	"	<i>Bitis gabonica</i> (Gabon Viper)	XX	V	-	
"	"	<i>Bitis nasicornis</i> (Rhinceros Viper)	XX	V	-	
"	Elapidae	<i>Naja nigricollis</i> (Spitting Cobra)	XX	S	-	
"	"	<i>Naja melanoleuca</i> (Forest Cobra)	X	S	-	
"	"	<i>Dendroaspis jamesoni</i> (Green Mamba)	X	S	-	
"	Colubridae	<i>Gastropyxis smaragdina</i> (Emerald Green Snake)	X	S	-	
"	"	<i>Grayia smythii</i> (Smyth's Water Snake)	X	S	-	
"	"	<i>Boiga blandingi</i> (Blanding's snake)	X	S	-	
"	Testudinidae	<i>Kinixys erosa</i> (back-hinged tortoise)	X	S	-	
"	Pelomedusae	<i>Pelusios niger</i> (Freshwater terrapin)	X	S	DD	
Amphibia	Bufonidae	<i>Bufo maculatus</i> (African toad)	XXX	S	LC	
"	"	<i>Dicroglossus occipitalis</i> (Bull-frog)	XX	S	LC	
"	Ranidae	<i>Ptychadena mascariensis</i> (Mascariene Frog)	XXX	S	LC	
"	"	<i>Ptychadena aequiplicata</i>	XX	S	LC	
"	Pipidae	<i>Xenopus tropicalis</i> (Claw-toed Frog)	XXX	S	LC	
"	Hyperolidae	<i>Hyperolius sp</i> (Tree frog)	X	V	LC	

Source: Fieldwork, 2012

(Common name in parenthesis); Abundance Index (AI): X = Few ; XX = Common ; XXX = Abundant; S = Satisfactory ; E= Endangered; V= Vulnerable; K = Suspected to be in E or V categories; I = Indeterminate; ? = Probably present

IUCN : International Ranking in 1994 IUCN Red list; WCMC: National Ranking in WCMC's 1988 Nigeria Biodiversity Report;

Act 11: Ranking in Federal Endangered Species Act 11 of 1985 (Schedule 1 & 2)

IUCN Red List Category Key

DD = Data Deficient; LR/lc or LC = Least Concern (Not Considered to be red listed); VU = Vulnerable; Avian Migratory and breeding Habit; RB = Resident Breeder; R(B) = Resident, but Breeding unproved; PM = Palaearctic Migrant; Afm = Migrates within Nigeria; AfM/B = Migrates to and from Nigeria to Breed in Nigeria; V = Vagrant; PM = Palaearctic Migrant



Plate 4.2: Protected Python (Source: Ogbeibu, 2009)

4.4.7: Baseline Socioeconomic Conditions

The Dodo-North project area covers the Amabuluo, Tamogbene (Ayama), Norgbene, Egbemo-Angalabiri and Agbidiana in Ekeremor Local Government area of Bayelsa State. The findings are presented hereunder:

4.4.7.1: Historical Perspective and Cultural Property /Settlement History and Length of Stay in Community

The indigenes of the project communities are largely of the Ekeremor tribe (Operemor, Operemo), which is an ancient Ijaw speaking ethnic community and historically, the

indigenes settled in the area several thousand years before the arrival of the Portuguese on the coast of the Niger Delta in the 15th century (Alagoa, 2005). The indigenes have close historical and kinship ties with the Oporoma, Eastern Olodiana and Ogbe tribes. These communities started as fishing port/temporary settlements, but over the years they are gradually evolving into a permanent status/settlement. Apart from the main settlements, there are fishing camps along the Dodo River, namely Adabia Camp, Clarks Camp, Setero Camp and Edimasoure K-Island Camp, etc. and these camps are owed and controlled by the landlords in the mother communities. The indigenes have a common migration story and this is tied to their common language, festivals and taboos.

4.4.7.2: Location and Distribution of Historical Site

Several field studies revealed that there are traditional sites of local cultural importance to the communities. These are mainly shrines and sacred bushes. The existence of these is acknowledged in all the communities. Of interest to development agencies is that, consultations be made with Chief Priests (custodians of traditional sites) if oil exploration activities will infringe on traditional grounds. This consultation is expected to be done before any activity can take place on such sites.

4.4.7.3: Religion, Customs, Belief Systems and Cultural Heritage

One of the most critical characteristics of Niger Delta as a region in Nigeria is cultural diversity. From language, religion, cultural insignia to the economic setting, diversity is the word. For instance, the linguistic diversity; Niger Delta has more languages than most of the regions in the country. While this diversity provides more localized identity for millions of Niger Deltans, this has also posed challenges.

Overall, the socio-cultural aspects of the population in the different ethnic groups are highly dependent on their ethnic background and religion. Specifically, the general belief/value system of the indigenes in Dodo-North project communities does not differ significantly from that of the neighboring tribes. However, the cultural heritage, migration pattern, and religion have considerable influence on the overall belief and value system of the people.

With respect to religious belief system, among the communities in the project area, Christianity predominates as evidenced in the presence of different denominations of churches. About 97.3 percent of the residents claim to have strong Christian affiliation. However, despite such overwhelming numbers of Christian adherence, there are strong influences of traditional religious beliefs in the area, especially among the indigenes. Specifically, some cultural practices are celebrated with a religious fervour in their seasons. Festivals are part of the cultural heritage of the people and such festivals like the *Asi Oge festival* is celebrated among the Ekeremor indigenes each year for the promotion of cultural cohesion among the Ijaws, promotion of cultural dances, arts and play, and provision of entertainment and relaxation.

There are other belief systems, which revolve around common taboos such as killing of tortoise, python and white coloured bird, damage of the red/white cocoyam by non-indigenes,

entering of masquerade buildings or shrine sites by non-indigenes and sales of periwinkles etc. Specifically, in Tamogbene (Ayama) community, tortoise is seen as divine and anyone who kills it is considered to have annoyed the gods of the land and must perform certain purification rites, including burying the dead it with all the traditional rights accorded to the son of the soil; and violations are frowned at and punished accordingly. Notable shrines in the area include *Okonusu* and *Baribe*. *Okilogboligbo* is known to be a very important sacred forest where women are forbidden to enter. Because of the cultural significance attached to these animals, the indigenes have been ensuring that their habitats are protected. Apart from these, the people really do not have so many forbidden food or cultural/traditional taboos. Non-indigenes therefore, find it easy to mix freely with the indigenes leading to considerable population of other ethnic groups residing in the area, including Kalabaris, Okrikas, Urhobos, Ogonis, Ibibios, Efiks and Igbos. Generally, to promote pro-environmental behaviour, order and social cohesion among the residents there are standard social norms that are common in the communities. Some of these include respect to the elders by the youth/children, wives, husbands and relations.

4.4.7.4: Family and Marriage

Marriage is a valued socio-cultural norm and is practised among the Ijaws as in all lands. A typical family in the community consists of a male member, his wife/wives and children. Polygamy is practiced in the community and this has to do with the traditional occupation of the community such as fishing and fish processing which requires many hands. In addition to a man's nuclear family, his household typically includes members of his extended family and/or those of his spouse(s). These may be relatives like brothers, sisters, cousin or siblings. The community is patrilineal; therefore, inheritance rights are reserved for biological offspring especially the male members of the household who may be obliged with education, welfare and such other benefits as the head of the family may be willing and able to afford.

In Dodo-north project communities there are no written restrictions to marriage on basis of tribe, religion, status education or social attainment. There are number of mixed marriages especially with member of other ethnic nationalities. Women married into the community are not discriminated against, but are usually completely assimilated. A good number of indigenes have mothers from outside the community and this does not prevent them from keeping positions of authority and entitlements in their immediate families and their community at large so long as their mothers are properly married in the native and customary way.

4.4.7.5: Demography Studies

Population Description

Dodo-North project communities are creeks and are therefore characterized by inadequate land for habitation. Ekeremor, which is the host Local Government Area occupies a land size of 1,820.232 square kilometer and is largely an Ijaw speaking area. The Nigeria 2006 Census puts the population of the LGA at 269,588 with males constituting 51% (137,753) and females 49% (131,835) but with a population growth rate of 2.553% the population figure is estimated to be about 310,883.5 comprising 57% (179048.5) males and 43% (173130.5)

females as at 2012 (Fig. 4.4a). This suggests an increase in population of the study area with implications on increased demand on social amenities. However, in the communities, males constituted about 61% while females made up about 39% of the population studied. 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 2:1.

Field reports revealed that although only few of the existing settlements appear to have some permanency in term of the physical layout and housing, many lay claims to longer existence. One is however tempted to believe that several of the settlements are secondary settlements established during the drilling of the oil wells and flow stations in the area, laying of pipelines/flow lines or other oil and gas facilities around which some of the settlements are established.

Field survey shows an average of 8 persons per dwelling unit with about 37% households having between 7 and 10 persons in a family (Table 4.9a). This is an indication of a large household size and depending on the age composition, existence of high dependency ratio in the area. The age composition of the community reveals the characteristic trends and spread of the people.

Table 4.9a: Distribution of Population by Household Size

Household size	Percentage
1-3	8.5
4-6	29.2
7-10	37.3
>10	25.0
Total	100

Source: SPDC, 2012

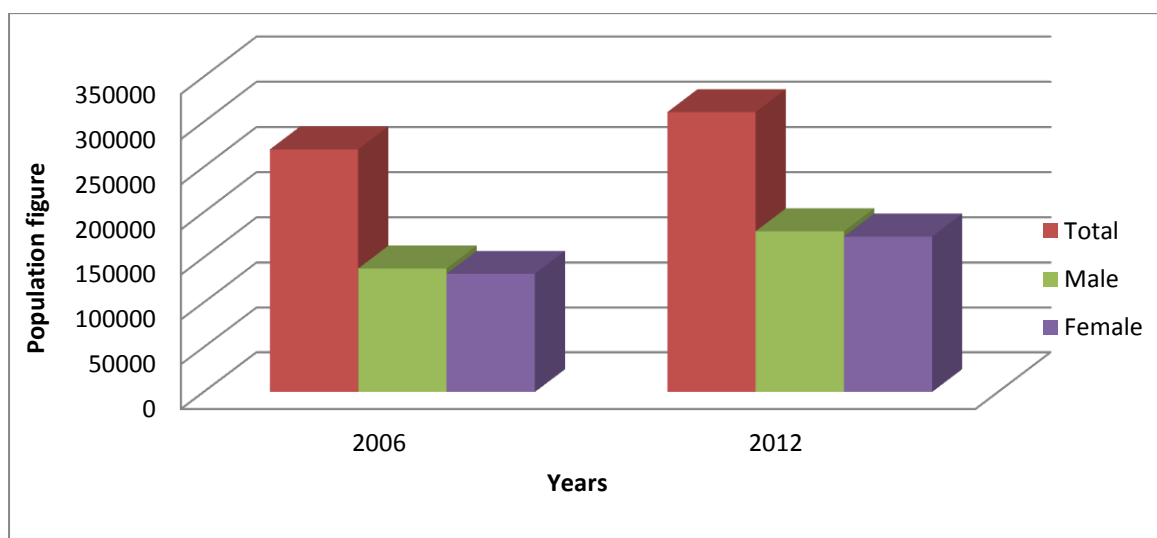


Fig 4.4a: Population Distribution of Ekeremor LGA

The household age structure and distribution of the study area population conforms to the overall Niger Delta and Nigeria.. The socioeconomic sample survey of the communities and settlements showed that persons below the 26 years age bracket constitute approximately 63 percent, with overall household structure more typically pyramidal for the fishing communities. In all, children are proportionately more, while the aged (>60 years) are fewest in the population. This also confirmed a broad-based population structure with children aged 0-12 years (i.e. infants and school-going children) dominating the entire population structure. The active age involved in economic activities contributing to family income is 35%. The rest are either children of school age or very old people. The overall implications of the age profile is that the population is young and growing and places a heavy burden on the adult population, a high dependency ratio, as well as huge unemployed human number. More importantly, the provision of educational facilities and health care services are paramount in the study area to accommodate this young population.

The age structure of households in Bayelsa State, confirms this age profile .This demographic feature has various implications for development planning and the financing of social services. A youthful age structure implies that many people remain outside of the working age bracket. In the formative years, social investment rather than economic investment is required. This creates an additional dependency burden for the average family or the economically active population, and states in the Niger Delta. The magnitude of such a burden tends to be greater for impoverished families or population units that are either unemployed, under-employed or lack the benefit of full employment. A comparatively high proportion of people below the working age also tend to reduce labour input per capita and income per capita (UNDP, 2006).

Men are typically the head of Nigerian households; there are overwhelmingly more male (93%) heads of households than female household heads (7%) in the Niger Delta. The three different types of male-headed household structures are traditional (one husband and one spouse), polygamous, and single male (male with no spouse, including widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

Settlement, Land Use and Housing System

The project areas are largely rural in nature. In terms of size it varies from small settlements with few houses to large settlements with many buildings. The settlement patterns are mostly linear, patterned along river/sea or coastal banks. The community's initial status as reflected in layout and housing types and structure was that of a temporary fishing port but over time, it is fast evolving into a permanent settlement. The community is not well planned and the pavement not well laid out, though it is central and well sand filled and concrete for human movement. The individual housing units are make/shift houses built with wooden/zinc walls and roofed with mats/grass (Plate 4.3a). In terms of physical appearances these buildings are unattractive.

However, some of the houses are designed and built with block/brick walls with corrugated galvanized zinc sheet, which have badly corroded due to acid rain common in the area. Most of the houses in the area are rooming houses built in tenement style with both kitchen and toilets outside the main building. There are also few bungalows buildings with modern amenities.



Plate 4.3a: Different housing structures in the study area

Many surveys carried out in the creek communities and all the settlements exhibited similar housing patterns and local architecture. Makeshifts constitute about 65-85% while about 25-35% are modern buildings. The 2006 population and housing census publication of the National Population Commission showed that majorities of the regular households in Ekeremor LGA in Bayelsa State are living in housing units that are made of ephemeral materials as showed in Figure 4.4b. The dilapidated housing cannot provide safe and adequate shelter. The structure design, location of the housing and population density within. can influence health both physically and mentally. The actual structure of a dwelling can be important for health in a number of ways. Make shift structures as was found in the communities' almost invariable fall to guide against extreme temperatures, heat and cold which can increase stickiness and death rates. Overcrowded houses spread Tuberculosis and large proportions of chronic respiratory disorders.

Field observation showed that residential buildings account for the major part of land use in the study area. Qualitative estimates indicate that such residential use of land accounts for over 90 %. Land is sold/leased in the areas; However, for an indigene, land is allocated by family heads. For major economic or community development purposes the traditional

community leadership is responsible for making land available to external development agencies.

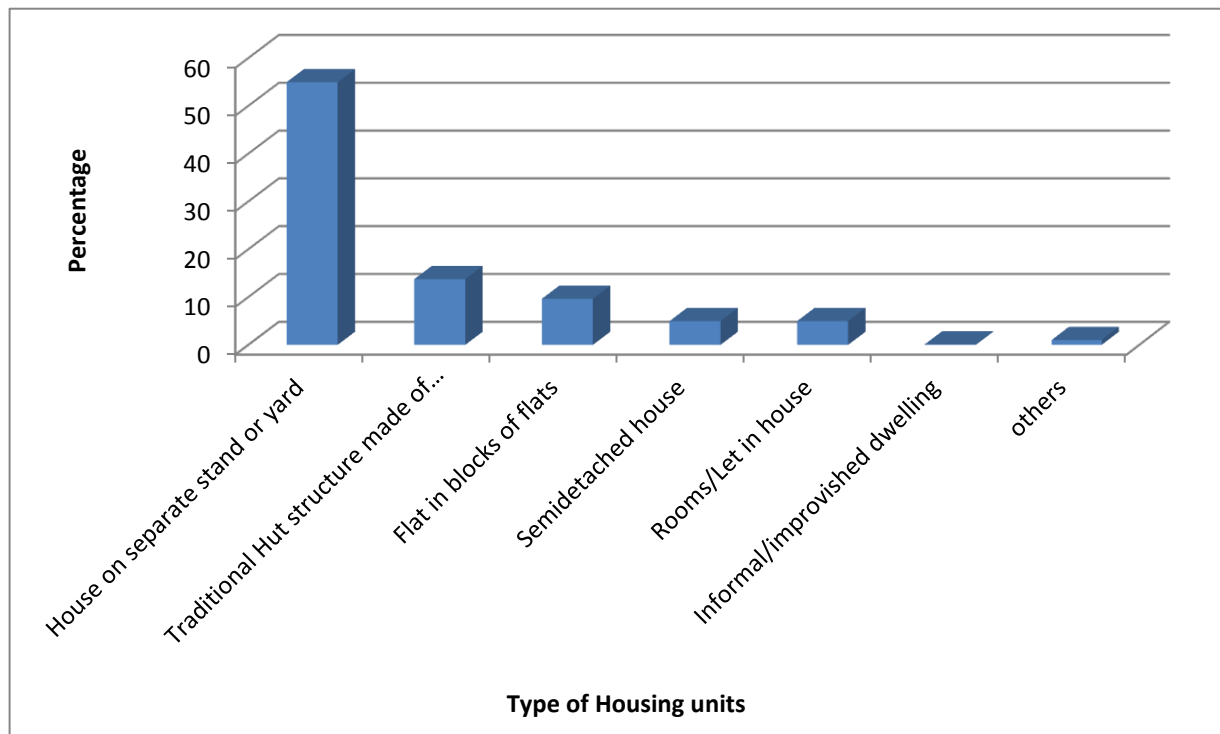


Fig. 4.4b: Distribution of Regular Households by Type of Housing Unit in Ekeremor LGA

Marital Status and Household Size

About 70% of the community members were married while 26.2% were single (Figure 4.4c). The low level of divorced household heads in the area is an indication that the indigenes valued marriage.

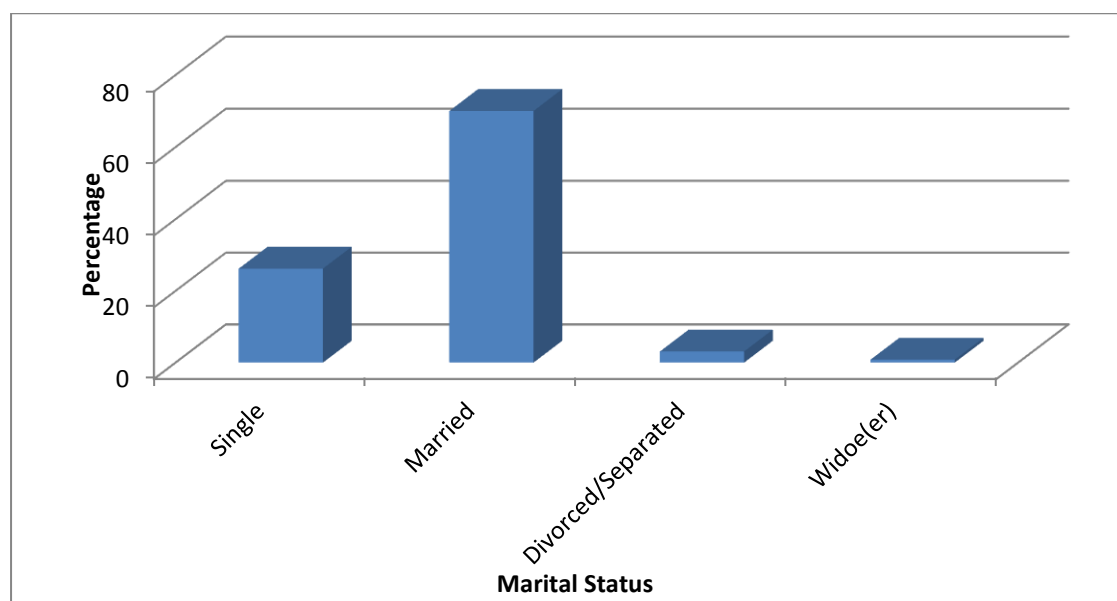


Fig. 4.4c: Marital status of the Households in the study area

Polygamy is a common feature in the community as most men have between 2-4 wives. 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. A total of 3,919,364 households were enumerated during the preparation of the Niger Delta Regional Master Plan Development with an average household size of 7.46, but with more than 70% of them having an average of 8 occupants. Large households were more prevalent in the rural areas (NDDC 2006).

Educational Attainment / Literacy Level

Knowledge of level of education is important in such a study because the perception and understanding of what is happening in the environment depends on the level of education. A large proportion of the inhabitants and sampled population has received some formal educational training indicating a sufficiently literate society. The modal educational attainment amongst the population in the communities is primary educational level. About 70 percent of the sampled population has the post primary education and close to one-tenth (8.1%) 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 problem and predominantly fishing occupation of the indigenes. But 5.0% of the population was reported not to have Formal Education (NFE) and this is particular with the aged members of the communities and mostly those living in the fishing settlements.

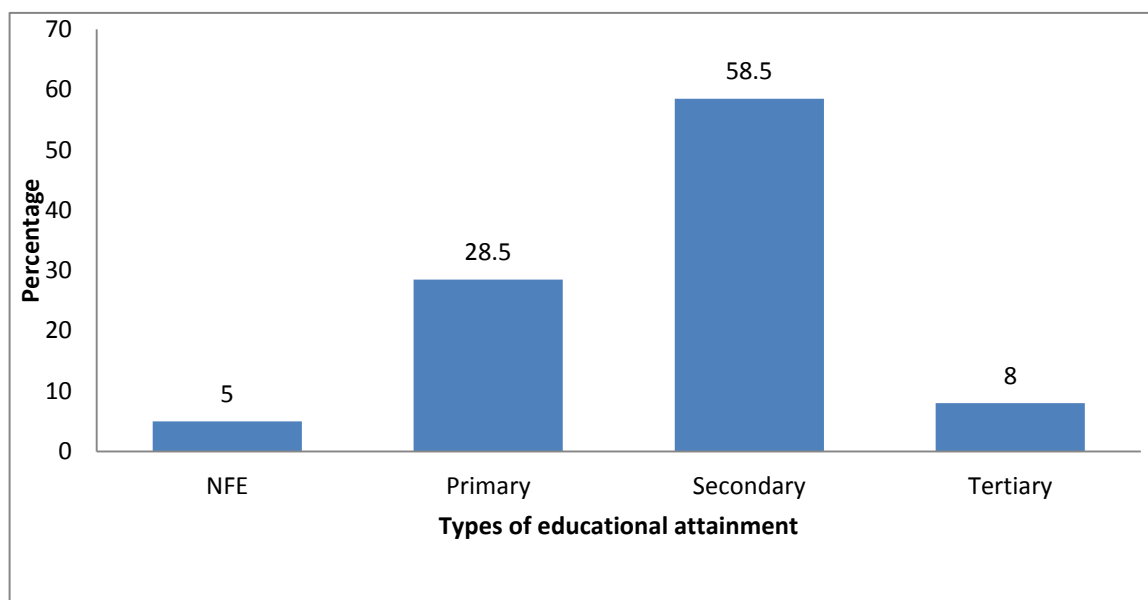


Fig. 4.4d: Educational attainment in the communities

Statistical estimates have put the proportion of children attending primary school in the Niger Delta region at 80 %, which compares favorably with the estimated national average of 54 % (UNDP, 2006). The adult literacy level of the population is 80.5%. The educational attainment at Primary and Secondary levels has however, been reported to suffer from a high

teacher-pupil ratio (1:42), compared with the national average of 1:36. The high ratio reduces the ability to control classes and impart knowledge.

There are several schools in the State, some of which are owned by the Government and most are also privately owned. Historically, the coastal people had early contact with Europeans since the 15th century, but western education was not introduced till 1864, when the first missionary schools were established in Bonny. However, by 1916, primary schools had been established in other parts of the region (Table 4. 9b).

Table 4. 9b: Education – Current Conditions in the Niger Delta States

STATE	Adult Literacy(%)	Attainment of Primary School (%)	Attainment of Secondary school (%)	Attainment of Post secondary education (%)	No. of jobs in Sector 2000 (teachers)
Abia	84.1	39.6	43.6	16.8	9276
Akwa Ibom	76.3	54.4	44.4	8.3	13,683
Bayelsa	78.7	38.8	49.3	11.9	3,515
Cross River	82.2	44.6	42.8	12.6	11,425
Delta	77.4	37.9	43.6	18.5	15,720
Edo	69.7	49.3	38.8	11.9	10,959
Imo	79.3	46.1	42.7	11.2	14,145
Ondo	78.8	45.0	44.2	10.8	12,342
Rivers	79.9	33.4	49.5	17.1	4,011
The region	78.7	43.3	43.2	13.5	95076

Source (NDDC, 2006): Niger Delta Regional Development Master Plan

4.4.7.6: Local Governance and Social Structure

The communities of the affected areas operate independent but similar administrative structures. The traditional political administrative structure of the communities is basically title holding, executive committees and youth association. There exists a strong leadership structure at the community level in the study area. The political administration is well structured with the paramount ruler/community chiefs at the apex of authority. Four major traditional tiers can be distinguished:

- The traditional authority structure comprising the traditional leader and the Chief –in-Council.
- Community Development Committee (CDC)
- The youth comprising of the youth leader and his executive, and the
- The women group comprising of the women leader and her executive.

The CDC, youth and women leaders report to the traditional leader/Chief-in-Council. It should be borne in mind that the CDC and Youth Chairman wield great authority at the community level. Every project activity must of necessity get the approval of these leadership arms if it is to be successfully implemented. These positions were considered financially lucrative and had constituted a source of clash at the community level especially in deciding the next leadership. Fortunately, some communities had evolved a tenural arrangement especially for the position of Youth Chairman by pegging the leadership duration at one year

without option of recontesting. This, no doubt, had greatly contributed to the existence of peaceful transition from one leadership to the next. These tiers of leadership structure aligned with those obtained in other studies (EIA of SSAGG of 2003, EIA of SSAGS+ of 2013 and EIA of Benisede Catchment Area Phase I 2004). This suggests no change in community leadership structure over the years which implied a sense of leadership stability at the community level.

The paramount ruler is called or addressed as the Amayanabo or King appointed by the Royal House. He is assisted by the Council of Chiefs, Council of Elders, Community Development Committees (CDC), the Youth Council and Women Council. The power flow of the study area is presented in Figure 4. 4e. The Council of Chiefs consists of traditional chiefs among whom a chairman is elected. Their responsibility is to ensure peace, progress and stability. The Elders' Council is made up/drawn from the oldest members of individual families; old men of proven integrity and impeccable characters.

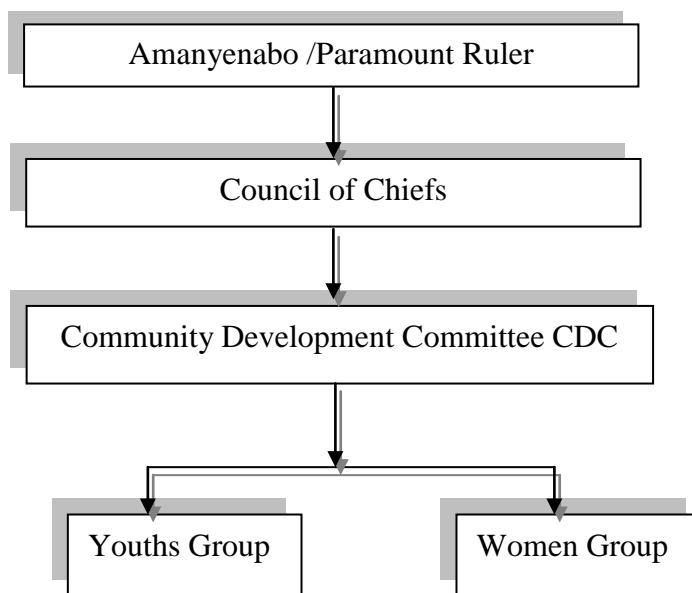


Fig. 4.4e: Showing Power Flow in the Study Area

4.4.7.7: The role of Youth and Women Group/Association

The youths of the area are quite active and their most significant role is in the mobilization of the youths for development and in the sensitization of the community about political issues and government projects. They are more militant and appear to be in control over information input and dissemination. They are responsible for swift coordination of activities and alertness in the event of day to day running of the community affairs especially when confrontational actions are involved. Like the CDC, the youths are a formidable pressure group. They maintain law, order and security in their communities.

In the study area, there existed a number of women groups. Their associations were usually welfare oriented; they render financial and moral assistance to members that are in need. They pursue peace in the land and also carry out sanitation exercises to keep the

environments clean. Women also play major roles during ceremonial functions such as festivals, marriage ceremonies and burials.

Joint meetings between the various bodies are held from time to time to discuss various issues affecting the communities. It can therefore be stated that the political administration and local level of governance in the Dodo-North communities is basically traditional title holding, executive committees and group association, local power authority and the direction of flow of power is clearly exhibited, in general the traditional authority is valued with utmost significance. The basis of social stratification is the age of the individual, education and social attainment.

4.4.7.8: Conflict Management and Resolution Mechanism

Field studies and observations indicate a peaceful co-existence among the numerous tribes and ethnic nationalities that live in the communities. There were also good and cordial relationships among the various groups- youth, elders, and the women organization. According to our key informants, conflicts were rare, except sometimes over land boundaries. This happens when any multi-national oil company establishes project(s) at the boundaries of communities. The most recent inter community conflict recorded was the 2002 conflict between Tamogbene (Ayama) and Amabolou communities, which had been peacefully resolved. Conflicts and contentious issues are resolved in the communities and settlements by collaboration among the village chiefs/heads, the Executives, the CDC, youth and women wings. The rungs of power are well established and guided by unwritten byelaws.

There are procedural guidelines for conflict resolution and management in these communities. These include;

- Adjudication by the traditional customary process
- Dialogue
- Reaching of consensus
- Proclamation of sanctions
- Administration of fines such as payment of fines with such things like wines/drink, goat and of cash depending on the adjudged magnitude of the offence
- Administration of oath of sincerity and allegiance to the interest of the community
- Use of law enforcement agents e.g. Police, local police or vigilante.
- Use of court
- Banishment of the culprit for a specified period of time

In the event that a matter is not resolved on the spot when the community member runs foul of the law, the matter is handed over to the lower organ (youth and women) for prosecution according to the gravity of the offence. Serious cases therefore involve meting out serious punishments including ostracism or handing over the offender to the police. In most cases , disputes were amicably settled without resort to the police or court proceedings.

4.4.7.9: Local Security Arrangement/Management

The youths of Dodo-North project communities are vibrant and are in-charge of labour, security and protection of their environment. However, with the upsurge and escalation of militancy in the region, the region has been militarized with the Joint Task Force (JTF) taking over the security and defense of the Niger Delta to protect lives and property especially multi-national oil workers and installations in the rich oil and gas region of the Niger Delta

4.4.7.10: Social Groupings

There are social groups/clubs in the communities' e.g. Cooperative societies, Women club, fishing club and Credit groups. These clubs/groups are organized on the basis of common interest and affiliations and are also mostly on gender basis. The women with common social identity like marriage or visions such as fostering friendship and solidarity within their community can form their own social clubs.

Typical women social clubs have lots of cultural trappings which are usually indicated in their names and strict adherence to traditional dresses at public functions. Entertainment through dances at social functions is another area of culture which is commonly practiced by the social clubs. The social clubs provide mutual support for their members in times of child birth, marriage, bereavement and other festive occasions. They also provide common fronts for support of community development programmes, like donations of equipment, physical infrastructures and other items for public use. Women are also known to intercede for peace during inter/intra community crises.

As is the case in other Niger Delta communities, there are also age groups in the study communities and each age group embraces children born within a period of three years. The contributions of age groups are generally recognized but their direct roles/responsibilities and involvements in developments differ from community to community. In some communities, they have contributed to the development of physical infrastructures. Generally however, they are effective vehicles for social mobilizations and they also offer mutual support for their members during times of bereavement and festivities.

4.4.7.11: Social Infrastructures, Utilities and Services

The level of infrastructure and amenities available and functional in any area or community has direct implications on the quality of life in that area, and therefore the willingness of people to live and remain there. It also influences other socio-cultural and economic variables in the area. The field study revealed a general lack of basic amenities, for quality living.

School and Educational Facilities

Most communities have primary and secondary schools, many of which were government owned while few were privately owned. In communities like Agbidiana and Tamogbene (Ayama), community support for indigene education is seen in the establishment of community secondary schools. (Plate. 4.3b) Regardless of the school ownership, these schools suffer from inadequate staff and facilities such as tables and chairs. Some of the

school buildings were dilapidated. None of the schools had a functional staff quarters for teachers, although in Agbidi-Ama, SPDC was responsible for constructing the staff quarters.



Plate 4.3b: Schools Facilities in the Study Area

Potable Water Sources and Facilities

Most communities lacked potable water. The existing borehole facility at Tamogbene (Ayama) that was provided by SPDC had broken down and had not been functional for the past 12 years. Thus, most communities have had to depend on river water as their major water source, which has implication for health as it is not uncommon to see the same river being used for waste disposal. Some communities noted that a reason for their lack of borehole water was because past attempts to drill bore-hole water in the community only produced salty water which is unfit for human consumption. They believed that if the bore-hole is drilled to the appropriate depth they would get fresh water (Plate 4.3c).



Plate 4.3c: Broken down Water Schemes in the Study Area

Data from the National Bureau of Statistics revealed that in the majority of Niger Delta States, water comes from unsafe supply facilities, including rivers, lakes or ponds, 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. A safe and reliable water supply is currently available to only a small fraction of the population in the Niger Delta Region. In the supply systems surveyed and reported in the Niger Delta Region Development Master Plan (NDRDMP) Report (NDDC, 2006), approximately 8% of the population actually enjoyed

water supply in urban and rural centers, while only 3% of the population in rural villages were actually served by the supply.

Electricity and Power Sources

Electricity is a key indicator of development in any economy. It is generally considered an essential ingredient for development. Unfortunately, most communities in the project area either lack electricity or have irregular supply. Available electricity infrastructures in some communities remain in poor condition either due to vandalization or breakdown. It is pertinent to note that none of the communities with electricity is serviced by PHCN. Rather electricity is supplied by oil companies operating in the areas, such as Mobil and SPDC. Agbidiana is an example of a community with electricity supplied by SPDC. Few members of the community employ private generators as a coping mechanism in dealing with the erratic or non-availability of electricity. Unfortunately, only few members of the communities can afford this. SPDC has assisted in providing generators in communities like Tamogbene (Ayama) but provision of diesel to power the generating set and maintenance constitute major constraints to the functionality of this generator (Plate 4.3d)

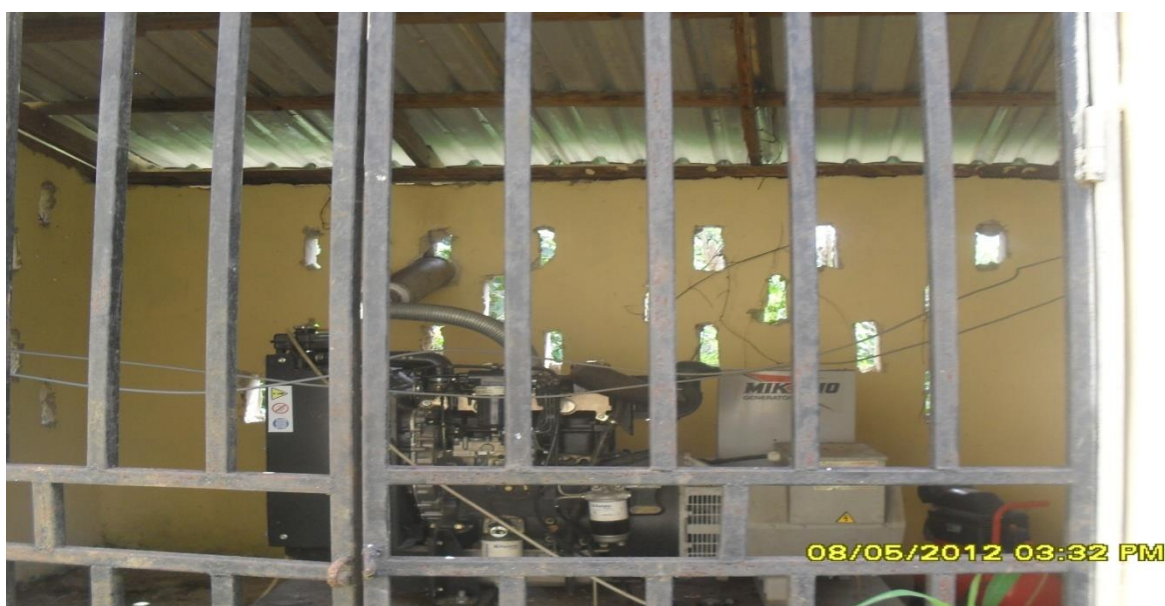


Plate 4.3d: Broken Down Generating Set Donated to the Community by SPDC

Recreational Facilities

There were no recognized recreational centres in the communities, except football fields located in the primary and secondary schools. During the field study, children were observed basking themselves in the sun light, playing football and other games in the open field. Other recreation centres included a community hall where youths played indoor games, cultural dances, wrestling contest, hide and seek games etc. The most prominent recreational activities in the study area were swimming, boating and fishing. In the Tamogbene (Ayama) community, there was an SPDC guest house, which was known to provide recreational facility to staff.



Plate 4.2e: Guest House Built by SPDC in the Study Area

Transportation and Communication

In the study area, common mode of transportation was by water (Table 4.9c). Accessibility to and movement within the fishing communities and settlements is therefore, greatly limited; there were no roads so land transport facilities and services are not provided. There were therefore, great difficulties and the cost of accessing the creeks and coastal villages were unusually high. Located by the water side and surrounded by water, these villages are accessible only through water using hand-dug canoes and the popular fiber or outboard engine boats usually fitted with various grade of HP engines. Marine transport to the coastal and riverine settlements can be cumbersome, risky, and costly. For instance, a 20 litre fuel that cost about N2000 in other states in the south of Nigeria costs about N4,000-4,500 in the project area. The turbulent nature of the water is a cause for concern while low tide constrains attempts to access some of the settlements via the creeks since these are influenced by the tidal regime of the ocean. There were no concrete landing jetties in the villages. Cargo boats used by the women for trading navigate the rivers and creeks during high tide



Plate 4.2f: Common Means of Transportation in the Study Area

Access to public communication facilities like the telephone and postal services in the study area communities was also found to be limited. However, GLO and Airtel GSM network facilities were available in the area providing network services and coverage to the residents of the communities. A GLO mast and its base station were established in the area by SPDC for its staff that was stationed in the staff quarters.

Table 4.9c: Summary of Status of Social Amenities in Dodo-North Communities

Infrastructure	Communities and Settlements in the Study area
Electricity	<ul style="list-style-type: none"> • SPDC donated the generator but the power was highly erratic.
Water	<ul style="list-style-type: none"> • Access to potable water in fishing communities was limited. • Sources of water included shallow-hand-dug wells, ponds, and rain water
Roads	<ul style="list-style-type: none"> • Communities were accessed via water and footpaths
Transportation	<ul style="list-style-type: none"> • Intra-community was by foot; footpaths were waterlogged during rainy season • Inter-community was by speed boats and canoes
Housing	<ul style="list-style-type: none"> • Walls and roofs of most were built of thatch and forest resources. However few were constructed with cement blocks/bricks
Education	<ul style="list-style-type: none"> • Community based primary and secondary schools for children and wards.

Waste Management

There were no organized sanitary waste management systems. Solid waste materials mainly garbage were dumped into the water courses, drainages or bushes and allowed to rot, burnt, or buried as a form of disposal. The quantity of refuse varies from one locality to the other depending on the food habits and customs of the people. The quantity of refuse in the rural areas is less than that of the urban areas, but whatever the /quality/quantity, they must be sanitarily disposed to avoid breeding of vermin's, fire outbreaks and injuries from broken bottles and sharp metal cans. For effective waste management, dust bins must be provided to collect the waste which must be water resistant. It must also be provided with a cover lid.

Suitable methods of waste disposal in the communities of the study area include;-

- Controlled tipping into a chosen site and covered with suitable material
- To cover depressions or to be used for reclamation
- Incineration in mud/laterite incinerator

4.4.7.12: Livelihood and Economy of the Study Area

Occupation, Employment and Income-Generating Activities

Economic conditions have a vital role to play in people's experience and perceptions of a place. A person or a household's socioeconomic status influences the range of opportunities and constraints that people face. In fact, socioeconomic status affects almost all aspects of life. It affects nutrition levels and health, geographic mobility, educational attainment, and overall quality of life.

The occupational distribution (Fig. 4.4f) of the people in the studied area revealed that majority (52%) were fisher folks, 18% were into trading while about 15 % were into non-fish or crop farming as a major occupation. The findings suggested that different occupation or income generating activities existed in the communities. Fishing and fisheries related activities were the predominant economic activities. The type of fishing was mainly artisanal in nature; no industrial fishing operations were observed. Two major types/categories of artisanal fisheries were recognizably discernible, namely inshore and swamp fisheries with gillnets deployed with the help of dug-out canoes or those motorized with low-grade HP engines. In all cases, more of the males were involved in the actual fishing, while the women folks, mostly wives of the fishers bought the fish from their husbands; carried out the processing activity and final sales in the markets. Women also participated actively in inshore fishing, including the collection of periwinkles, oysters and barnacles.

This is in line with the of EIA SSAGG of 2003 and EIA of SSAGS+ 2013, which noted that fishing was the major occupation of community members. Fishing techniques employed remained largely unchanged as in previous studies and included hooks and lines, cast nets, drag nets, sweep nets, fish traps and conical baskets.



Plate: 4.2g: Artisanal Fishing Activity in the Study Area

Trading is the second most important income-generating activity in the area, and on very few exceptions, the females did more of the petty trading; dispensing goods from stores and open places since structured community markets were non-existent. Trading is largely undertaken by women and trading items include fish in fresh and roasted forms, foodstuff, confectionaries, etc.



Plate 4.2h: A Common Retail Shop in the Study Area

Mixed cropping was a dominant farming system of the area. Common crops grown include maize, cassava, yam, plantain, banana and vegetables . Simple farm tools, such as cutlasses and hoes characterized the farming system in the area.



Plate 4.2i: Farming Activities in the Study Area

A few respondents (5%) were also engaged in other fisheries-related industry activities such as boat making and repairs, boat engine servicing, sales and mending of nets, weaving of traps and baskets, firewood collection for fish processing among others, while fashion designing and hair-dressing were artisan occupations found to engage some women-folks in the fishing settlements.



Plate 4. 2j: Fisheries-related Activities in the Study Area

However, 10% of the household heads were not involved in any income generating activities and this is an indication of high level of employment in the project area.

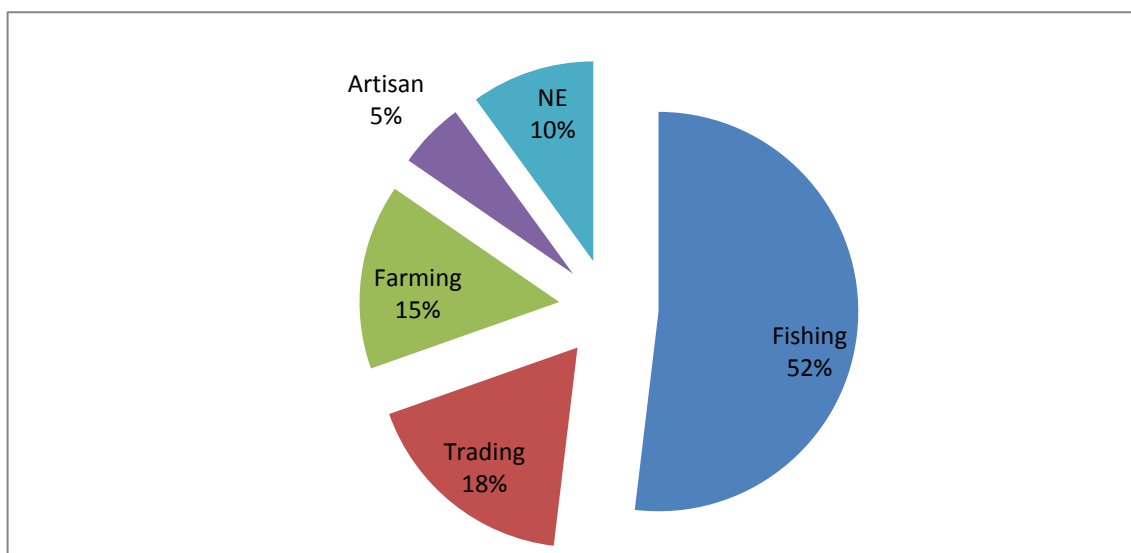


Fig. 4.4f: Major Occupation of Respondents

Fishing and agriculture are the two major traditional occupations of the Niger Delta people (NDDC, 2006; UNDP, 2006). The urban sector, with its concentration of informal sector activities, plays a growing role in the economy of the Niger Delta region.

Respondents appeared to be quite experienced in their occupation as shown in Table 4. 9d. About 27.3% had about 1 to 10 years experience in their jobs while about 52% had 11-20 years. An interesting implication of this was that the individuals would be quite familiar with the challenges associated with their current economic activities.

Table 4.9d: Working Experience of Respondents

s/n	Experience (Years)	Percentage
1	Unemployed	10
2	1-5	14.2
3	6-10	13.1
4	11-15	30.8
5	16-20	22.3
6	>20	9.6
Total		100

Market System

Although the livelihood system is predominantly subsistent, residents of Dodo-North project communities who were engaged in artisanal fishing and small scale farming took their excess produce to markets for sales to earn incomes. Unfortunately, none of the fishing settlements had a structured and well developed market place, but the tradable produces were either traded along the shore of the rivers/creeks or transported to Warri town by women for sale. The major means of transporting the market wares was the engine powered boats. The women, who were the major marketers, carried out different marketing functions beside transportation to make the produces available and acceptable to the final consumers.

Common marketing functions usually carried out included size grading, smoking/drying, retailing/bulk breaking and price speculations.

4.4.7.13: Natural Resource Acquisition, Ownership and Management

Land Ownership/Access and Tenure System

Land is Nigeria's most important long-term resource base. In areas where this finite resource is in short supply, it can be very contentious. Land means many things, and the manner in which it is acquired, owned, used, and transferred is referred to as *land tenure* (NEST, 1991; Igbozurike, 1978). Before rights can be exercised over land, it has to be acquired in one of six principal methods of land acquisition, namely, inheritance, purchase, lease, pledge, exchange and gift.

In and around the Dodo-North project communities and settlements, land resource availability was very limited because of the overwhelming influence of hydrology- myriads of rivers, creeks and creeklets criss-cross the terrain, leaving very limited land space either for habitation or cultivation. Consequently, the little land available is held in very high value, especially since lands on which oil wells and facilities are located confer additional advantages on the land-owning individual, family or community. Two forms of land-ownership are common, namely, *family* and *communal land ownership*. By historical antecedents, the mainland permanent communities own lands that fall within their territory.

The 'temporary smaller fishing ports/camps' also belong to the parent communities. Those dwelling in them and carrying out some form of economic activity on the 'land' owe allegiance to the parent community and 'pay nominal fees or rent' to the land-owning community. Most of the fishing ports are gradually evolving to a more permanent settlement. The study revealed that dry lands were scarce hence many of the settlements were hemmed in by water from all sides, making community expansion difficult.

Forest and wildlife exploitation

The primary source of energy for cooking in the community is fuel wood which is sourced from the mangrove swamps. The red mangrove is very good for making fire and is especially important to fish smoking, processing and subsequent preservation. More than 90% of the community members use fuel wood as energy source about 10% use kerosene for cooking. Some members of the communities are engaged in hunting as a source of livelihood, a few others as past time. The wildlife provides the much needed proteins, vitamins and mineral salts and also income for the people.

Local conservation practices

Members of the communities do not kill or eat python, tortoise and pure white birds, rather their habitats were protected. Equally, sharks were neither killed nor eaten but worshipped as gods. Even though the community members are not doing this as conservation practice per se, it constitutes or serves as a means of conservation of the natural resource base.

4.4.7.14: Quality of Life

Income and Expenditure Levels

Income is an important variable that influences socio-economic status of individuals and its distribution pattern has the potential of influencing other demographic variables. However, personal income levels of self-employed rural households was always difficult to assess because many local people did not keep records and were uncertain of the gross or net amount actually earned from self-endeavors. Some who may have information about their earnings were also not willing to divulge such sensitive data, fearing the effects of taxation. The consequence was that incomes of rural householders were very unreliable. The non-existence of income and expenditure receipts among households made some respondents to over- exaggerate their income while others under-estimated theirs depending on how they perceived the implications of the questions. Those who believed that the figures might be used as a basis for the payment of compensation in the future normally over-exaggerated their income while others thought it was better to paint a pathetic condition of abject poverty.

In most riverine communities of Niger Delta, income range for a weekly mean catch of “small fishing” was between N4,000.00 and N10,000.00, using hand-pulled canoes, with a monthly average income of about N80, 000.00. (SPDC, 2001 and SPDC, 2011). However, in the Dodo-North project communities, an examination of the income level (Fig. 4.4g) revealed that 13.5% earned N5000 and below weekly, about 30.8% earned N5000-10,000 while 16.9% earned N11, 000 -15,000, but the average weekly income was estimated to be about N15,450.00. Respondents however noted that the income range was not consistent through the years as it changed with seasons and festivities.

Household expenditure followed the distribution of income level as shown in Fig 4.4g in the study area. About 24.2% of households spend between N5,000.00 and N10,000.00 weekly while about 12.3% spend less than N5,000.00 weekly. Only 1.6% of the households spend over N30,000.00 in a week and the average expenses per household amounts to about N13,971.00. The observed expenditure profile may be explained by the fact that most families produce what they need and only purchase other items they do not produce. The EIA of SSAGG, 2003 and SSAGS+ 2013 noted that most community residents were subsistence in their livelihood pursuits i.e. producing largely for themselves and selling only the little surplus they had from their fishing and farming activities.

The pattern of both income and expenditure distribution provided insight into the standard of living/quality of life of the Dodo-North project communities’ residents. Given that the average household size in the area is about 8 persons per family, it implies that in a week, per capita income and expenditure were about N1,927.50 and N1,746.37 respectively. Therefore, on the basis of one dollar or N160.00 per day poverty line thresholds, it can be inferred that majority of the residents were relatively poor. When asked to self-evaluate their poverty status most ranked themselves as very poor (71.9%), while 28.1% saw themselves as being averagely poor. Interestingly none perceived themselves as being non-poor. This self-evaluation by the respondents and the proportion of income spent daily, gives an insight into the high rate of poverty prevalent in the communities.

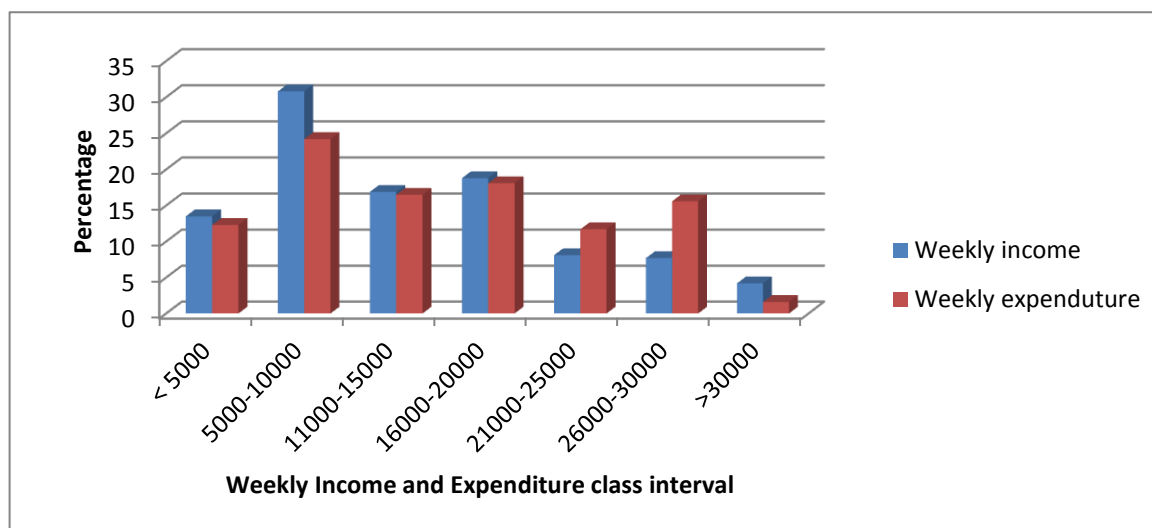


Fig. 4. 2g: Weekly Income and Expenditure Distributions

Household Asset Ownership

A typical household in the communities lacks modern home assets probably because of low household purchasing power and temporary nature of settlement. Besides dug-out canoe, which is virtually owned by all the households, about over 69 percent of the households possess sets of Radio. Also, according to Table 4.9e few members of the community possess valuable household items such as television (4.6%), Engine boats (3.1%) and generating sets (2.7%). Only about 5.2% of the respondents claimed to have purchased and have titled ownership to farmland.

Table 4. 9e: Household Assets ownership structure

s/no	Household Assets	Percentage of ownership
1	Beddings (mattress, pillow, etc)	43.6
2	Radio/ Dc Players	69.2
3	Television	34.6
4	Freezer/Fridge	3.8
5	Cushion Chairs	1.3
6	Generating set	2.7
8	Dug-out canoe	96.9
9	Engine boat	3.1
10	Land	5.2

Housing Types, Pattern and Quality

The individual housing units are built with wooden/zinc walls, roofed with grass/mat while some are constructed with cement block/brick, late rite, mud mixed with cement walls and roofed with either galvanized corrugated iron sheets, asbestos or aluminum sheets. The settlements exhibited similar housing patterns and local architecture. There are number of houses depicting modern architectural design. The most popular roofing material is the corrugated iron sheets (zinc). The commonest toilet disposal system is the pier system.

Qualitatively, rural and urban housing in Niger Delta falls below minimum standards in all aspects. There are several factors, which may be used in assessing the quality of housing, including livability, level of comfort afforded, safety, and ease of maintenance. These factors include wall and roofing materials, as well as household facilities. Traditionally, most Nigerians (about 80%) live in their own houses, which are constructed of locally available materials (NEST, 1991; FMAWRRD, 1992). These include mud walls and bamboo and thatch roofs particularly in the rural areas and cement blocks and corrugated iron sheets/zinc roofs in the urban areas.

4.4.7.15: Lifestyle and Social Vices

Alcohol and drug use

During the field studies the community members admitted to drinking alcohol especially local dry gin. Alcoholism has become a lifestyle in the community. About 80% of the community members take alcohol. Smoking of cigarettes, heroine, weeds, and cocaine is openly done, about 40% of the community members openly admitted smoking cigarettes.

Discrimination Against Women

There appears to be some level of discrimination against women. For example they have no inheritance rights to land/buildings. However, they are allowed to contest or hold some political positions. The observation at the community level was that women leadership role is expressed within women groups. Only few respondents agreed (25.4%) that women are indeed given the freedom to contest political positions. Some community members interviewed noted that women do not wield real power at the community level.

Child Labour

Child work as an aspect of child entrepreneurship instead of child labour was a common feature in the communities as children are known to assist parents in their economic activities. Children were seen to help their parents in fish catching, processing and in cutting firewood required for fish processing and this did not affect the school enrolment, retention and completion of the children. This was not perceived as an abuse; though parents succinctly accepted the responsibility of caring for their wards, but current realities suggest that assistance of all household members is required to sustain the home economically.

Sex Trade (Prostitution)

As in the case of other Niger Delta communities, there is high rate of prostitution in the communities probably due to poverty and hunger.

Crime Rate

The level of crime was low because the communities are homogenous except for the few non-indigenes. The commonest crime in the area was crude oil theft. The JTF has been working very hard to combat this menace.

Domestic and Industrial Accidents

Road traffic accident (RTA) was not a problem in the study communities due to lack of road transport system. However, accidents did occur at homes due to the dilapidated and make-shift nature of the houses and from fish processing, fishing gears, firewood cutting, improper and unsanitary waste management practices and improper housekeeping. Accidents also occurred due to boat mishap and fuel explosion.

4.4.7.16: Physically Challenged People

The study examined the status of the physically challenged in the communities. There was no form of social exclusion of the physically challenged persons but all were completely absorbed/assimilated into the communities. Nevertheless there were no programmes specifically designed to assist them. Obviously the physically challenged, which were acknowledged to exist in the communities, were left to fend for themselves and can only expect to be supported by their families. According to the elders, the foundation of the communities was built on justice, equity and fair play.

4.4.7.17: People’s Support for the proposed Project

The general populace in the area had a mixed outlook on the presence of the SPDC facilities. Responses from the community members (elders, women and youth respectively) confirmed varying perceptions with respect to positive and negative impacts the proposed project would have on the communities, resulting in respective degrees of support. Field survey revealed a generally wide support for the proposed project (Fig. 4.2h). About 70% gave their full support while 18.5% said their support was with reservations. Similarly 11.2% had little support for the proposed project. Their lack of full support was borne out of fear that the project will only end up benefiting few individuals in the community. Equally of concern was that the proposed benefits of the project may be hijacked or diverted by the community leadership who may take the funds and fail to apply such to development projects.

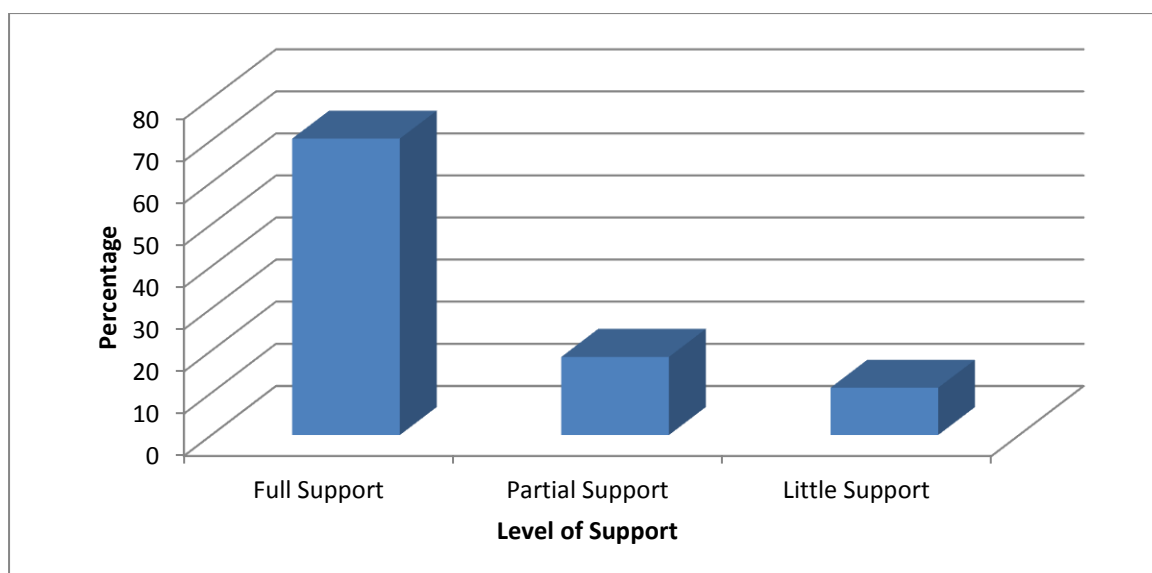


Fig. 4.2h: Support for Proposed Project

4.4.7.18: People’s Perceptions, Fears and Expectations

Potential Benefits of Proposed Project

Community residents held high expectations of the proposed project. As shown in Table 4.9f, provision of portable drinking water and equipping of the schools within the communities ranked the most desired expectations of the people. Providing gainful employment to indigenes and constant electricity were the second and third positive benefits that the Dodo-north project communities were expecting to benefit from the proponent of the project. The least ranked expectation, though with high percentage of response was the construction of befitting town hall as indicated in the Table 4.9f.

Table 4.9f: Potential Beneficial Impacts of Proposed Project

People’s Positive benefits	Percentage of response
Equipping of schools	100.0
Water Project (provision of bore-hole water)	100.0
Employment of indigenes	99.2
Electricity	97.7
Given of business loan/credit	91.2
Scholarship for indigenes	90.8
Construction of primary/secondary school	89.2
Provision of public toilet facilities	87.3
Vocational training/skill acquisition for youths/women	80.4
Construction/maintenance of health centers	75.4
Construction/grading of roads or walk ways	75.0
Provision of agricultural inputs	70.4
Construction of concrete Jetty	66.9
Construction of market Stall	63.1
Town hall	58.1

From the result of community’s need assessment, the people’s expectations were considered to be very high. It is hoped that when these projects are completed, it will enhance more positive attitude to SPDC operations in the area.

Perceived Fear of the Project

Community fears toward the project centered on the different forms of diseconomies that would accompany the project. These fears are grouped into three separate areas, namely, health, environmental and socioeconomics issues.

Perceived Health Concerns of Project

The major health concerns were as enumerated in Table 4.9g. These included contamination of local water supplies (71.9%), increased incidence of ill health (64.6%) and disturbance as a result of noise/vibration(s) of the heavy equipment that would be used at project sites (45%). Concern over river contamination was understandable considering that it constitutes their source of water for drinking and other domestic purposes. Such contamination may lead to serious health issues. The fear of community members over machine noise/vibration was its

implications on the surrounding wildlife and human beings. They fear the noise might scare the wild life, forcing them to migrate to other areas. Other environmental studies carried out in the study area did not capture community perception of potential impacts of projects.

Table 4.9g: Perceived Health Impact of Project

Forms of Health impacts people’s perceived fears	Percentage of response
Contamination of local water supplies (e.g. rivers, etc.)	71.9
Increased incidence of sickness such as malaria	64.6
Disturbances by noise and vibration of machines and vehicles that will be working in the area	45.0
Transmission of diseases e.g. by oil workers to community members	23.8
Poor health conditions as a result of dust created by project activities and vehicular movement	36.2
Foul environment as a result of indiscriminate human waste disposal by the company workers	18.5

Perceived Physical Environmental Impact of Project

Most (75%) community members were worried that the project may affect or destroy community farmlands/forest, which is an important component of their livelihoods (Table 4.9h). Another fear equally expressed was air pollution (56.2%). Members’ fear centred on the fact that such air pollution eventually find their way back into the rivers killing fishes and also affect roofing sheets of residential buildings.

Table 4.9h: Perceived Physical Environmental Impact of Project

Forms of Environmental impacts people’s perceived fears	Percentage of response
Water pollution due to oil spillage and disposal of wastes from construction sites into rivers/streams	79.2
Destruction of farmlands/forest	75.0
Scarcity of wild animals for food as a result because of project activities	70.8
Soil erosion	23.1
Air pollution from fumes from exhaust of machines/equipment used by drilling company	56.2
Noise pollution from construction vehicles movements and machine activities	26.5
Destruction of the environmental beauty of the village	24.2
Indiscriminate disposal of human waste by project workers	25.8

Perceived Socio-Economic Impact of Proposed Project

Forceful acquisition of land without settlement of community/land owners (63.5%) and consequent conflict that may arise (56.5%) were the major social concerns expressed by community members (Table 4.9i). About 39.2% of the respondents feared conflict between project workers and community. There will be need to properly orientate field or project workers on community relations to prevent such from happening. Some (18.5%) members feared the coming of the project may encourage some youths to engage in active militancy as a means of getting money from SPDC. Shell Petroleum Development Company (SPDC) will

need to carry the community along in the course of the project by engaging community youths at different phases of the project. Some also expressed fear that kidnapping of project workers may not be completely ruled out (14.6%). Thus there will be need to provide security for project staff during construction.

Table 4.9i: Potential Socio-economic impact

Forms of socio-economic impacts people’s perceived fears	Percentage of response
Forceful acquisition of land without settlement of community/owners	63.5
Conflict as a result of unsettled acquisition of land	56.5
Conflict between construction workers or project owners and community citizens	39.2
Increase in inter-community conflict	17.7
Increase in youth militancy	18.5
Increase kidnapping	14.6
Increased crime rate as a result of people moving in to village to stay	39.6
Increased demand on existing infrastructure facilities/services such as health and schools which is already inadequate as a result of people coming to live in community.	59.6
Disruption of fishing and other business of community members	65.0

The possibility of the project leading to increased crime rate in the community exists (39.6%) However, members felt putting in place adequate security measures at the community level will mitigate this. It was assumed that the project, if properly managed, will enhance the wellbeing of community residents. Another major concern expressed was the increased demand on existing social services such as school and health facilities as a result of increased migration of people into the community (59.6%). This shows the need to have existing social facilities upgraded and equipped to cope with the projected influx of people into the communities. Another dysfunctional impact of the project is the disruption of fishing and other farm activities (65%). This undoubtedly arises from the indirect consequences of river pollution.

The EIA of SSAGG of 2003 and EIA of Benisede Catchment Area Phase I 2004 revealed that similar concerns and expectations have been expressed by community members over proposed project. Some key concerns expressed included: increased gas flaring with its attendant ecological, human health and socio-environmental impacts, loss of wildlife in the area due to continuous lighting (especially at night time), reduction in wildlife and hunting activities. Other concerns included excessive heat flux in the area, increased ocular and dermal ailments in the area, especially among children and the elderly. The findings therefore showed that these concerns still exist in the study area.

4.4.8: Health Baseline Status

The main communities in the Dodo North NAG Wells project area are the Amabolou Federated communities (i.e. Amabolou, Tamogbene and Norgbene) in Ekeremor LGA of Bayelsa State. In addition, the communities in the Tunu Field where the proposed new pipelines from the NAG Wells would terminate are Agbidiana and Egbemo-Angalabiri (Akpediana). All the project communities are “riverine” communities, because they are only accessible by water (Plate 4.2j), and their indigenous occupation are predominantly fishing.



Plate 4.2j: Study team boat enroute project communities

4.4.8.1 Morbidity and Mortality Pattern

Available information on the prevalence of the three common childhood illnesses, i.e., malaria, diarrhea and acute respiratory tract infection (ARI) was not disaggregated for communities in the project area. The National Demographic and Health Survey (NDHS) conducted in 2008, four years before this baseline assessment, provided relevant data on these diseases for Bayelsa State and the South-South geopolitical zone where the proposed project was to be located.

The 2008 NDHS indicated that fever (mainly due to malaria) remains an important cause of illness among children under-five. As shown in Table 4.9j, 18.1% and 20.6% of under-five children recorded a febrile illness in the two weeks preceding the survey in Bayelsa State and in South-South zone – both being higher than the national median of 15.9%.

The Nigeria Malaria Indicator Survey of 2010 reported a malaria slide positive rate of 32.2% among children 6-59 months old in Bayelsa, showing the relative importance of malaria as a cause of febrile illness in the area. The Bayelsa State Integrated Disease Surveillance & Response (IDSR) data archive for 2012 showed that 453 cases of suspected malaria were recorded at all reporting health facilities in Ekeremor LGA, of which 35 warranted hospital admission and 65 were pregnant women. No death was recorded in the year.

Though the prevalence of diarrhoea and ARIs (mainly due to pneumonia) reported in the 2008 NDHS were less in Bayelsa State and the South-South zone than the national average, they were no less significance as causes of ill health among children.

Table 4.9j: Morbidity Pattern among Children in Project Area

	Proportion of children under age five who had a fever in the two weeks preceding the survey	Proportion of children under age five who had diarrhoea in the two weeks preceding the survey	Proportion of children under age five who had ARI in the two weeks preceding the survey
Bayelsa State	18.1%	3.2%	n.a.
South-South Zone	20.6%	3.8%	3.5%
National	15.9%	10.1%	2.8%

Source: NPC and ICF Macro, 2009

Analysis of the Weekly Epidemiology Report published by the Federal Ministry of Health on epidemic prone diseases for Week 52 revealed the following cumulative data for Bayelsa State in 2012: one case of cerebro-spinal meningitis occurred; cholera, 2 cases; measles, 86 cases and yellow fever, 6 cases (FMoH, 2012). However, there was no fatality recorded.

Non-communicable diseases have also been documented as important causes of ill health in Bayelsa State where the proposed project would be located. Oni *et al.* (2009) reported that stroke patients constituted 2.3% of the total hospital admissions and 9.3% of medical admissions at the Niger Delta University Teaching Hospital, Okolobiri. Hypertension was found in 89% of these individuals that had stroke.

Mortality (deaths) among the most vulnerable population groups; children under-five and women of child-bearing age, have been reported to be high in Bayelsa State where the project communities are located. The Multiple Indicator Cluster Survey of 2011 reported that infants (under-1 year old) died at a rate of 107/1000 live births, which was higher than the average rates in the South-South zone and Nigeria as a whole (Table 4.9k). Similarly, the death rate in children under-5 was also relatively higher in Bayelsa State.

Table 4.9k: Mortality Rates in Project Area

	Infant Mortality Rate* (per 1000 live births)	Under-Five Mortality Rate* (per 1000 live births)
Bayelsa State	107	178
South South Zone	75	118
National	97	158

*Using North Model

Source: Nigeria Multiple Cluster Indicator Survey 2011 (NBS, UNICEF and UNFPA, 2013)

4.4.8.2 Nutritional Status and Immunization

Indices commonly used to assess nutritional status at community level based on anthropometric measurements among under-five children include Height-for-Age (stunting), Weight-for-Height (wasting) and Weight-for-Age (under-nutrition); stunting indicates chronic malnutrition, while the latter two indices reflect recent or acute malnutrition occurring in under-five children. Though primary information from the project communities were not available, disaggregated data from two national surveys for Bayelsa State and the South-South Zone show that malnutrition is a health concern.

The 2011 Multiple Indicator Cluster Survey reported a prevalence of chronic and acute malnutrition as 15.9% and 7.3%, respectively in Bayelsa State where the project is located. However, these figures represent a decrease in the rates from the 2008 NDHS findings, and are lower than the South-South and national averages. Nonetheless, qualitative information gathered during the fieldwork indicate that the local populace reported health concerns regarding a declining state of household food security, which they attributed to the lull in economic activities.

Regarding the immunization status of children under-five in the communities, Bayelsa State figures for percentage of DPT3 coverage have remained below the averages for South-South zone and Nigeria. This is in spite of the increase observed between 2008 and 2011 as shown in Table 4.9I.

Table 4.9I: Nutritional status and immunization status of under-five children in the Communities

	Bayelsa State		South-South Zone		National	
	2008*	2011‡	2008*	2011‡	2008*	2011‡
Proportion of children under age five with Height-for-Age below -2 SD of reference value (Stunting)	28.7%	15.9 %	31.1%	19.5%	40.6%	35.8%
Proportion of children under age five having Weight-for-Height below -2 SD of reference value (Wasting)	7.4%	7.3%	7.5%	6.5%	13.9%	10.2%
Proportion of children under age five with Weight-for-Age below -2 SD of reference value (Under-nutrition)	8.0%	12.9%	12.8%	12.1%	23.1%	24.2%
Proportion of children aged 12-23 months who had received DPT3 vaccination	27.6%	38.3%	54.2%	60.2%	35.4%	70.5%

*National Demographic and Health Survey 2008 (NPC and ICF Macro, 2009)

‡Nigeria Multiple Cluster Indicator Survey 2011 (NBS, UNICEF and UNFPA, 2013)

4.4.8.3 Lifestyle and Health Knowledge, Attitude, Practice & Behaviour

According to the 2008 NDHS Report, the proportion of women and men with comprehensive knowledge of HIV/AIDS in Bayelsa State was found to be higher, at 41.7% and 76.2%, respectively, than figures for South-South zone and Nigeria (Table 4.9m). However, it appeared that this level of knowledge did not translate into lower risk behaviours in Bayelsa State as higher rates of multiple sex partners were also found among women and men (2.7% and 22.1%) than the average rates for South-South zone and Nigeria (Table 4.9m).

Qualitative information obtained from informal interviews with key informants in the communities in 2012 indicated that many of them had heard of HIV/AIDS; that polygamy was common; and there were allusions to preponderance of male infidelity. Use of alcohol and tobacco was also reported in the SSAGG+ EIA Report of 2013, from qualitative assessments. It was noted that, “alcoholic beverages were freely available and at all times in the communities, while about 20% of the adult males in the communities smoke cigarette”.

Table 4.9m: Sexual Behaviour and HIV/AIDS Knowledge in Project Area

	Proportion of women aged 15-49 with comprehensive knowledge of HIV/AIDS	Proportion of men aged 15-49 with comprehensive knowledge of HIV/AIDS	Proportion of women aged 15-49 who had 2+ sex partners in past 12 months	Proportion of men aged 15-49 who had 2+ sex partners in past 12 months
Bayelsa State	41.7%	76.2%	2.7%	22.1%
South South Zone	26.0%	37.0%	2.2%	18.4%
National	23.4%	44.9%	1.0%	9.9%

Source: NPC and ICF Macro, 2009

4.4.8.4 Health Care Infrastructure

Examination of records from Bayelsa State Ministry of Health (MoH) revealed that government-owned health facilities exist in Ekeremor LGA, however they are in various states of functionality. Within the Dodo North NAG Wells project area, the distribution of health facilities is as follows:

Table 4.9o: Public Health Facilities in Dodo North NAG Wells Project area

Community	Health Facility	Level	Status
Amabolou	Health Centre Amabolou	Primary	Physical structure not completed
Tamogbene	Health Centre Tamogbene	Primary	Functional
Tamogbene	Cottage Hospital Tamogbene	Secondary	Functional
Norgbene	NIL	NIL	NIL
Agbidiana	Health Centre Agbidiana	Primary	Non-functional
Egbemo-Angalabiri	Health Centre Egbemo-Angalabiri	Primary	Functional
Egbemo-Angalabiri	Cottage Hospital Egbemo-Angalabiri	Secondary	Functional

Information from the Bayelsa State MoH also revealed that the Primary Health Care (PHC) centres within the communities do provide basic health services in line with the eight components of PHC including treatment of minor ailments such as uncomplicated malaria; maternal and child health services such as immunization and antenatal care. A number of special health intervention programmes were also reported to be present in the area such as Roll Back Malaria and National Programme on Immunization.

It is worthy of note to mention that the Cottage Hospital in Tamogbene was built by SPDC as part of its tri-partite community health partnership; the hospital was observed to be under going renovations during the field study (Plate 4.2k). On the other hand, the Amabolou PHC Centre has remained uncompleted over the years the construction project was commenced.



Plate 4.2k: Signpost of renovation works at Tamogbene Cottage Hospital

Tertiary Health Care services, provided at the Niger Delta University Teaching Hospital (NDUTH), Okolobiri and the Federal Medical Centre, Yenagoa, were not within close reach of members of the project communities due to distance. These health care facilities have in-patient beds, and provide services in several specialties of medicine, including emergency care, orthopedics, medical and surgical care. The NDUTH was undergoing facility expansion at the time of the study. Medical Emergency Evacuation System was inadequate in the project area; none of the health care facilities in the communities had a boat ambulance, and were not served by any company-owned emergency medical service due to security reasons and decline in industrial activities within the area.

Alternative health care was observed in the area. As displayed in Plates 4.2l and 4.2m self-medication and patronage of Patent Medicine Vendors (PMVs) and traditional medicine practitioners (especially Traditional Birth Attendants (TBA) trained by an SPDC-supported project) were observed in the project communities.



Plate 4.2l: Patent Medicine Vendor in project community



Plate 4.2m: Signpost of a Trained Traditional Birth Attendant at Egbemo-Angalabiri

4.4.8.5 Access to Safe Drinking Water

Data from the 2011 Multiple Indicator Cluster Survey showed that less than one-third (27.5%) of households in Bayelsa State have access to improved drinking water sources (Table 4.9p). Though this represents a slight increase from the 26.6% reported in the 2008 NDHS, the figure is lower than the zonal and national averages.

Qualitative information obtained from the field supported this; while boreholes were present among respondents in the major settlements of Amabolou, Tamogbene and Egbemo-Angalabiri most of the respondents reported that they relied on rainwater for drinking.

Table 4.9p: Access to Improved Drinking Water Sources and Sanitation Facilities

Proportion (%) of Households having:	Bayelsa	South-South	National
Improved drinking water			
Piped into dwelling, plot or yard	1.3	4.1	4.7
Other improved	26.2	66.4	53.9
Unimproved drinking water	72.5	29.5	41.5
Total	100.0	100.0	100.0
Improved Sanitation	8.4	30.4	31.0
Unimproved Sanitation			
Shared improved facilities	8.7	25.3	20.3
Unimproved facilities	50.8	21.7	20.2
Open defeacation	32.1	22.6	28.5
Total	100.0	100.0	100.0
Improved drinking water sources and improved sanitation	4.3	25.4	21.6

Adapted from National Bureau Of Statistics (NBS) [Nigeria], UNICEF and UNFPA. Nigeria Multiple Indicator Cluster Survey 2011: Main Report. Abuja, Nigeria: National Bureau Of Statistics. April 2013.



Plate 4.2n: Rainwater Harvesting at Agbidiana

4.4.8.6 Access to Sanitation Facility

Sanitation facility was defined as a private excreta disposal facility that is either a toilet or a latrine, but not an overhung toilet, or a flush toilet without septic tanks that channels its effluents directly into the river (NBS, UNICEF and UNFPA, 2013). A household is classified as having an improved toilet if the toilet is used only by members of one household (i.e. it is not shared with other households) and if the facility used by the household separates the waste from human contact (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2004).

Data from the 2011 Multiple Indicator Cluster Survey showed that only 8.4% of households in Bayelsa State had access to improved sanitation facilities. Though this represents a slight increase from the 6.1% reported in the 2008 NDHS, the figure is far lower than the zonal and national averages of 30.4% and 31.0% respectively. Among those that use unimproved sanitation facilities, over-hung toilets and open defecation were pronounced. Open defecation was reported as high as 32.1% of households in Bayelsa State.

Qualitative assessments conducted in 2012 among members of the project communities corroborated the widespread use of over-hung (jetty-type) toilet (Plate 4.2o). The use of overhung toilet not only contaminates the receiving water body with fresh feces, but also has been linked to several excreta-related diseases, including diarrhea, typhoid and schistosomiasis.



Plate 4.2o: An Over-hung Toilet in a Riverine Community in Bayelsa State

4.4.8.7 Waste Management

From Direct Observation techniques, the wastes generated in the communities were noted to be mainly refuse and other domestic wastes. Open dumping of wastes was observed as prevalent; close to residential accommodation or by riverbanks, as enunciated by the socio-economic baseline section of this report.

Solid wastes constitute breeding sites for common vectors of diseases such as malaria, diarrhoeal illnesses and plague. Leachates from the wastes are also a source of contamination of water bodies.

4.4.8.8 Housing Characteristics

From Direct Observations, the preponderant form of building materials in the major communities such as Tamogbene was cement block walls and corrugated iron roofing sheets. This contrasted with the housing conditions observed in the fishing camps, which were mainly mud walls with thatch roofs (Plate 4.2p). Poor housing conditions have been implicated as risk factors for a number of diseases and health conditions such as respiratory illnesses and also malaria where there is little or no barrier against man-vector contact.

The 2008 NDHS Report showed that not many households in Bayelsa State own insecticide-treated mosquito nets (ITNs) or reported that household members sleep under them, as shown in Table 4.9q. However this figure increased from 2.4% to 19.0% following the mass distribution of 576,192 Long-Lasting Insecticide-treated Nets by the National and Bayelsa State Malaria Control Programmes in 2011. However, the nets utilization rate reduced from 8.1% to 6.7%, and this was lower than rates reported for the South-South zone and the national average.



Plate 4.2p: A thatch house at a fishing port in Tamogbene

Table 4.9q: Ownership and Use of Mosquito Nets in Project Area

	Bayelsa State		South-South Zone		National	
	2008*	2011‡	2008*	2011‡	2008*	2011‡
Proportion of households with at least 1 Insecticide-Treated Net (ITN)	2.4%	19.0%	10.3%	39.6%	8.0%	38.6%
Proportion of under-five children who slept under an ITN	8.1%	6.7%	9.4%	21.5%	5.5%	16.4%

4.4.9 Consultations

4.4.9.1 Consultation/Stakeholder Engagement

The project activities involved extensive consultation with authorities and communities. Relevant stakeholders were identified and engaged during the scoping exercise. Consultation is a continuous process that spans through the life cycle of the project. Stakeholders engagement is encouraged at various phases of the EIA process (fieldwork, laboratory analysis, open forum, etc.). Scoping workshops were held, stake holders invited included:

- Regulators – DPR, FMEnv, Bayelsa State Ministry of Environment; Delta State Ministry of Environment (DSMEnv).
- Southern Ijaw Local Government Area and Ekeremor Local Government Area Chairman (Bayelsa State) and Burutu Local Government Area Chairman (Delta State).
- SPDC.
- Non-Governmental Organizations (NGOs) – Niger Delta Peace Coalition (NDPC).
- EIA Consultants.
- Representatives of twenty three (23) Stakeholders communities within the proposed project area.

4.4.9.2 Scoping Workshop Aims and Objectives

- Identify and inform stakeholders about the project.
- Find out the concerns of stakeholders.
- Consider feasible and practical alternatives to the project.
- Identify the main issues and impacts to be studied.
- Define the boundaries of the Environmental Impact Assessment (EIA) study.
- Agree on means of public involvement and methods of analysis.

Stakeholders were made to express their perceptions and expectations, identify potential impacts (adverse and beneficial), propose measures to mitigate the negative impacts and enhance the positive impacts.

The Terms of Reference (ToR) addressed the various issues raised during the Scoping Workshop. It was developed in an integrated manner to include the Scope of Work for Biophysical, Social and Health Impact Assessments. This is in compliance with regulatory

requirements and the SPDC Environmental Impact Assessment (EIA) process. It also aimed at giving equal coverage to the Biophysical, Social and Health aspects of the environment. The purpose of the Terms of Reference was to identify, for the public and the study executors, information required by government regulatory agencies for an Impact Assessment (IA) report for the proposed project.



Plate 4.2q: Focus Group Discussion in Tamoghene Community



Plate 4.2r: Focus Group Discussion in Egbemor-Angalabiri Community



Plate 4.2s: Focus Group Discussion at Agbidiana and Egbmo Angalabiri Communities



Plate 4.2t: Focus Group Discussion at Agbidiana and Egbmo Angalabiri Communities



Plate 4.2u: Personal Interview session at Agbidiana and Egbemo Angalabiri Communities.



Plate 4.2v: Focus Group Discussion Amabolou Federated (Amabolou, Tamogbene and Norgbene).



Plate 4.2w: Focus Group Discussion Amabolou Federated (Amabolou, Tamogbene and Norgbene)



Plate 4.2x: Focus Group Discussion Amabolou Federated (Amabolou, Tamogbene and Norgbene)

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1: Introduction

A number of methods exist for evaluating potential impacts of any project on the environment. These include the Overlays techniques (McHarg, 1968), Leopold matrix (Leopold et al., 1971), Battelle Environmental Evaluation System (Dee et al., 1973), and Peterson Matrix (Peterson et al., 1974) and ISO 14001. The method employed in this EIA study is the ISO 14001 method. The ISO 14001 method is simple to apply and provides a high level of detail, and also relies on limited data.

5.2: Impact Identification and Evaluation

In line with general guidelines for an Environmental Impact Assessment (EIA) process, the following were the basic steps adopted for identification and evaluation of impacts (Fig. 5.1):

- Impact identification
- Impact qualification
- Impact rating
- Impact description

5.2.1 Impact Identification

The objective of impact identification is to account for the entire potential and associated bio-physical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. The identified potential impacts during the different phases of the proposed project are listed in Table 5.1.

5.2.2: Impact Qualification

The identified impacts of the project were qualified based on the following four criteria:

- Positive or negative
- Short-term or long-term
- Reversible or irreversible
- Direct or indirect

Negative impacts are those that adversely affect the biophysical, health and social environments while positive impacts are those, which enhance the quality of the environment. For this study, short term means a period of time less than three months while any period greater than three months is considered long term. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated.

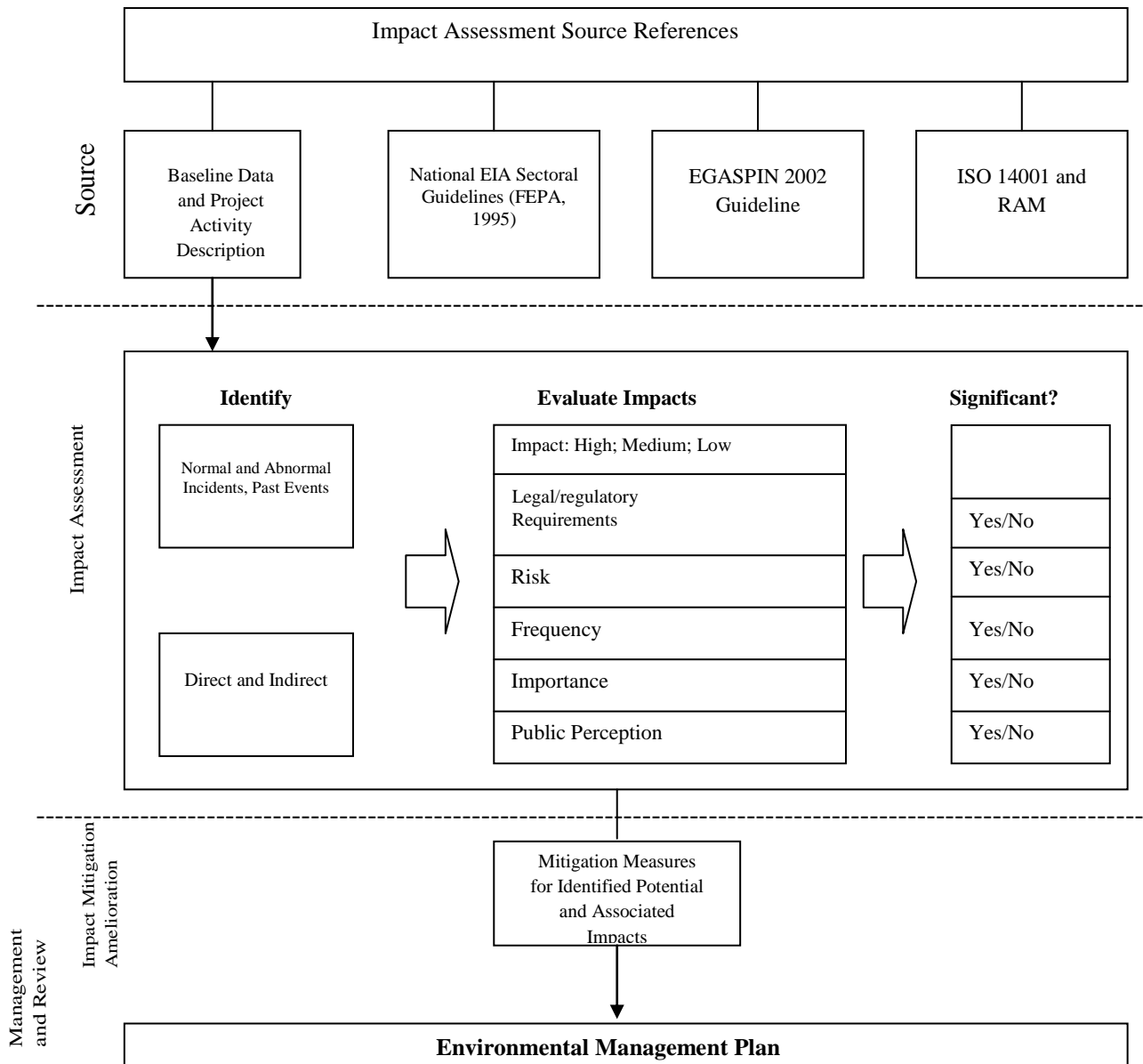


Fig. 5.1: Approach to Impact Assessment

Table 5.1: Checklist of Associated and Potential Impacts of Proposed outstanding Activities in Dodo North NAG Wells Project

Project Phase	Project Activity	Potential and Associated Impacts
Pre-construction phase	<ul style="list-style-type: none"> ▪ Land Acquisition ▪ Site survey ▪ Pre-Mobilization/ Mobilization ▪ Site clearing ▪ Location preparation/ Dredging ▪ Sandfilling 	<ul style="list-style-type: none"> ▪ Alteration of local topography during sand filling ▪ Air/Noise pollution from increased vehicular movement ▪ Encroachment on cultural, historical and ecological resources ▪ Erosion hazard arising from topographic changes ▪ Increase in employment opportunities ▪ Increased cash flow and stimulation of local economies within the communities due hiring of labour from the community ▪ Increased morbidity from pressure on existing social amenities/infrastructure ▪ Increased social vices and incidence of STIs including HIV ▪ Injuries/trauma and deaths ▪ Interference with drainage pattern ▪ Opportunities for contracting ▪ Opportunity to re-use wastes such as firewood ▪ Risk of water traffic accidents ▪ Stimulation of local economy and markets from increased demand for food, and other products in the local market ▪ Third party/community agitation
Construction Phase	<p>Wells (Drilling & Completion)</p> <ul style="list-style-type: none"> ▪ Slot sweeping ▪ Rig Move (including personnel, equipment and supplies logistics) ▪ Drilling Campaign ▪ Casing and cementing ▪ Completion and perforation ▪ Well testing ▪ Flowline hook – up ▪ Site Demobilisation 	<ul style="list-style-type: none"> ▪ Accidents ▪ Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges ▪ Continuous glare from rig operation ▪ Disruption of fish spawning sites ▪ Impairment of air quality by emissions of air pollutants including greenhouse gases ▪ Increase in employment opportunities ▪ Increased cash flow and stimulation of local economies within the communities due hiring of labour from the community ▪ Increased morbidity from pressure on existing social amenities/infrastructure ▪ Increased security risk and criminality (militants and pirates) ▪ Increased social vices and STIs including HIV ▪ Injuries/trauma and death from blowouts ▪ Interference with fishing and farming ▪ Mental Stress from noise nuisance and sleep disturbance from glare ▪ Noise and vibration nuisance ▪ Opportunities for contracting ▪ Third party agitation

Project Phase	Project Activity	Potential and Associated Impacts
Construction Phase	Flowline Design and Installation <ul style="list-style-type: none"> ▪ Site Mobilisation ▪ Right of Way Survey ▪ Ditching / excavation / Dredging ▪ Bevelling, Fitting and Welding ▪ Field Joint Coating ▪ Non Destructive Weld Inspection / Testing ▪ Laying, Backfilling and Site Restoration ▪ Hydrotest ▪ Facilities hook up at Tunu GCP and Dodo North Wells. 	<ul style="list-style-type: none"> ▪ Accidents ▪ Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges ▪ Disruption of fish spawning sites ▪ Encroachment on cultural, historical and sensitive ecological zones ▪ Erosion hazard due to construction impediments to natural drainage ▪ Impairment of air quality by emissions of air pollutants including greenhouse gases ▪ Increase in employment opportunities ▪ Increased cash flow and stimulation of local economies within the communities due hiring of labour from the community ▪ Increased morbidity from pressure on existing social amenities/infrastructure ▪ Increased security risk and criminality (militants and pirates) ▪ Increased social vices and STIs including HIV ▪ Injuries/trauma and death from work-related accidents ▪ Interference with drainage pattern ▪ Interference with fishing and farming ▪ Interference with water transport ▪ Loss of biodiversity ▪ Noise and vibration nuisance ▪ Opportunities for contracting ▪ Radiation burns and sickness from exposure to radioactive emissions ▪ Third party agitation ▪ Wildlife habitat fragmentation
Demobilization	Clearing of materials and movement of personnel from site	<ul style="list-style-type: none"> ▪ Air, water and land pollution arising from improper disposal of cleared materials ▪ Impairment of air quality by emissions of air pollutants from vehicular movement ▪ Increase in noise and vibration level ▪ Increased opportunity for business and employment. ▪ Loss of employment/ income ▪ Marine/land accident resulting to injuries and fatality ▪ Opportunities for contracting ▪ Pirates attack and hostage taking ▪ Third party agitation
Operation & maintenance	Wellhead and flowline maintenance	<ul style="list-style-type: none"> ▪ Air pollution from gas flaring, venting and leakages ▪ Environmental pollution arising from improper disposal of lubricants and oily debris

Project Phase	Project Activity	Potential and Associated Impacts
		<ul style="list-style-type: none"> ▪ Equipment failure and damage leading to injuries/fatality ▪ Noise from operational activities (equipment, water and air transport, pumps) ▪ Sanitary and domestic wastes ▪ Revenue generation to government and company
Decommissioning & Abandonment	Decommissioning Abandonment	<ul style="list-style-type: none"> ▪ Air pollution from emissions arising from leaks and trapped oils ▪ Employment and income generating opportunity ▪ Job-related and traffic accidents resulting from removal of structures from site ▪ Loss of job and project-related economic benefits ▪ Opportunities for contracting ▪ Restoration of aesthetic value of the environment ▪ Third party agitation ▪ Soil contamination from excavation during removal of well heads ▪ Solid wastes from decommissioning activities ▪ Water contamination and soil degradation from effluents and excavation

5.3 Risk Assessment for Environmental Consequences

Risk (R) – What is risk/hazard rating based on Risk Assessment Matrix (RAM) (Fig. 5.2 and Table 5.2)

1= Low risk

3 = Medium/intermediate risk

5 = High risk

Table 5.2: Risk Assessment Matrix

Consequence		Increasing Probability				
		A	B	C	D	E
Severity	Environment	Never heard of incident in industry	Incident has occurred in oil industry	Incident has occurred in SPDC	Happens several times per year in SPDC	Happens several times per year in District
0	No effect					
1	Slight effect		Low			
2	Minor effect		Risk			
3	Localized effect			Medium		
4	Major effect			Risk	High	

Table 5.3: Further definition of consequence – severity rating for risk matrix

Severity	Potential Impact	Definition
0	Zero effect	No environmental damage. No change in the environment. No financial consequences.
1	Slight effect	Local environmental damage within the fence and within systems. Negligible financial consequences.
2	Minor effect	Contamination, damage sufficiently large to affect the environment. Single exceedance of statutory or prescribed criteria, single complaint. No permanent effect on the environment
3	Localized effect	Limited loss of discharges of known toxicity. Repeated exceedance of statutory or prescribed limit. Affecting neighborhood
4	Major effect	Severe environmental damage. The company is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedance of statutory or prescribed limits
5	Massive effect	Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservancy, a major economic loss for the company. Constant high exceedance of statutory or prescribed limits.

Source: SIEP (1996)

5.4 Impact Assessment Methodology

Stage one: Classification

The first stage involved in the assessment of impact is impact classification. Impacts are classified as follows:

- Adverse (-) or Beneficial (+) in nature,
- Short term < 3 months (S) or Long term > 3 months (L), and
- Reversible (R) or Irreversible (I).

Adverse impacts are those, which impact negatively on the environmental components while beneficial impacts are those that enhance the quality of the environment. For this study, short term means a period of time less than three months while any period greater than three months is considered long term. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent once the activity causing the impact is terminated.

Stage two: Significance

The second stage involves evaluation to determine whether or not the impact is significant. The criteria and weighting scale employed in evaluation are as follows:

- Legal/regulatory requirements (L);
- Risk factor (R);
- Frequency of occurrence of impact (F);
- Importance of impact on an affected environmental component (I); and
- Public perception/interest (P).

The quantification scale of 0, 1, 3 and 5 was used. This is a modification of the arbitrary scale proposed by Vesilind, *et al.* (1994). The ratings are as described below and are adapted from The International Organization for Standardization ISO 14001 – Environmental Management System Approach.

- **Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit required?**
 - 0 = There is no legal/regulatory requirement
 - 3 = There is legal/regulatory requirement
 - 5 = There is a legal/regulatory requirement and permit required
- **Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix?**
 - 1 = Low risk
 - 3 = Intermediate risk
 - 5 = High risk
- **Frequency of Impact (F) – What is the frequency rating of impact based on the Risk Assessment Matrix?**
 - 1 = Low frequency (rare)
 - 3 = Intermediate frequency (likely)
 - 5 = High frequency (very likely)
- **Public interest/perception (P) – What is the rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?**
 - 1 = Low interest/perception
 - 3 = Intermediate interest/perception
 - 5 = High interest/perception
- **Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions?**
 - 1 = Low
 - 3 = Medium
 - 5 = High

This approach combines the following factors in assessing the overall impact rating of the project on the environment:

- The sensitivity/vulnerability of the ecosystem components;
- The productivity evaluation/rating of the ecosystem components;
- Knowledge of the possible interactions between the proposed project and the environment;
- Envisaged sustainability of the project environment;
- The economic value of the proposed project activities; and
- Projected duration of the impact of each project activity on various environmental components.

The frequency of occurrence of each impact was determined from historic records while the importance of affected environmental component was determined through consultation and consensus of opinions. The perception of the communities and the general public on each potential impact and its effects were determined through consultation with the communities and consensus of opinions of environmental professionals. The overall impact rating is determined as shown in Table 5.4. The potential and associated impacts of the project are presented in Table 5.5a.

Table 5.4: Impact Value and Rating

Impact value	Cut off values	Impact Rating
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	High
F + I	≥6	
P	= 5	
Positive		Positive

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Table 5.5a: Potential and Associated Impacts of Proposed Dodo North NAG Wells Development Project

Project Activities	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
PRE-CONSTRUCTION	Alteration of local topography during sand filling		√	√			√		√	0	1	1	3	3	8	4	M
▪ Land Acquisition ▪ Site survey	Air/Noise pollution from increased vehicular movement		√	√		√		√		3	1	3	1	3	11	4	M
▪ Pre-Mobilization /Mobilization ▪ Site clearing	Encroachment on cultural, historical and ecological resources		√	√			√		√	3	1	1	3	5	13	4	M
▪ Location preparation/Dredging and sandfilling	Erosion hazard arising from topographic changes		√	√			√		√	3	1	1	3	3	11	4	M
	Increase in employment opportunities	√		√		√		√		-	-	-	-	-	-	-	P
	Increased cash flow and stimulation of local economies within the communities	√		√		√		√		-	-	-	-	-	-	-	P
	Increased morbidity from pressure on existing social amenities/infrastructure		√	√		√		√		0	3	3	3	3	12	6	M
	Increased social vices and incidence of STIs including HIV		√		√		√	√	√	0	5	3	5	5	18	8	H

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
	Injuries/trauma and deaths		√	√			√		√	3	5	3	5	5	21	8	H
	Interference with drainage pattern		√	√		√		√		0	1	1	3	3	8	4	M
	Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	P
	Opportunity to re-use wastes such as firewood	√		√		√		√		-	-	-	-	-	-	-	P
	Risk of water traffic accidents		√	√		√		√		3	5	3	5	5	21	8	H
	Stimulation of local economy and markets from increased demand for food, and other products in the local market	√		√		√		√		-	-	-	-	-	-	-	P
	Third party/community agitation		√	√		√		√		3	1	1	5	5	15	6	H
CONSTRUCTION	Accidents		√	√			√		√	3	5	3	5	5	21	8	H
Well Drilling & Completion	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and		√	√		√	√	√	√	3	3	3	5	5	19	10	H
	<ul style="list-style-type: none"> ▪ Slot sweeping ▪ Rig Move (including personnel, equipment 		√	√		√	√	√	√	3	3	3	5	5	19	10	H

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
and supplies logistics)	effluent discharges																
▪ Drilling Campaign	Continuous glare from rig operation		√	√			√	√		0	3	5	3	1	12	4	M
▪ Casing and cementing	Disruption of fish spawning sites		√	√			√	√		3	3	3	5	5	19	10	H
▪ Completion and perforation ▪ Well testing ▪ Flowline hook – up	Impairment of air quality by emissions of air pollutants including greenhouse gases		√	√		√		√		3	1	1	5	5	15	6	H
▪ Site Demobilisation	Increase in employment opportunities	√		√		√		√		-	-	-	-	-	-	-	P
	Increased cash flow and stimulation of local economies within the communities	√		√		√		√		-	-	-	-	-	-	-	P
	Increased morbidity from pressure on existing social amenities/infrastructure		√	√		√		√		0	5	5	3	3	16	8	H
	Increased security risk and criminality (militants and pirates)		√	√		√		√		3	5	5	5	5	23	10	H

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						F+I	Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		
	Increased social vices and STIs including HIV		√		√		√	√	√	0	5	3	5	5	18	8	H
	Injuries/trauma and death from blowouts		√	√			√		√	3	5	3	5	5	21	8	H
	Interference with fishing and farming		√	√		√		√		0	3	5	5	5	18	10	H
	Mental Stress from noise nuisance and sleep disturbance from glare		√		√	√		√		0	3	5	3	3	14	6	M
	Noise and vibration nuisance		√	√		√		√		3	1	3	1	3	11	4	M
	Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	P
	Third party agitation		√	√		√		√		3	1	1	5	5	15	6	H
	Encroachment on cultural and historical resources		√	√			√	√		3	1	3	3	3	13	6	H
	Reduction in species diversity population		√	√			√	√		3	1	3	3	3	13	6	H
	Habitat depletion or fragmentation and disruption in food chains		√	√			√	√		3	1	3	3	3	13	6	H
CONSTRUCTION	Accidents		√	√			√		√	3	5	3	5	5	21	8	H

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
Flowline Design & Installation <ul style="list-style-type: none"> ▪ Site Mobilisation ▪ Right of Way Survey ▪ Ditching / excavation / Dredging ▪ Bevelling, Fitting and Welding 	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges		√	√		√	√	√	√	3	3	3	5	5	19	10	H
<ul style="list-style-type: none"> ▪ Field Joint Coating 	Disruption of fish spawning sites		√	√			√	√		3	3	3	5	5	19	10	H
<ul style="list-style-type: none"> ▪ Non Destructive Weld Inspection / Testing 	Encroachment on cultural, historical and sensitive ecological zones		√	√			√		√	3	1	1	3	5	13	4	M
<ul style="list-style-type: none"> ▪ Laying, Backfilling and Site Restoration 	Erosion hazard due to construction impediments to natural drainage		√	√			√		√	0	3	1	3	3	10	4	M
<ul style="list-style-type: none"> ▪ Hydrotest ▪ Facilities hook up at Tunu GCP and Dodo North Wells. 	Impairment of air quality by emissions of air pollutants including greenhouse gases		√	√		√		√		3	1	1	5	5	15	6	H
	Increase in employment opportunities	√		√		√		√		-	-	-	-	-	-	-	P

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
	Increased cash flow and stimulation of local economies within the communities	√		√		√		√		-	-	-	-	-	-	-	P
	Increased morbidity from pressure on existing social amenities/infrastructure		√	√		√		√		0	5	5	3	3	16	8	H
	Increased security risk and criminality (militants and pirates)		√	√		√		√		3	5	5	5	5	23	10	H
	Increased social vices and STIs including HIV		√		√		√	√	√	0	5	3	5	5	18	8	H
	Injuries/trauma and death from work-related accidents		√	√			√		√	3	5	3	5	5	21	8	H
	Interference with drainage pattern		√	√		√		√		0	1	1	3	3	8	4	M
	Interference with fishing and farming		√	√		√		√		0	3	5	5	5	18	10	H
	Interference with water transport		√	√		√		√		0	3	3	3	3	12	6	H
	Loss of biodiversity		√	√			√		√	3	1	1	5	3	13	6	M

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification						F+I	Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		
	Noise and vibration nuisance		√	√		√		√		3	1	3	1	3	11	4	M
	Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	P
	Radiation burns and sickness from exposure to radioactive emissions		√	√			√		√	3	5	3	5	1	17	8	H
	Third party agitation		√	√		√		√		3	1	1	5	5	15	6	H
	Wildlife habitat fragmentation		√	√			√	√		0	1	3	3	3	10	6	M

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Demobilization	Air, water and land pollution arising from improper disposal of cleared materials		√	√		√		√		3	3	3	3	3	15	6	H
	Impairment of air quality by emissions of air pollutants from vehicular movement		√	√		√		√		3	1	3	3	3	13	6	H
	Increase in noise and vibration level		√	√		√		√		3	1	3	3	3	13	6	H
	Increased opportunity for business and employment.	√		√		√		√		-	-	-	-	-	-	-	P
	Loss of employment/ income		√	√		√		√		3	1	5	5	5	19	10	H
	Marine/land accident resulting to injuries and fatality		√	√			√	√		3	5	3	5	5	21	8	H
	Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	P
	Pirates attack and hostage taking		√	√		√		√		3	5	5	5	5	23	10	H
	Third party agitation		√	√		√		√		3	1	1	5	5	15	6	H
Operations and Maintenance	Air pollution from gas flaring, venting, leakages and fire		√	√			√	√		3	3	3	3	3	15	6	H
	Environmental degradation from oil spills		√	√			√	√		3	5	3	5	5	21	8	H

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I		
	Environmental pollution arising from improper disposal of lubricants and oily debris		√	√		√		√		3	3	3	3	3	15	6	H	
	Equipment failure and damage leading to injuries/fatality		√	√		√		√		3	3	1	1	3	11	2	M	
	Noise from operational activities (equipment, water and air transport, pumps)		√	√		√		√		3	1	1	1	3	9	4	M	
	Sanitary and domestic wastes		√	√		√		√		3	3	3	3	3	15	6	H	
	Revenue generation to government and company	√		√				√	√	-	-	-	-	-	-	-	-	P
Decommissioning and Abandonment	Air pollution from emissions arising from leaks and trapped oils		√	√		√		√		3	1	3	3	1	11	6	H	
	Employment and income generating opportunity	√		√		√		√		-	-	-	-	-	-	-	-	P
	Job-related and traffic accidents resulting from removal of structures from site		√	√			√		√	3	5	3	5	5	21	8	H	
	Loss of job and project-related economic benefits		√	√		√		√		3	1	5	5	5	19	10	H	
	Opportunities for contracting	√		√		√		√		-	-	-	-	-	-	-	-	P
	Restoration of aesthetic value of the environment	√		√		√		√		-	-	-	-	-	-	-	-	P
	Third party agitation		√	√		√		√		3	1	1	5	5	15	6	H	

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Project Activities	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Soil contamination from excavation during removal of well heads		√	√		√		√		3	1	3	3	1	6	1 1	H
	Solid wastes from decommissioning activities		√	√		√		√		3	3	3	3	3	1 5	6	H
	Water contamination and soil degradation from effluents and excavation		√	√		√		√		3	1	3	1	1	9	4	M

Table 5.5b: Existing Impacts of the Tunu, Ogbotobo, Benisede and Opukushi Flowstations and Pipelines

Project Activity	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
OPERATION AND MAINTENANCE	Improvement in the air quality at Tunu, Ogbotobo, Benisede and Opukushi Flowstations	x	x	x			x	x									P
	High TPH of the soils around Tunu and Benisede flowstations despite concentrations occurring within DPR intervention limits		x	x			x	x		3	3	3	3	3	15	6	H
	Increased metal content in soils around Ogbotobo and Opukushi flowstations		x	x			x	x		3	3	3	3	3	15	6	H
	High TPH in sediments around Benisede and Opukushi		x	x			x	x		3	3	3	3	3	15	6	H
	High levels of Cu and Cr in groundwater in Tunu, and Opukushi fields and Zn and Cr in Benisede		x	x			x	x		3	3	3	3	3	15	6	H
	Increase in salinization (salt water intrusion) of surface and groundwater as a result of dredging and channelization		x	x			x		x	5	3	5	5	5	23	10	H
	Increase in salinization (salt water intrusion) of surface waters around Tunu, Ogbotobo, Benisede and Opukushi as a result of dredging and channelization		x	x			x		x	5	3	5	5	5	23	10	H
	Changes in species composition of phytoplankton and benthic macroinvertebrates due to salt water intrusion		x	x			x		x	0	1	1	1	1	4	2	L

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
	Succession changes in the plant cover due to dumping of dredge spoils along the shoreline and slots		x	x			x		x	0	5	5	5	5	20	10	H
	Increased levels of heavy metals in plant tissues especially plants far from direct sea influx		x	x			x		x	0	3	3	5	3	14	8	H
	Decrease in wildlife as a result of increased hunting and habitat loss		x	x			x	x		3	3	3	5	3	18	8	H
	Increased access to forest resources as a result of channelization and pipeline right of way (RoW), leading to deforestation		x	x			x		x	3	3	3	5	3	18	8	H
	Nominal increase in income of members of the community as a result of employment generating activities from oil and gas exploration	x		x			x	x									P
	Decrease in access to potable water as a result of salt water intrusion into the aquifer		x		x	x		x		0	3	3	5	5	16	8	H
	Increase in numbers and access to health facilities	x		x			x		x								P
	Decrease in child and maternal mortality	x		x		x		x									P
	Increase in non-communicable diseases		x		x		x	x		0	3	3	3	3	12	6	M
	Increase in levels of alcohol and cigarette consumption		x		x		x	x		0	3	5	3	3	14	6	M

Table 5.5c: Potential and Associated Impacts of the Proposed SSAGS+ Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
Pre-mobilization and Mobilization Phase • Land Acquisition • Land survey • RoW Clearance, Tree felling/De-stumping, Civil Works, and Facilities Construction site • Waste Disposal • Dredging/Sweeping/Piling • Piling • Dredging Waste Disposal	Loss of vegetation through cutting of line traces		x	x		x		x		3	1	1	1	1	7	2	M
	Increased erosion potential due to removal of vegetation canopies and road paving		x	x		x		x		5	3	3	3	1	15	6	H
	Loss of economic trees and ecologically important vegetation (mangroves and rain forests),		x	x		x		x		5	3	1	3	5	17	4	H
	Loss of habitats for wildlife.		x	x		x		x		5	1	3	1	3	13	4	M
	Loss of farmland, fishponds, gin distilleries and shines may result along the pipeline routes.		x	x		x		x		5	3	3	3	5	19		H
	Income to local	x		x		x		x		0	3	1	5	5	14		P

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	workers that may be employed for the bush clearing activities																
	Improved quality of life may result from increased project spending which will stimulate economic activity in the area.	x		x		x		x		0	3	1	5	5	14		P
	More infrastructures may be built or developed in the communities as part of the projects' CD initiatives.	x		x			x		x	0	3	1	5	5	14		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		H

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	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
	Accidents to workers will increase especially for local labour not sufficiently skilled for the type of work.		x	x		x		x		0	3	3	5	5	16	8	H
	Increased in suspended solids in water		x	x		x		x		3	5	3	5	3	19	8	H
	Discharge of faecal waste into the water will contaminate drinking water sources and increase water related disease (cholera etc).		x	x		x		x		5	5	3	5	3	21	8	H
	Shoreline erosion,		x	x		x		x		3	3	5	1	3	15	6	H
	Disturbance of riverbed		x	x		x		x		5	1	1	1	1	9	2	M

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating		
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total	
	topography and re-suspension of fine sediments and bottom materials																	
	Increased turbidity and suspended solids,		x	x		x		x		3	3	3	3	3	15	6	H	
	Disaggregation of benthic habitats and loss of benthic organisms.		x	x		x		x		3	1	3	3	1	11	6	M	
	Displacement of water by increased frequency of badge traffic may result in flooding of low lying communities.		x	x		x		x		3	1	1	3	3	11	4	M	
	Loss of juvenile fishes due to gill damage from silt particles.		x	x		x		x		3	3	1	5	5	17	6	H	
	Dredging improves circulation of water currents and transport	x		x		x		x		3	1	1	3	1	9	4	M	

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	of nutrients for marine life food chain.																
	Loss of buffer effects of shoreline vegetation may result from creek widening		x	x		x		x		3	3	3	5	3	17	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
	Acidification of the soil and surface water as a result of deposition of dredge spoils on the banks of the river		x	x			x	x		3	3	3	3	5	17	6	H
	Salt water intrusion (surface and ground water) as a result of dredging activities		x	x			x	x		3	3	3	3	5	17	6	H
	Water traffic disruption		x	x		x		x		3	3	3	3	5	17	6	H

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	with possible increase in marine accidents																
	Impairment of hearing due to noise and vibrations		x	x		x		x		3	1	1	3	3	11	4	M
	Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas		x	x			x	x		3	3	3	5	1	15	8	H
	Pollution of drinking water sources may occur if domestic waste is discharged directly into the river.		x	x		x		x		3	3	1	3	5	15	4	H
	Climate Extremes – Heavy rainfall and Lightning strikes; May increase safety hazards of the work. Delay in project schedule may increase		x	x		x		x		0	5	3	3	5	16	6	H

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	time of delivery and cost;																
	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
Construction Phase <ul style="list-style-type: none"> • Pipeline/ Bulkline Construction and Laying Optic Fibre Cable • Trenching/ Backfilling • Welding / NDT/ Coating/Wrapping • Hydrostatic Testing • River Crossing • Waste/Spoil Disposal • Communities electrification • Transportation of 	Emissions from internal combustion engines		x	x			x	x		3	1	1	3	1	9	4	M
	In tidal swamps, this will increase surface water sediment loading and suspended solids.		x	x		x		x		5	3	5	5	3	21	8	H
	Irreversible soil compaction which may alter the topography of the RoW.		x	x			x		x	5	1	1	1	1	9	8	M
	Salt water intrusion into ground water, through ELPS		x	x			x		x	3	3	1	3	5	15	8	H

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
<ul style="list-style-type: none"> Module/ Equipment • Water transportation • CPF Installation(AG Booster Compressor facility, AG Compression facility, Slug Catcher, Hydrocarbon Dew-Point facility,, Gas Compression and Metering System, Condensate Handling System), Power Generators FLB Construction • Welding • Installation, tie-in and pre-commissioning of facilities. • Unloading and installation of CPF/ Modules 	(hydraulic seepage around the circumference of the pipe)																
	Exposure to radioactivity and release of chemicals		x	x		x		x		3	3	3	3	5	17	6	H
	Impairment of vision		x	x		x		x		3	1	3	3	3	13	6	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
	Discharge of untreated test water into the receiving environment.		x	x		x		x		5	1	1	1	1	9	2	M
	Disaggregation of benthic habitats and loss of benthic organisms.		x	x		x		x		5	1	1	3	1	11	4	M
	Disturbance of riverbed		x	x		x		x		3	3	1	1	1	9	2	M

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	topography.																
	Shoreline erosion		x	x			x	x		3	3	3	3	3	15	6	H
	Improper disposal of backfill residue will alter the morphology of the area and impede drainage.		x	x		x		x		5	1	1	1	1	9	2	M
	Increased income to local workers	x		x		x		x		0	3	1	5	5	14	6	P
	Improved quality of life may result from increased project spend which will stimulate economic activity in the area.	x		x		x		x		0	3	1	5	5	14	6	P
	More infrastructures may be built or developed in the communities as part of the projects' CD initiatives.	x		x		x		x		0	3	1	5	5	14	6	P

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	Water related disease might increase due to poorer 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 (HIV AIDS) and other disease strains may result through migrant workers.		x	x		x		x		0	5	5	3	5	18	8	H
	Improve socio-economic activities	x		x		x		x		0	1	1	1	5	8	2	P
	The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small		x	x		x		x		0	5	3	3	5	16	6	H

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	canoes/boats and curtail fishing activities.																
	Welding activities will release toxic fumes.		x	x		x		x		3	3	3	1	3	13	4	M
	Contamination of water with paints and corrosion inhibitors.		x	x		x		x		3	3	1	3	1	11	4	M
	Leaks and spills of diesel fuel and lubricants into water.		x	x		x		x		3	3	1	1	3	11	2	M
	Potential leakage and spills of glycol during installation.		x	x		x		x		3	3	3	3	3	15	6	H
	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
Well Drilling & Completion	Accidents		x	x			x		x	3	5	3	5	5	21	8	H
	Contamination and		x	x		x	x	x	x	3	3	3	5	5	19	10	H

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
Slot sweeping Rig Move (including personnel, equipment and supplies logistics) Drilling Campaign	degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges																
Casing and cementing Completion and perforation	Continuous glare from rig operation		x	x			x	x		0	3	5	3	1	12	4	M
Well testing	Disruption of fish spawning sites		x	x			x	x		3	3	3	5	5	19	10	H
Flowline hook – up Site Demobilisation	Impairment of air quality by emissions of air pollutants including greenhouse gases		x	x		x		x		3	1	1	5	5	15	6	H
	Increase in employment opportunities	x		x		x		x		-	-	-	-	-	-	-	P
	Increased cash flow and stimulation of local economies within the communities	x		x		x		x		-	-	-	-	-	-	-	P

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	Increased morbidity from pressure on existing social amenities/infrastructure		x	x		x		x		0	5	5	3	3	16	8	H
	Increased security risk and criminality (militants and pirates)		x	x		x		x		3	5	5	5	5	23	10	H
	Increased social vices and STIs including HIV		x		x		x	x	x	0	5	3	5	5	18	8	H
	Injuries/trauma and death from blowouts		x	x			x		x	3	5	3	5	5	21	8	H
	Interference with fishing and farming		x	x		x		x		0	3	5	5	5	18	10	H
	Mental Stress from noise nuisance and sleep disturbance from glare		x		x	x		x		0	3	5	3	3	14	6	M
	Noise and vibration nuisance		x	x		x		x		3	1	3	1	3	11	4	M
	Opportunities for contracting	x		x		x		x		-	-	-	-	-	-	-	P

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	Third party agitation		x	x		x		x		3	1	1	5	5	15	6	H
Commissioning and Operation Phase • Commissioning and System Operation/ Maintenance • Pigging	Exhausts from gas turbines and the residual flaring during process upsets over the facility lifespan		x	x			x	x		3	1	5	3	5	17	8	H
	Air pollution from gas flaring, venting and leakage		x	x			x	x		3	5	3	3	3	17	6	H
	Contamination of soil as a result of oil spillage		x	x			x	x		3	3	3	3	3	15	6	H
	Effluent Discharges		x	x		x		x		3	1	5	3	5	17	8	H
	Discharge of untreated effluents from flowstations /CPF into water.		x	x		x		x		5	1	1	3	3	13	4	M
	Leaks and spills of TEG during storage,		x	x		x		x		3	3	1	5	3	15	6	H

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	handling and decanting.																
	Domestic wastewater and sewage disposal from the logistic centre.		x	x		x		x		3	3	1	5	3	15	6	H
	Domestic and industrial solids from the logistic centre.		x	x		x		x		5	1	3	3	3	15	6	H
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
	Reduction in adverse effect of flaring	x		x			x			3	1	1	3	3	11	4	P
	Alteration of vegetation pattern and disturbance of aesthetic		x	x		x		x		3	1	1	3	3	11	4	M

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	beauty of the original environment.																
	Contamination of surface water from large volumes of flush water produced during shut down		x	x		x		x		3	3	1	3	1	11	4	M
	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
	Poor aesthetic features from abandoned structures on site.		x	x		x		x		3	1	1	3	3	11	4	M

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	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
	Noise from operational activities (equipment, water & air transport, pumps)		x	x		x		x		3	3	3	3	5	17	6	H
DECOMMISSIONING AND ABANDONMENT •Cutting/Lifting •Waste Disposal •Restoration	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
	Poor aesthetic features from abandoned structures on site.		x	x		x		x		3	1	1	3	3	11	4	M

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Project Activity	Description of Impact	Impact Qualification								Impact Quantification					F+I	Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P			Total
	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

5.5 Cumulative Impacts

The cumulative impact is a combination of existing impacts (Tables 5.6) derived from operations and maintenance of the flowstations, manifolds and pipelines at Tunu, Benisede, Ogbotobo and Opukushi, the potential impacts from the slight modifications in the new SSAGSPlus Project (Table 5.7) and the potential and associated impacts derived from the Dodo North Project in of the whole SSAGS with that of the Dodo North Project (Table 5.5).

5.6: Description of Impacts

However this section provides a detailed description of the major and moderate negative impacts of the Dodo North the project is as follows:

Pre-Construction Phase

Air/Noise pollution from increased vehicular movement

The values of air quality measurements from this study were all within regulatory limits before commencement of the project. Marine transportation is known to produce obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM), and sulphur dioxide (SO₂). Greenhouse gases including carbon dioxide (CO₂) can also be emitted.

Encroachment on cultural, historical and ecological resources

Some culturally sensitive sites such as shrines and burial grounds are located in the mangrove forest and along the watercourses. The project activities have a high potential of encroaching on these culturally sensitive sites.

Erosion hazard arising from topographic changes

About 3 hectares of mangrove vegetation will be destroyed during project execution. This area of the mangrove will not regenerate and will be lost at least through the lifetime of the pipeline. This clearing of vegetation with excavation of soil would lead to change in topography and result in erosion in an area that is already prone to flooding and erosion. This impact was rated high.

Increase in employment opportunities

The site clearing will be done using both skilled and unskilled labour. Due to SPDC local content policy, this could create opportunity for employment, contracting and increase in income for the communities.

Increased morbidity from pressure on existing social amenities/infrastructure

The prevalence of selected diseases would increase as a result of pressure on available health services, housing and sanitation facilities due to population influx. Water-washed (water-impounded) diseases could result from shortage of potable water sources; water-borne diseases from faecal contamination of water sources due to inadequate sanitation facilities; and respiratory and skin disorders from over-crowding and poorly ventilated housing.

Increase in social vices and incidence of STIs including HIV

The increase in population and earnings arising from project execution could lead to social vices like violence, alcoholism, attraction of commercial sex workers (CSW), substance abuse, teenage pregnancies and increase in sexually transmissible diseases like STIs and HIV/AIDS.

Injuries/trauma and deaths

Site clearing is typically done using both heavy and light equipment such as dredgers, swamp buggies, bulldozers etc. In the process of the clearing there could be injuries and possibly fatality among the workforce.

Interference with drainage pattern

Pipeline construction activities could alter the topography and drainage pattern of the site, which could result in soil erosion and biodiversity of the site. This impact was described as negative, direct and was rated as medium.

Opportunities for contracting

The implementation of the various phases of the proposed project require contracting and also hiring of some members of host communities, as required by the law of the Federal Government of Nigeria. Thus a source of livelihood and meaningful engagement and the attendant diversion from idleness and social vices are of benefit and should be enhanced.

Opportunities to reuse waste such as firewoods

One of the major fallouts of site clearing either for construction or for maintenance of pipeline ROW is the generation of sizeable quantities of wood depending on the nature of the initial terrain. At tree stands of approximately 190 per ha in the area, site clearing is likely to generate at least 20-30 tons of fuel wood. Firewood for smoke drying of fish and other domestic purposes is a vital environmental resource for the local population, a segment of which, mainly the womenfolk, is devoted to collection and sale of firewood. Consistent with SPDC practice, any wood resulting from site clearance shall be released for the use of the communities will minor shrubs may be left to decompose and add unto soil fertility

Risk of water traffic accidents

Mobilization of equipment and personnel to site will involve the use of watercrafts. These routes are also used by the locals for intra-community. Increase in traffic volume during the mobilization phase may increase the chances of accidents.

Stimulation of local economies within the communities

Monetary compensation shall be paid for land acquired for this project. This is an opportunity for communities to enhance their income. This is a windfall income and there are chances that the money will be used for other income generating ventures. The influx of people and flurry of activities has the potential to increase buying and selling of consumer goods and lead to a boost in the local economy.

Third party/community agitation

There is usually community agitations over compensations paid for acquired land in the Niger Delta. The execution of this project is unlikely to be different. This was rated as negative and high impact.

Construction: Well Drilling and Completion

Accidents

Work-related accidents involving company personnel and contractor personnel have been reported over the years in the oil and gas industry and in Nigeria. This is regardless of the adoption and implementation of the best practice strategies in the oil and gas industry because of the mishaps and injuries are also based on human error. There is high potential for this to occur in the proposed project.

Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges

Drilling of oil wells is associated with large volumes of wastes including sanitary wastes and drill cuttings. Improper disposal of solid wastes and effluents can lead to groundwater contamination particularly considering the high water table in the project area.

Continuous glare from rig operation

Rig operation requires floodlight in the night. Continuous glare associated with rig operations has negative impact on wildlife leading to changes in their physiological and reproductive rhythms.

Disruption of fish spawning sites

Fishery activities could be disrupted during this phase of the project but also the known spawning sites of fishes could be disrupted by the proposed project, thereby affecting the fish catch per effort.

Impairment of air quality by emissions of air pollutants including greenhouse gases (GHG)

The values of air quality measurements from this study were all within regulatory limits before commencement of the project. Marine transportation is known to produce obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM), and sulphur dioxide (SO₂). Greenhouse gases including carbon dioxide (CO₂) can also be emitted.

Increase in employment opportunities

Drilling of the proposed well would require recruitment of field labour. Sixty percent of the unskilled labour will be from the locals in the project area according to the local content policy of the federal government. In addition, the influx of people to the project sites will provide opportunities for local businesses such as petty trading and provision of services to the field workers.

Increased cash flow and stimulation of local economies within the communities

The influx of people and flurry of activities has the potential to increase buying and selling of consumer goods and lead to a boost in the local economy.

Increased morbidity from pressure on existing social amenities/infrastructure

The prevalence of selected diseases would increase as a result of pressure on available health services, housing and sanitation facilities due to population influx. Water-washed (water-impounded) diseases could result from shortage of potable water sources; water-borne diseases from faecal contamination of water sources due to inadequate sanitation facilities; and respiratory and skin disorders from over-crowding and poorly ventilated housing. This impact was rated high.

Increased security risk and criminality (militants and pirates)

Attacks by pirates and armed bandits and kidnappings are among the major security concerns in the Niger Delta especially in the coastal communities. This often happens along the waterways and could be occur during this project. This was described as negative and was rated as high impact.

Increase in social vices and STIs including HIV

The increase in population and earnings arising from project execution could lead to social vices like violence, alcoholism, attraction of commercial sex workers (CSW), substance abuse, teenage pregnancies and increase in sexually transmissible diseases like STIs and HIV/AIDS.

Injuries/trauma and death from blowouts

System failures and human error during the drilling of the proposed well could result in blowouts, which could cause serious fatalities/injuries to the personnel and oil spills to the environment.

Interference with fishing and farming

Fishing and farming activities could be disrupted during this phase of the project. Fisheries activities that could be disrupted include trap setting, destruction of fishing gears, disturbance of water causing the migration of fish, thereby affecting the fish catch per effort.

Mental Stress from noise nuisance and sleep disturbance from glare

Noise and vibration could arise from rig movement, drilling, and the use of heavy equipment for such as pile drivers, dredgers, swamp buggies, bulldozers etc. could affect the workers, project communities and even wildlife. These can interfere with sleep causing insomnia leading to mental stress. Similarly continuous glare can also lead to insomnia resulting in mental stress.

Noise and vibration nuisance

The values of noise measurements from this study were all within regulatory limits before commencement of the project. Rig operation and drilling have potential for high noise

impact. This is likely to constitute serious nuisance to nearby communities and wildlife with greater effect in the night.

Opportunities for contracting

The implementation of the various phases of the proposed project require contracting and also hiring of some members of host communities, as required by the law of the Federal Government of Nigeria. Thus a source of livelihood and meaningful engagement and the attendant diversion from idleness and social vices are of benefit and should be enhanced.

Third party agitation

Third party agitation is common in major projects in the area. Such agitation may be associated with employment, contracts and environmental issues.

Construction: Flowline Design and Installation

Accidents

Work-related accidents involving company personnel and contractor personnel have been reported over the years in the oil and gas industry and in Nigeria. This is regardless of the adoption and implementation of the best practice strategies in the oil and gas industry because of the mishaps and injuries are also based on human error. There is high potential for this to occur in the proposed project.

Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids and effluent discharges

Dredged spoils and dredged spoil leachates, solids and effluents could contaminate the soil, surface and groundwater especially during pipeline/flow line construction activities. The groundwater in the project area could be vulnerable because of the sandy texture of the soil formation and the high level of the groundwater almost all year round. This impact was described as negative, direct, which could either be reversible or irreversible and was rated as major.

Disruption of fish spawning sites

Site construction activities could disrupt fish spawning sites particularly flowline and pipeline construction. Oil well access dredging, pipeline ditching and back filling activities could damage and smother juveniles. This impact was described as negative, direct and irreversible and was rated major.

Encroachment on cultural, historical and ecological resources

Some culturally sensitive sites such as shrines and burial grounds are located in the mangrove forest and along the watercourses. The project activities have a high potential of encroaching on these culturally sensitive sites.

Erosion hazard due to construction impediments to natural drainage

Pipeline ditching and back filling activities could alter the topography of the project area, which could impede natural drainage especially in the wetland ecosystem of the project area. This impact was described as negative, direct and was rated moderate.

Impairment of air quality by emissions of air pollutants including greenhouse gases (GHG)

The values of air quality measurements from this study were all within regulatory limits before commencement of the project. Use of heavy equipment during pipeline construction is known to produce obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM), and sulphur dioxide (SO₂). Greenhouse gases including carbon dioxide (CO₂) can also be emitted.

Increase in employment opportunities

Pipeline laying for the proposed project would require recruitment of field labour. Sixty percent of the unskilled labour will be from the locals in the project area according to the local content policy of the federal government. In addition, the influx of people to the project sites will provide opportunities for local businesses such as petty trading and provision of services to the field workers.

Increased cash flow and stimulation of local economies within the communities

The influx of people and flurry of activities has the potential to increase buying and selling of consumer goods and lead to a boost in the local economy. This impact was described as direct, and rated as positive.

Increased morbidity from pressure on existing social amenities/infrastructure

The prevalence of selected diseases would increase as a result of pressure on available health services, housing and sanitation facilities due to population influx. Water-washed (water-impounded) diseases could result from shortage of potable water sources; water-borne diseases from faecal contamination of water sources due to inadequate sanitation facilities; and respiratory and skin disorders from over-crowding and poorly ventilated housing. This impact was rated high.

Increased security risk and criminality (militants and pirates)

Attacks by pirates and armed bandits and kidnappings are among the major security concerns in the Niger Delta especially in the coastal communities. This often happens along the waterways and could be occur during this project. This was described as negative and was rated as high impact.

Increase in social vices and incidence of STIs including HIV

This could result from increase in social vices and risky sexual behaviour due to the improvement in the local economy and/or due to the influx of migrant population or so-called “camp followers”. This impact was rated high.

Injuries and death from blowouts

System failures and human error during the drilling of the proposed well could result in blowouts, which could cause serious fatalities/injuries to the personnel and oil spills to the environment. It is however a rare occurrence in the oil and gas industry in Nigeria.

Interference with drainage pattern during construction and pipeline laying

Pipeline construction activities particularly ditching and backing filling could alter the topography and drainage pattern of the site, which could result in soil erosion and biodiversity of the site. This impact was described as negative, direct and was rated as medium.

Interference with fishing and farming

Pipeline/flowline construction activities could interfere with fishing and farming activities. Such interference could have socio-economic implications. Hence the impact was described as negative, direct, reversible and was rated major.

Mental Stress from noise nuisance and sleep disturbance from glare

Noise and vibration arising from the use of heavy equipment for site excavation such as dredgers, swamp buggies, bulldozers etc. could affect the workers, project communities and even wildlife. These can interfere with sleep causing insomnia leading to mental stress. Similarly continuous glare can also lead to insomnia resulting in mental stress.

Noise and vibration nuisance

The values of noise measurements from this study were all within regulatory limits before commencement of the project. The operation of a rig is associated with potential for high noise impact. This is likely to constitute serious nuisance to nearby communities and wildlife with greater effect in the night.

Opportunities for contracting

Pipeline and flow line construction activities could require contracting and also hiring of some members of host communities, as required by the law of the Federal Government of Nigeria. Thus a source of livelihood and meaningful engagement and the attendant diversion from idleness and social vices are of benefit and should be enhanced. This impact was rated as positive.

Radiation burns and sickness from exposure to radioactive emissions

The integrity of the welded pipeline joints will be checked visually and by radiography. Radioactive materials emitted during radiography could burns for the worker, with possibility of radiation sickness in the long run. The impact was described as direct, negative, long term, irreversible and rated medium.

Third party agitation

Third party agitation is common in major projects in the area. Such agitation may be associated with employment, contracts and environmental issues.

Demobilization Phase

Air, water and land pollution arising from improper disposal of cleared materials

A large quantity of waste and other disposables are expected at the demobilization phase of the rig. Improper disposal of the wastes and cleared materials may lead to environmental degradation and community agitation/conflicts.

Impairment of air quality by emissions of air pollutants The values of air quality measurements from this study were all within regulatory limits before commencement of the project. Rig demobilization and associated transportation may emit obnoxious gases that could lead to atmospheric pollution. Some of these air pollutants are carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM), and sulphur dioxide (SO₂). Greenhouse gases including carbon dioxide (CO₂) can also be emitted.

Increase in Noise and vibration level

The values of noise measurements from this study were all within regulatory limits before commencement of the project. The demobilization and transportation of a rig may lead to high noise impact. This is likely to constitute serious nuisance to nearby communities and wildlife with greater effect in the night.

Increased opportunity for business and employment

Demobilization of the rig would require recruitment of skill and unskilled labour. Sixty percent of the unskilled labour should be from the locals in the project area according to the local content policy of the federal government. Evacuation of waste and other cleared materials from site will also provide opportunities for local businesses.

Loss of employment/ income

The demobilization of the rig at the end of the drilling phase will bring about loss of job for the project workers particularly the unskilled labour force. This will translate to loss in income and business opportunities.

Marine/land accident resulting to injuries and fatality

Accidents are common in most major roads in the project area. Increase in traffic volume during the mobilization phase may increase the chances of marine accident.

Opportunity for contracting

There shall be loss of employment/income associated with demobilization. On the other hand, this activity could bring opportunity for business and employment. There could be payoffs. Business opportunities and employment could arise during movement of materials and personnel. Hence, the impact was described and rated as positive.

Pirates attack and hostage taking

Attacks by pirates and armed bandits and kidnappings are among the major security concerns in the Niger Delta especially in the coastal communities. This often happens along the waterways and could occur during this project. This was described as negative and was rated as high impact.

Third party agitation

Third party agitation can arise from employment issues and loss of benefits within the pipeline project communities. This impact was described as negative, direct, short-term, and reversible and was rated high impact.

Operations and Maintenance

In the course of operation of the Dodo North NAG wells and associated flowlines, certain impacts could occur. These are described below;

Air pollution from gas flaring, venting and leakages

Air pollution could arise from gas flaring, venting and leakages during operations of the wells and associated pipeline. This impact was described as negative, direct and was rated major.

Environmental pollution arising from improper disposal of lubricants and oily debris

Measurements of oil and grease in the present study were generally low in all environmental media. Lubricants and oily wastes are associated with maintenance operations on wellheads and associated facilities. Improper management and disposal of oily wastes and lubricants can lead to serious environmental degradation.

Environmental pollution arising from improper disposal of lubricants and oily debris

Lubricants are routinely used in industrial machineries. Environmental pollution could arise from the use and disposal of lubricants and oily debris. This impact was described as negative, direct and was rated major.

Equipment failure and damage leading to injuries/fatality

System failure and human errors during operation could result in serious injuries or fatality.

Noise from operational activities (equipment, water and air transport, pumps)

Noise could be generated during routine operational activities such as transportation (water, road and air modes), equipment operations (pumps, generators) and other human activities. This impact was described as negative, direct and was rated moderate.

Sanitary and domestic wastes

Sewage and other sanitary wastes could be generated during the operations of Dodo North NAG wells. Sanitary wastes are typically generated from accommodation and site offices. Sanitary wastes if not appropriately handled could cause pollution of the environment, nuisance odours, poor aesthetics and transmission of diseases. This impact was described as negative, direct and was rated major.

Revenue generation to government and company

A substantial proportion of government revenue derives from oil sales. Sale of oil derived from the project will contribute to oil revenue to the company and federal government.

Decommissioning and Abandonment

Air pollution from emissions arising from leaks and trapped oils

Air pollution could arise from the decommissioning and abandonment of NAG facilities. Oil and grease, lubricants and condensates could contaminate the environment. This impact was described as negative, direct, reversible and was rated moderate.

Employment and income generating opportunity

Decommissioning would require employment of labour (both skilled and unskilled) most of whom will be from the project area. Payments for such labour are a good source of income to persons who might be employed.

Job-related and traffic accidents resulting from removal of structures from site

These would result from traffic-related accidents due to the increase in vehicular movements, and also work-related accidents. This impact was rated high.

Loss of job and project-related economic benefits

The end of the project will bring about loss of job for the project workers. This will translate to loss in income and business opportunities.

Opportunities for contracting

Site rehabilitation could demand for employment of labour (both skilled and unskilled). Payments for such labour are a good source of income to persons who might be employed. The impact was described as positive.

Restoration of aesthetic value of the environment

Proper restoration of the environment will improve the aesthetic and agricultural value of the environment.

Third party agitation

Third party agitation can arise from employment issues and loss of benefits within the pipeline project communities. This impact was described as negative, direct, short-term, and reversible and was rated major impact.

Solid wastes from decommissioning activities

Large amount of solid wastes could be generated from decommissioning and abandonment operations. If the wastes are not well managed, they could pollute the environment. This impact was described as negative, direct, short-term, and reversible and was rated major impact.

Water contamination and soil degradation from effluents and excavation

Sediment disturbance during pipeline decommissioning could increase the turbidity of the water over a stretch of the river thereby impairing its quality and rendering it unsuitable as a source of household water. High turbidity can cause potential problems for both aquatic flora, which depend on light transmission through the water column for growth, and fauna which feed on the submerged vegetation.

CHAPTER SIX MITIGATION MEASURES

6.1: Introduction

The actions and measures that SPDC intend to take to reduce (or eliminate) significant negative impacts and promote positive Environmental, Social and Health impacts of the proposed project are presented in this chapter. These actions and measures are aimed at reducing the impacts to As Low As Reasonably Possible (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of Health, Safety and Environment (HSE) plans put in place during the different phases of the project.

The mitigation measures proposed are in keeping with the following:

- Department of Petroleum Resources guidelines and standards,
- Environmental laws at national, regional and internal levels,
- FMEEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management.
- Bayelsa State Ministry of Environment policies,
- Best Available Technology for Sustainable Development;
- Social wellbeing and
- Concerns of stakeholders.

The following criteria were used to define mitigation measures for the identified associated and potential impacts:

Prevention - Exclude significant potential impacts and risks by design and management measures.

Reduction - Minimise the effects or consequences of those significant associated and potential impacts that cannot be prevented to a level as low as reasonably possible by implementing operational and management measures.

Control - Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practical.

6.2: Mitigation Measures

A summary of the mitigation measures is presented In Table 6.1, 6.2 and 6.3. Table 6.1 addresses the mitigation measures for the Dodo North Project. Tables 6.2 and 6.3 addresses mitigation measures for the existing impacts of the SSAGs and the potential and associated impacts of the SSAGS Plus Project since they are all linked together. These measures are recommended to ameliorate all the significant associated and potential impacts identified for the proposed project.

Table 6.1: Impact Mitigation Measures for Proposed Dodo North NAG Wells Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
PRE-CONSTRUCTION	Air(VOCs and BTEX Compounds) /Noise pollution from increased vehicular movement	H	SPDC shall: use only pre-mobbed and regularly maintained vehicles SPDC shall enforce the use of appropriate PPEs. SPDC shall provide radiation counter to workers for monitoring individual radiation levels. SPDC shall ensure that the activity is carried out in accordance with standard procedures.	L
<ul style="list-style-type: none"> ▪ Land Acquisition ▪ Site survey ▪ Pre-Mobilization ▪ /Mobilization ▪ Site clearing ▪ Location preparation 	Encroachment on cultural, historical and sensitive ecological areas	M	SPDC shall <ul style="list-style-type: none"> • minimize movement into these sites and respect sacred and historical sites • limits land takes to sites that are necessary • SPDC shall limit clearing and all earth digging activities to necessary areas. • SPDC shall carry out re-vegetation of cleared area 	L
	Erosion hazard arising from topographic changes	M	<ul style="list-style-type: none"> • SPDC shall limit clearing and all earth digging activities to necessary areas. • SPDC shall carry out the re-vegetation of cleared area 	L
	Increase in employment opportunities	P	SPDC shall ensure adherence to local content policy	P
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P
	Increased morbidity from pressure on existing social amenities/infrastructure	M	SPDC shall ensure: <ul style="list-style-type: none"> • Alternative recreational facilities shall be provided at camp sites 	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			<ul style="list-style-type: none"> • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: <ul style="list-style-type: none"> • Awareness campaign and health education. • Implementation of SPDC Alcohol and Drug Policy for work personnel 	M
	Injuries/trauma and death	H	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • high quality chemicals and materials are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards • provide On-site/Referral health care (including MEDEVAC) 	M
	Opportunities for contracting	P	SPDC shall ensure adherence to local content policy	P
	Opportunity to re-use wastes such as firewood	P	SPDC shall ensure that all the trees fell be gathered and make accessible to the communities	P
	Risk of marine traffic accidents	H	SPDC shall ensure <ul style="list-style-type: none"> • compliance with SPDC journey management policy for marine transport • Only pre-mobbed vehicles are used • daily pep talk is carried out for marine transportation • all drivers undertake defensive driving training and are certified • vehicle monitoring and communication devices are installed 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			and tracked	
	Stimulation of local economy and markets from increased demand for food, and other products in the local market	P	SPDC shall: Introduce and encourage programmes for skills acquisition, and for money savings schemes	P
	Third party/community agitation	H	SPDC shall <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoU programmes and projects. • identify and address legacy issues 	M
CONSTRUCTION ▪ Well Drilling and Completion	Accidents	H	SPDC shall: <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be condoned off as restricted areas with ample warning signals 	M
	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges	H	SPDC shall <ul style="list-style-type: none"> • treat all effluents to regulatory limits before discharging into the environment. • Dispose all waste in line with regulatory approval 	M
	Continuous glare from rig operation	M	No mitigation measure	M
	Disruption of fish spawning sites	H	SPDC shall ensure: Timing of activities to avoid known spawning seasons	M
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Increase in employment opportunities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	P
	Increased morbidity from pressure on existing social amenities/infrastructure	H	SPDC shall ensure: <ul style="list-style-type: none"> • Alternative recreational facilities shall be provided at camp sites • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	M
	Increased security risk and criminality (militants and pirates)	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. • ensure staff are sensitized on the peculiarity of the project environment 	M
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: awareness campaign and health education.	M
	Injuries/trauma and death from blowouts and work-related accidents	H	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • high quality chemicals and materials are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards • provide On-site/Referral health care (including MEDEVAC) 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Interference with fishing and farming	H	SPDC shall <ul style="list-style-type: none"> • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear • issue timely information to stakeholders particularly fisherfolks on nature and timing of activities • carry out the movement in phases to avoid prolonged interruption of fishing activities • schedule project activities to minimize disruption of fisheries activities. 	M
	Mental Stress from noise nuisance and sleep disturbance from glare	M	SPDC shall ensure: <ul style="list-style-type: none"> • machines are tuned off when not in use • ensure combustion engines are fitted with effective silencers. • ensure regular maintenance of machines. • machinery covers and panels are closed and well fitted at all times • equipment with low noise level are used • implementation of 'No Night Work' Policy 	L
	Noise and vibration nuisance	M	SPDC shall: <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • generators are fitted with effective silencers • provide adequate enclosures for noise producing equipment • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Third party agitation	H	SPDC shall: <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoU programmes and projects. • identify and address legacy issues 	M
CONSTRUCTION Flowline Design and Installation	Accidents	H	SPDC shall: <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be cordoned off as restricted areas with ample warning signals 	M
	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solid wastes and effluent discharges	H	SPDC shall <ul style="list-style-type: none"> • treat all effluents to regulatory limits before discharging into the environment. • Dispose all waste in line with regulatory approval • Proper flowline insulation 	M
	Loss of contained gas and to avoid vapour and gas explosion	M	SPDC shall ensure best engineering of pipeline design, construction and installation. Design to incorporate auto leak detection for pipelines. Proper flowline insulation SPDC shall establish effective gas leak monitoring programme for the pipelines	L
	Disruption of fish spawning sites	H	SPDC shall ensure: Timing of activities to avoid known spawning seasons	M
	Encroachment on cultural, historical and sensitive ecological zones such as	H	SPDC shall <ul style="list-style-type: none"> • minimize movement into these sites and respect sacred and 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	mangrove		historical sites • limit land takes to sites that are necessary	
	Reduction in species diversity population	H	SPDC shall • minimize movement into these sites and respect sacred and historical sites • limit land takes to sites that are necessary	M
	Habitat depletion or fragmentation and disruption in food chains	H	SPDC shall • minimize movement into these sites and respect sacred and historical sites • limit land takes to sites that are necessary	M
	Erosion hazard due to construction impediments to natural drainage	H	• SPDC shall limit clearing and all earth digging activities to necessary areas. • SPDC shall carry out the re-vegetation of cleared area • HSE plans shall be drawn before activities are carried out to ensure that construction activities are carried out in a manner that is least intrusive to the environment.	M
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	M
	Increase in employment opportunities	P	SPDC shall • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management	P
	Increase morbidity from pressure on existing social amenities/infrastructure	H	SPDC shall ensure: • Alternative recreational facilities shall be provided at camp	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			sites <ul style="list-style-type: none"> • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	P
	Increased security risk and criminality (militants and pirates)	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. • ensure staff are sensitized on the peculiarity of the project environment 	M
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: awareness campaign and health education.	M
	Injuries/trauma and death from blowouts and work-related accidents	H	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • high quality chemicals and materials are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards • provide On-site/Referral health care (including MEDEVAC) 	M
	Interference with drainage pattern	M	SPDC shall ensure appropriate engineering design for all facilities	L
	Interference with fishing and farming	H	SPDC shall <ul style="list-style-type: none"> • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear • issue timely information to stakeholders particularly fisherfolks on nature and timing of activities 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			<ul style="list-style-type: none"> • carry out the movement in phases to avoid prolonged interruption of fishing activities • schedule project activities to minimize disruption of fisheries activities. 	
	Interference with water transport	H	SPDC shall <ul style="list-style-type: none"> • ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear • issue timely information to stakeholders particularly fisherfolks on nature and timing of activities • carry out the movement in phases to avoid prolonged interruption of fishing activities • schedule project activities to minimize disruption of fisheries activities. 	L
	Loss of biodiversity	M	SPDC shall: Ensure regular compliance monitoring Enlightenment campaigns against hunting and poaching and the support of biodiversity campaigns by Government and SPDC	L
	Mental Stress from noise nuisance and sleep disturbance from glare	M	SPDC shall ensure: <ul style="list-style-type: none"> • machines are tuned off when not in use • ensure combustion engines are fitted with effective silencers. • ensure regular maintenance of machines. • machinery covers and panels are closed and well fitted at all times • equipment with low noise level are used • implementation of 'No Night Work' Policy 	L
	Noise and vibration nuisance	M	SPDC shall: <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment 	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			and vehicles <ul style="list-style-type: none"> • generators are fitted with effective silencers • provide adequate enclosures for noise producing equipment • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P
	Third party agitation	H	SPDC shall: <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoU programmes and projects. • identify and address legacy issues 	M
	Wildlife habitat fragmentation	M	SPDC shall minimize movement into these sites and respect sacred and historical sites limits land takes to sites that are necessary	L
Demobilization	Air, water and land pollution arising from improper disposal of cleared materials	M	SPDC shall ensure <ul style="list-style-type: none"> • all wastes are properly segregated before disposal • all cleared wastes are properly disposed of and monitored from cradle to grave 	L
	Impairment of air quality by emissions of air pollutants from vehicular movement	M	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Increase in noise and vibration level	M	SPDC shall <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L
	Increased opportunity for business and employment.	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P
	Loss of employment/ income	H	SPDC shall support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities.	M
	Marine/land accident resulting to injuries and fatality	H	SPDC shall ensure <ul style="list-style-type: none"> • compliance with SPDC journey management policy for marine transport • Only pre-mobbed vehicles are used • daily pep talk is carried out for marine transportation • all drivers undertake defensive driving training and are certified • vehicle monitoring and communication devices are installed and tracked 	M
	Opportunities for contracting	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy 	P

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Pirates attack and hostage taking	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. • ensure staff are sensitized on the peculiarity of the project environment 	M
	Third party agitation	H	SPDC shall <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoU programmes and projects. • identify and address legacy issues 	M
Operations and Maintenance	Air pollution from gas flaring, venting, leakage and fire	M	SPDC shall <ul style="list-style-type: none"> • use only pre-mobbed equipment. • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • Minimize routine gas venting and flaring • Install scrubbers in their flare stacks 	L
	Environmental pollution arising from improper disposal of lubricants and oily debris	H	SPDC shall ensure <ul style="list-style-type: none"> • all oily wastes are properly segregated and contained before disposal • all oily wastes are properly disposed of and monitored from cradle to grave • Hazardous wastes such as drill cuttings and spent drilling fluids will be transported to Thermal Destruction Unit at Onne Rivers state • Well of cuts will be assembled and transported to SPDC Scrap yard in Port Harcourt 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Equipment failure and damage leading to injuries/fatality	M	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards 	L
	Noise from operational activities (equipment, water & air transport, pumps)	M	SPDC shall <ul style="list-style-type: none"> • Use equipment with low noise level • Use of appropriate PPE such as ear muff • Install acoustic muffler to equipment with high noise level • Regular compliance monitoring • Ensure safe distance to the equipment 	L
	Sanitary and domestic wastes	H	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy to the environment • Sanitary wastes on houseboats shall be treated to achieve regulatory limits before been discharged by approved vendors • Waste shall be trucked by approved vendors to approved Government dump sites 	M
Decommissioning and Abandonment	Air pollution from emissions arising from leaks and trapped oils	M	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy • Contentment of trapped oil and send same to Forcados terminal for treatment/recovery • Regular compliance monitoring 	L
	Employment and income generating opportunity	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition 	P

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			and personal financial management	
	Job-related and traffic accidents resulting from removal of structures from site	H	SPDC shall <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be cordoned off as restricted areas with ample warning signals • ensure that health talks and awareness and job hazard analysis are carried out prior to work activities 	M
	Loss of job and project-related economic benefits	H	SPDC shall support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities.	M
	Opportunities for contracting	P	SPDC shall ensure adherence to local content policy	P
	Restoration of aesthetic value of the environment	P	SPDC shall ensure adequate remediation of all impacted areas	P
	Soil contamination from excavation during removal of well heads	M	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy • Contentment of trapped oil and send same to Forcados terminal for treatment/recovery • Regular compliance monitoring 	L
	Solid wastes from decommissioning activities	H	SPDC waste management policy shall be enforced; SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy • Waste shall be trucked by approved vendors to approved discharge points 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			<ul style="list-style-type: none"> Regular compliance monitoring 	
	Third party agitation	H	SPDC shall <ul style="list-style-type: none"> ensure effective consultation with stakeholders ensure commitment and transparent adherence to GMoU programmes and projects. identify and address legacy issues 	M
	Water contamination and soil degradation from effluents and excavation	M	SPDC shall <ul style="list-style-type: none"> Maintain zero discharge policy Contentment of trapped oil and send same to Forcados terminal for treatment/recovery Regular compliance monitoring 	L

Table 6.2: Summary of Existing Impacts and Mitigation Measures

Project Activity	Description of Impact	Rating before Mitigation	Mitigation Measure	Rating after Mitigation
Operation of flowstations, manifolds and pipelines	Improvement in the air quality at Tunu, Ogbotobo, Benisede and Opukushi Flowstations	P	Positive	P
	High TPH of the soils around Tunu and Benisede flowstations despite concentrations occurring within DPR intervention limits	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M
	Increased metal content in soils around Ogbotobo and Opukushi flowstations	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M
	High TPH in sediments around Benisede and Opukushi	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M

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High levels of Cu and Cr in groundwater in Tunu, and Opukushi fields and Zn and Cr in Benisede	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M
Increase in Stalination (salt water intrusion) of surface and groundwater as a result of dredging and channelization	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M
Increase in Stalination (salt water intrusion) of surface waters around Tunu, Ogbotobo, Benisede and Opukushi as a result of dredging and channelization	H	Limit channelization to as low as possible	M
Succession changes in the plant cover due to dumping of dredge spoils along the shoreline and slots	H	Re-use of dredge spoil for reclamation purposes	L
Increased levels of heavy metals in plant tissues especially plants far from direct sea influx	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes and Remediation (bioremediation) of	M
Decrease in wildlife as a result of increased hunting and habitat loss	H	Limit land take to RoW Increase surveillance to reduce poaching and lumbering activities Create alternative source of income generation	L
Increased access to forest resources as a result of channelization and pipeline right of way (RoW), leading to deforestation	H	Limit land take to RoW Increase surveillance to reduce poaching and lumbering activities Create alternative source of income generation	L
Nominal increase in income of members of the community as a result of employment generating activities from oil and gas exploration	P	Positive Impact	P
Decrease in access to potable water as a result of salt water intrusion into the aquifer	H	Proactive engagement with communities Implementation of PGMoU	M
Increase in numbers and access to health facilities	P	Positive Impact	P
Decrease in child and maternal mortality	P	Positive Impact	P

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	Increase in non-communicable diseases	M	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.	L
	Increase in levels of alcohol and cigarette consumption	M	Step-up health education and sensitisation activities prior commencing construction activities	L

Table 6.3: 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 Security Policy	L
Pre-mobilization and Mobilization Phase <ul style="list-style-type: none"> Land Acquisition Land survey 	Increased erosion potential due to removal of vegetation canopies and road paving	H	<ul style="list-style-type: none"> 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

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
<ul style="list-style-type: none"> • RoW Clearance, Tree felling/De-stumping, Civil Works, and Facilities Construction site • Waste Disposal • Dredging/ Sweeping/Piling • Piling • Dredging Waste Disposal 				
	Loss of economic trees and ecologically important vegetation (mangroves and rain forests),	H	<ul style="list-style-type: none"> • SPDC shall minimise land-take as much as practicable • SPDC shall pay adequate compensation for loss economic trees/plants 	L
	Loss of habitats for wildlife.	M	<ul style="list-style-type: none"> • SPDC shall not cut down timber-size trees greater than 60 cm girth, as they are protected by law. • Site preparation land shall be limited. • Low-noise equipment shall be used. • Habitat loss shall be limited as much as practicable 	L
	Loss of farmland, fishponds, gin distilleries and shines may result along the pipeline routes.	H	<ul style="list-style-type: none"> • SPDC shall pay compensation for loss of income to those affected. • SPDC shall pay adequate compensation for lost economic trees/plants. • Site preparation land shall be limited. • Low-noise equipment shall be used. • Habitat loss shall be limited as much as practicable 	L
	Income to local workers that may be employed for the bush clearing activities	P	N/A (impact is beneficial)	P
	Improved quality of life may result from increased project spending which will stimulate economic activity in the area.	P	N/A (impact is beneficial)	P
	More infrastructures may be built or developed in the communities as part of the projects' CD initiatives.	p	N/A (impact is beneficial)	
	Communicable disease may increase due to poor sanitation practices when more pressure is put on already poor state of housing.	H	<ul style="list-style-type: none"> • SPDC shall Step-up health education and sensitisation activities prior commencing construction activities and support condom donation initiatives. • SPDC shall organise awareness session on 	M

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			communicable diseases related to water and sexual behaviour. <ul style="list-style-type: none"> • SPDC shall Step-up HIV/AIDS awareness programmes. • SPDC shall 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 and other disease strains may result through migrant workers.	H	<ul style="list-style-type: none"> • 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
	Accidents to workers will increase especially for local labour not sufficiently skilled for the type of work.	H	<ul style="list-style-type: none"> • 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 faecal waste into the water will contaminate drinking water sources and increase water related disease (cholera etc).	H	SPDC shall: <ul style="list-style-type: none"> • Treat all waste water to DPR standards prior disposal • Provide 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
	Shoreline erosion,	H	<ul style="list-style-type: none"> • SPDC shall carry-out shore protection in areas susceptible to shoreline erosion. 	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			<ul style="list-style-type: none"> SPDC shall use sheet piling of the area affected. 	
	Disturbance of riverbed topography and re-suspension of fine sediments and bottom materials	M	SPDC shall use the best available technology (suction dredging) to minimize disturbance to riverbed topography	L
	Increased turbidity and suspended solids,	H	SPDC shall deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	L
	Displacement of water by increased frequency of barge traffic may result in flooding of low lying communities.	M	Adherence to journey management guidelines and sensitization of boat captains	M
	Loss of juvenile fishes due to gill damage from silt particles.	H	Use of appropriate technology (suction dredging) and silt curtain to reduce turbidity	L
	Dredging improves circulation of water currents and transport of nutrients for marine life food chain.	P	Positive impact	P
	Loss of buffer effects of shoreline vegetation may result from creek widening	H	SPDC shall Limit widening of creek or any other creeks and rivers to be used for Barge movement,, to a width that will cause minimal shoreline erosion	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
	Acidification of the soil and surface water as a result of deposition of dredge spoils on the banks of the river	H	SPDC shall ensure dredge spoil is deposited at least 10 metres into the buffer zone or Cap spoil with clean sand.	L
	Salt water intrusion (surface and ground water) as a result of dredging activities	H	<ul style="list-style-type: none"> SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach. SPDC shall ensure the use of shore protection techniques 	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			to achieve rapid stability of the excavated area for the shore approach area after the installation of offshore section of pipeline	
	Water traffic disruption with possible increase in marine accidents	H	<ul style="list-style-type: none"> 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
	Impairment of hearing due to noise and vibrations	M	SPDC shall enforce the use of appropriate PPE	L
	Spoil disposal will smother epifauna and impair surface drainage especially in wetland areas	H	SPDC shall dispose dredge spoils in an environmentally-friendly manner	L
	Pollution of drinking water sources may occur if domestic waste is discharged directly into the river.	H	SPDC shall adopt dredging technology that minimises re-suspension of sediments, such as Silt Curtains	L
Construction Phase <ul style="list-style-type: none"> Pipeline/ Bulkline Construction and Laying Optic Fibre Cable Trenching/ Backfilling Welding / NDT/ Coating/Wrapping Hydrostatic Testing River Crossing Waste/Spoil Disposal 	In tidal swamps, this will increase surface water sediment loading and suspended solids.	H	SPDC shall deploy the most appropriate technology, to minimize loss of benthic organisms.	L
	Irreversible soil compaction which may alter the topography of the RoW.	M	SPDC shall use low pressure tracked equipment for construction	L
	Salt water intrusion into ground water, by hydraulic seepage around the circumference of the pipe	H	<ul style="list-style-type: none"> SPDC shall ensure no hydraulic connection between the sea and the coastal forest by using cofferdams and sheet piling for the shoreline approach, <p>The use of shore protection techniques to achieve rapid</p>	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
<ul style="list-style-type: none"> • Communities electrification • Transportation of Module/ Equipment • Water transportation • CPF Installation(AG Booster Compressor facility, AG Compression facility, Slug Catcher, Hydrocarbon Dew-Point facility,, Gas Compression and Metering System, Condensate Handling System), Power Generators FLB Construction • Welding • Installation, tie-in and pre-commissioning of facilities. • Unloading and installation of CPF/ Modules • 			stability of the excavated area for the shore approach area after the installation of offshore section of pipeline.	
	Exposure to radioactivity and release of chemicals	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
	Impairment of vision from arc welding	M	SPDC shall enforce the use of appropriate PPE.	L
	Improper disposal of lay barge deck drainage will contaminate surface water and sediment.	M	SPDC shall ensure that effluents and solid wastes are collected for off-site disposal	L
	Discharge of untreated test water into the receiving environment.	M	SPDC waste management specifications and guidelines (especially with regards to the discharges into the environment) shall be complied with.	L
	Disaggregation of benthic habitats and loss of benthic organisms.	M	SPDC shall adopt due diligence to minimize adverse impacts on benthic organisms	L
	Disturbance of riverbed topography.	M	SPDC shall ensure minimal disturbance to the river bed during pipeline crossing.	L
	Shoreline erosion	H	SPDC shall carry-out shore protection in areas susceptible to shoreline erosion	L
	Improper disposal of backfill residue will alter the morphology of the area and impede drainage.	M	SPDC shall ensure that no soil mounds are left after back-filling	L
	Increased income to local workers	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	
Improved quality of life may result from increased project spend which will stimulate economic activity in	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management		

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	the area.			
	More infrastructures may be built or developed in the communities as part of the projects' CD initiatives.	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	
	Water related disease might increase due to poorer sanitation practices when more pressure is put on already poor state of housing.	H	SPDC shall strengthen health education programs. and improve healthcare institutions	L
	Increase in cases of sexually transmitted disease (HIV AIDS)and other disease strains may result through migrant workers.	H	SPDC shall step-up 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.	L
	Improved socio-economic activities	P	Positive impact	
	The size and number of barges conveying equipment, materials & personnel and the associated waves may endanger small canoes/boats and curtail fishing activities.	H	SPDC shall consult with the relevant Local Government and give adequate notice to the communities, of impending work and route plan, Train marine vessel operators prior deployment. Adhere to journey management guidelines Adhere to safety procedures	L
	Welding activities will release toxic fumes.	M	SPDC shall enforce the use of appropriate PPEs.	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
	Leaks and spills of diesel fuel and lubricants into water.	M	SPDC shall ensure that appropriate containment (drip pans) and clean up procedures are adopted	L
	Potential leakage and spills of glycol during installation.	H	SPDC shall incorporate into the design and install in TEG plant, an auto transfer device for charging and topping of the glycol.	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			Install glycol plant without the initial charge, and thereafter fill in glycol charge	
	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 the use of appropriate use of PPEs	L
Well Drilling & Completion Slot sweeping Rig Move (including personnel, equipment and supplies logistics) Drilling Campaign Casing and cementing Completion and perforation Well testing Flowline hook – up Site Demobilisation	Accidents	H	SPDC shall: <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be condoned off as restricted areas with ample warning signals 	M
	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges	H	SPDC shall <ul style="list-style-type: none"> • treat all effluents to regulatory limits before discharging into the environment. • Dispose all waste in line with regulatory approval 	M
	Continuous glare from rig operation	M	SPDC shall Ensure implementation of ‘No Night Work’ Policy	L
	Disruption of fish spawning sites	H	SPDC shall ensure: Timing of activities to avoid known spawning seasons	M
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	M
	Increase in employment opportunities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	P

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Increased morbidity from pressure on existing social amenities/infrastructure	H	SPDC shall ensure: <ul style="list-style-type: none"> Alternative recreational facilities shall be provided at camp sites Implementation of SPDC Alcohol and Drug Policy for work personnel Movement of personnel shall be restricted to camps and worksites 	M
	Increased security risk and criminality (militants and pirates)	H	SPDC shall: <ul style="list-style-type: none"> make adequate security arrangements for the mobilization. ensure staff are sensitized on the peculiarity of the project environment 	M
	Increased social vices and STIs including HIV	H	SPDC shall ensure: awareness campaign and health education.	M
	Injuries/trauma and death from blowouts	H	SPDC shall ensure that <ul style="list-style-type: none"> only skilled personnel and certified equipment are used high quality chemicals and materials are used emergency response procedures are in place hazard identification has been conducted Daily pep talks are conducted on identified hazards provide On-site/Referral health care (including MEDEVAC) 	M
	Interference with fishing and farming	H	SPDC shall <ul style="list-style-type: none"> ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear issue timely information to stakeholders particularly fisherfolks on nature and timing of activities carry out the movement in phases to avoid prolonged interruption of fishing activities schedule project activities to minimize disruption of fisheries activities. 	M
	Mental Stress from noise nuisance and sleep disturbance from glare	M	SPDC shall ensure: <ul style="list-style-type: none"> machines are tuned off when not in use ensure combustion engines are fitted with effective silencers. ensure regular maintenance of machines. 	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			<ul style="list-style-type: none"> • machinery covers and panels are closed and well fitted at all times • equipment with low noise level are used • implementation of 'No Night Work' Policy 	
	Noise and vibration nuisance	M	SPDC shall: <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • generators are fitted with effective silencers • provide adequate enclosures for noise producing equipment • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P
	Third party agitation	H	SPDC shall: ensure effective consultation with stakeholders Ensure commitment and transparent adherence to PGMoU programmes and projects. Identify and address legacy issues	M
Commissioning and Operation Phase <ul style="list-style-type: none"> • Commissioning and System Operation/ Maintenance • Pigging 	Exhausts from gas turbines and the residual flaring during process upsets over the facility lifespan	H	Upgrade to high efficiency flare nozzle	L
	Air pollution from gas flaring, venting and leakage	H	SPDC shall Use only pre-mobbed equipment. Ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. Minimize routine gas venting and flaring Install scrubbers in their flare stacks	L
	Contamination of soil as a result of oil spillage	H	Immediate clean-up of crude oil spill (likely source of heavy metals) by physical processes Remediation (bioremediation) of contaminated soil	M
	Effluent Discharges	H	SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
			standards prior discharge at the Tunu logistics Base.	
	Discharge of untreated effluents from flowstations /CPF into water.	M	SPDC shall provide effluent and waste water treatment facilities of adequate capacity and treat effluent to DPR standards prior discharge at the Tunu logistics Base.	L
	Leaks and spills of TEG during storage, handling and decanting.	H	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
	Domestic wastewater and sewage disposal from the logistic centre.	H	SPDC waste management plan shall be vigorously adhered to. SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible	L
	Domestic and industrial solids from the logistic centre.	H	SPDC waste management plan shall be vigorously adhered to SPDC shall regularly audit the waste management practices of the contractor and recover dumped wastes as much as possible	L
	Noise from operational activities (equipment, water & air transport, pumps)	H	SPDC shall Use equipment with low noise level Use of appropriate PPE such as ear muff Install acoustic muffler to equipment with high noise level Regular compliance monitoring Ensure safe distance to the equipment	L
DECOMMISSIONING AND ABANDONMENT Cutting/Lifting	Accidents from demolition activities - explosions, falling objects etc, especially when unskilled personnel are employed for the works.	M	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

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
<ul style="list-style-type: none"> • Waste Disposal • Restoration 	Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment.	M	SPDC shall ensure that indigenous species are employed in restoration activities	L
	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
	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	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
	Employment opportunities	P	Positive impact	P
	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
	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 of all staff especially local hands SPDC shall adopt safe operating procedures consistent with good statutory and SPDC HSE requirements	L
	Poor aesthetic features from abandoned structures on site.	M	Where abandonment will lead to poor aesthetics, the structures. shall be removed	L

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation
	Alteration of vegetation pattern and disturbance of aesthetic beauty of the original environment.	M	SPDC shall ensure that native species are employed in restoration activities	L

CHAPTER SEVEN ENVIRONMENTAL MANAGEMENT PLAN

7.1: Introduction

In developing the Environmental Management Plan (EMP) for the Dodo North NAG Wells Project, considerations were given to specific project activities, emergency response procedures, mitigation plan, costing of alternatives and budget requirements, monitoring programme, methodology, auditing and inspection procedures, waste handling procedures, training programme, roles and responsibilities.

The EMP is a tool for managing the predicted environmental impacts of a project. It provides the framework for implementing and monitoring, throughout the project lifecycle, the mitigation measures developed for reducing the effects of moderate and major impacts to as Low As Reasonably Practicable (ALARP). For the purpose of sound environmental management during the course of the project, appropriate interaction is essential between environmental and engineering design teams at all stages of the project from conception through to design, construction and operation. Project construction and operation should be subjected to appropriate environmental audit/monitoring to ensure that environmental standards are met at each stage of project implementation. The EMP for the Dodo North NAG Wells Project is presented in Table 7.1.

7.2: Objectives of EMP

The EMP has the following specific objectives:

- The adoption of a systematic procedure to ensure that the Project activities are executed in compliance with all applicable legislations and SPDC HSSE & SP control framework;
- Demonstrate that mitigation measures for all impacts and effects have been put in place and that the measures shall be adhered to throughout the project development life cycle;
- Demonstrate that effective recovery measures for managing 'lost control' situations throughout the Project life cycle have been put in place;
- Establish a framework that will ensure compliance by SPDC and its Contractors with the EMP.

In order to accomplish the above targets, the EMP has considered each environmental, social and health impacts and parameters for their monitoring (Table 7.1). It also specifies the responsible party/parties for each action as well as the budget for implementation. The purpose of the EMP would be achieved by:

- Ensuring compliance with stipulated legislation on protection of the environment;
- Integrating environmental issues fully into the project development and operational philosophies;
- Promoting environmental management awareness among workers;
- Rationalizing and streamlining existing environmental activities to add value to efficiency and effectiveness;
- Providing standards for overall planning, operation, audit and review, and
- Ensuring that only environmentally sound procedures are employed during the project planning and execution.

- Presenting effective monitoring plan including parameters to be monitored, frequency of monitoring and responsibilities for the impact indicators of the project

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Table 7.1: Environmental Management Plan (EMP) of Dodo North NAG Wells Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
PRE-CONSTRUCTION	Air/Noise pollution from increased vehicular movement	M	SPDC shall: use only pre-mobbed and regularly maintained vehicles	L	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Compliance monitoring of air quality parameters such as CO, CO, SO₂ NO₂, NH₃ TSP 	Weekly/Monthly/ Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
<ul style="list-style-type: none"> ▪ Land Acquisition ▪ Site survey ▪ Pre-Mobilization /Mobilization ▪ Site clearing ▪ Location preparation 	Encroachment on cultural, historical and sensitive ecological areas	M	SPDC shall <ul style="list-style-type: none"> • minimize movement into these sites and respect sacred and historical sites • limits land takes to sites that are necessary • SPDC shall limit clearing and all earth digging activities to necessary areas. • SPDC shall carry out re-vegetation of cleared area 	L	<ul style="list-style-type: none"> • Historical records, archeological findings, compliance monitoring data 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Erosion hazard arising from topographic changes	M	SPDC shall limit clearing and all earth digging activities to necessary areas. SPDC shall carry out the re-vegetation of cleared area	L	<ul style="list-style-type: none"> • Topographic survey records, soil erosion studies 	Quarterly/Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Increase in employment opportunities	P	SPDC shall ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement Records 	Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> • Employment records • Register of contractors 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased morbidity from pressure on existing social amenities/infrastructure	M	SPDC shall ensure: <ul style="list-style-type: none"> • Alternative recreational facilities shall be provided at camp sites • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	L	<ul style="list-style-type: none"> • Household Demographic & Health Survey (DHS) • Routine health service surveillance 	<ul style="list-style-type: none"> • Quarterly • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: <ul style="list-style-type: none"> • Awareness campaign and health education. • Implementation of SPDC Alcohol and Drug Policy for work personnel 	M	<ul style="list-style-type: none"> • Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology) • Activity Reports • Reproductive Health Survey • Routine health service surveillance records 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly • Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Injuries/trauma and death	H	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • high quality chemicals and materials are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards • provide On-site/Referral health care (including MEDEVAC) 	M	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology) • Journey Management Reports • Facility Walk-Through Surveys • Routine health service surveillance • HSE Audits 	<ul style="list-style-type: none"> • Weekly • Weekly • Monthly • Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Opportunities for contracting	P	SPDC shall ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Register of contractors 	Quarterly	SPDC FMEnv, DPR Delta and

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
					<ul style="list-style-type: none"> Community Engagement Records 		Bayelsa States Ministry of Environment and Relevant LGA
	Opportunity to re-use wastes such as firewood	P	SPDC shall ensure that all the trees fell be gathered and make accessible to the communities	P	<ul style="list-style-type: none"> Records of firewood collections by community members 	Once, during site preparation	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Risk of marine traffic accidents	H	SPDC shall ensure <ul style="list-style-type: none"> compliance with SPDC journey management policy for marine transport Only pre-mobbed vehicles are used daily pep talk is carried out for marine transportation all drivers undertake defensive driving training and are certified vehicle monitoring and communication devices are installed and tracked 	M	<ul style="list-style-type: none"> Journey management records Pre-mob certificates Activity Report Certificate of defensive driving Vehicle Monitoring Analysis 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Stimulation of local economy and markets from increased demand for food, and other products in the local market	P	SPDC shall: Introduce and encourage programmes for skills acquisition, and for money savings schemes	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement Records 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Third party/community agitation	H	SPDC shall <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoU programmes and projects. • identify and address legacy issues 	M	<ul style="list-style-type: none"> • Records of Third Party Grievances • Records of work stoppages at locations. • Records of GMoU programmes implementation. • Minutes of meetings 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
CONSTRUCTION ▪ Well Drilling and Completion	Accidents	H	SPDC shall: <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be cordoned off as restricted areas with ample warning signals 	M	<ul style="list-style-type: none"> • Journey management records • Pre-mob certificates • Activity Report • Certificate of defensive driving • Vehicle Monitoring Analysis 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges	H	SPDC shall <ul style="list-style-type: none"> • treat all effluents to regulatory limits before discharging into the environment. • Dispose all waste in line with regulatory approval 	M	<ul style="list-style-type: none"> • Effluent and groundwater monitoring (cations, anions, organics, heavy metals and microbiology) • records • Discharge certificates • Compliance monitoring 	Weekly/Monthly/ Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Continuous glare from rig operation	M	SPDC shall Ensure implementation of 'No Night Work' Policy	L	<ul style="list-style-type: none"> • Certification of workforce • Emergency response plan • HAZID register • Pep-talk records 	Quarterly Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Disruption of fish spawning sites	H	SPDC shall ensure: Timing of activities to avoid known spawning seasons	M	<ul style="list-style-type: none"> • Compliance Monitoring Reports (cations, anions, organics, heavy metals and microbiology) • Activity Reports 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	M	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records 	• Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Increase in employment opportunities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> • Employment records • Register of contractors 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increase morbidity from pressure on existing social amenities/infrastructure	H	SPDC shall ensure: <ul style="list-style-type: none"> • Alternative recreational facilities shall be provided at camp sites • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	M	<ul style="list-style-type: none"> • Household Demographic & Health Survey (DHS) • Routine health service surveillance 	<ul style="list-style-type: none"> • Quarterly • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall: <ul style="list-style-type: none"> • Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement Records 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased security risk and criminality (militants and pirates)	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. 	M	<ul style="list-style-type: none"> • Security plan • Record of security orientation 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			<ul style="list-style-type: none"> ensure staff are sensitized on the peculiarity of the project environment 				Ministry of Environment and Relevant LGA
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: awareness campaign and health education.	M	<ul style="list-style-type: none"> Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology) Activity Reports Reproductive Health Survey Routine health service surveillance records 	<ul style="list-style-type: none"> Weekly Monthly Quarterly Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Injuries/trauma and death from blowouts and work-related accidents	H	SPDC shall ensure that <ul style="list-style-type: none"> only skilled personnel and certified equipment are used high quality chemicals and materials are used emergency response procedures are in place hazard identification has been conducted Daily pep talks are conducted on identified hazards provide On-site/Referral health care (including 	M	<ul style="list-style-type: none"> Compliance monitoring report Facility Walk-Through Surveys Routine health service surveillance 	<ul style="list-style-type: none"> Weekly Monthly Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			MEDEVAC)				
	Interference with fishing and farming	H	SPDC shall <ul style="list-style-type: none"> ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear issue timely information to stakeholders particularly fisherfolks on nature and timing of activities carry out the movement in phases to avoid prolonged interruption of fishing activities schedule project activities to minimize disruption of fisheries activities. 	M	<ul style="list-style-type: none"> Marine Journey management records Community Engagement Records Government Engagement records 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Mental Stress from noise nuisance and sleep disturbance from glare	M	SPDC shall ensure: <ul style="list-style-type: none"> machines are tuned off when not in use ensure combustion engines are fitted with effective silencers. ensure regular maintenance of machines. 	L	<ul style="list-style-type: none"> Compliance Monitoring Reports Activity (cations, anions, organics, heavy metals and microbiology) Reports Routine health service surveillance records 	<ul style="list-style-type: none"> Weekly Monthly Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			<ul style="list-style-type: none"> • machinery covers and panels are closed and well fitted at all times • equipment with low noise level are used • implementation of 'No Night Work' Policy 				
	Noise and vibration nuisance	M	SPDC shall: <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • generators are fitted with effective silencers • provide adequate enclosures for noise producing equipment • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Monitor noise levels • Records of PPE issuance and use 	<ul style="list-style-type: none"> • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Register of contractors 	Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
							and Relevant LGA
	Third party agitation	H	SPDC shall: <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoUprogrammes and projects. • identify and address legacy issues 	M	<ul style="list-style-type: none"> • Records of Third Party Grievances • Records of work stoppages at locations. • Records of GMoUprogrammes implementation. • Minutes of meetings 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
CONSTRUCTION	Accidents	H	SPDC shall: <ul style="list-style-type: none"> • carry out first aid training of workers including casual workers and locals. • provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) • ensure that work area shall be condoned off as restricted areas with ample warning signals 	M	<ul style="list-style-type: none"> • Journey management records • Pre-mob certificates • Activity Report • Certificate of defensive driving • Vehicle Monitoring Analysis 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
Flowline Design and Installation							

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Contamination and degradation of soil, groundwater and surface water from dredge spoils, solids/drilling wastes and effluent discharges	H	SPDC shall <ul style="list-style-type: none"> • treat all effluents to regulatory limits before discharging into the environment. • Dispose all waste in line with regulatory approval 	M	<ul style="list-style-type: none"> • Effluent and groundwater monitoring records(cations, anions, organics, heavy metals and microbiology) • Dischargecertificates 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Encroachment on cultural, historical and sensitive ecological zones such as mangrove	M	SPDC shall <ul style="list-style-type: none"> • minimize movement into these sites and respect sacred and historical sites • limit land takes to sites that are necessary 	L	<ul style="list-style-type: none"> • Historical records, archeological findings, compliance monitoring data(cations, anions, organics, heavy metals and microbiology, air quality parameters) 	Fortnightly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Erosion hazard due to construction impediments to natural drainage	H	<ul style="list-style-type: none"> • SPDC shall limit clearing and all earth digging activities to necessary areas. • SPDC shall carry out the re-vegetation of cleared area HSE plans shall be drawn before activities are carried out to ensure that construction activities are carried out in a manner that is least intrusive to	M	Topographic survey records, soil erosion studies	Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			the environment.				
	Disruption of fish spawning sites	H	SPDC shall ensure: Timing of activities to avoid known spawning seasons	M	<ul style="list-style-type: none"> • Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Activity Reports 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	M	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Compliance monitoring(cations, anions, organics, heavy metals and microbiology, air quality parameters) • 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increase in employment opportunities	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement records 	• Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Increase morbidity from pressure on existing social amenities/infrastructure	H	SPDC shall ensure: <ul style="list-style-type: none"> • Alternative recreational facilities shall be provided at camp sites • Implementation of SPDC Alcohol and Drug Policy for work personnel • Movement of personnel shall be restricted to camps and worksites 	M	<ul style="list-style-type: none"> • Household Demographic & Health Survey (DHS) • Routine health service surveillance 	<ul style="list-style-type: none"> • Quarterly • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased cash flow and stimulation of local economies within the communities	P	SPDC shall: Introduce and encourage programmes for skills acquisition and personal financial management	P	<ul style="list-style-type: none"> • Employment records • Register of contractors 	<ul style="list-style-type: none"> • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased security risk and criminality (militants and pirates)	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. • ensure staff are sensitized on the peculiarity of the project environment 	M	<ul style="list-style-type: none"> • Security plan • Record of security orientation 	<ul style="list-style-type: none"> • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Increased social vices and incidence of STIs including HIV	H	SPDC shall ensure: awareness campaign and health education.	M	<ul style="list-style-type: none"> • Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Activity Reports • Reproductive Health Survey • Routine health service surveillance records 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly • Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Injuries/trauma and death from blowouts and work-related accidents	H	SPDC shall ensure that <ul style="list-style-type: none"> • only skilled personnel and certified equipment are used • high quality chemicals and materials are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards • provide On-site/Referral health care (including MEDEVAC) 	M	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Facility Walk-Through Surveys • Routine health service surveillance 	<ul style="list-style-type: none"> • Weekly • Monthly • Weekly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Interference with drainage pattern	M	SPDC shall ensure appropriate engineering design for all facilities	L	<ul style="list-style-type: none"> Hydrological studies 	Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Interference with fishing and farming	H	SPDC shall <ul style="list-style-type: none"> ensure proper signposting and mapping of any sub-sea structures to exclude trawling and avoid damage to fishing gear issue timely information to stakeholders particularly fisherfolks on nature and timing of activities carry out the movement in phases to avoid prolonged interruption of fishing activities schedule project activities to minimize disruption of fisheries activities. 	M	<ul style="list-style-type: none"> Marine Journey management record Community Engagement records 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Interference with water transport	M	SPDC shall Ensure implementation of 'No Night Work' Policy	L	<ul style="list-style-type: none"> • Certification of workforce • Emergency response plan • HAZID register • Pep-talk records • Marine Journey Management 	<p>Quarterly</p> <p>Monthly</p>	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Loss of biodiversity	M	SPDC shall: Ensure regular compliance monitoring	L	<ul style="list-style-type: none"> • Compliance Monitoring Reports • Activity Reports 	Monthly/Quarterly/Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Mental Stress from noise nuisance and sleep disturbance from glare	M	<p>SPDC shall ensure:</p> <ul style="list-style-type: none"> • machines are tuned off when not in use • ensure combustion engines are fitted with effective silencers. • ensure regular maintenance of machines. • machinery covers and panels are closed and well fitted at all times • equipment with low noise level are used • implementation of 'No Night Work' Policy 	L	<ul style="list-style-type: none"> • Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Activity Reports • Routine health service surveillance records 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Noise and vibration nuisance	M	SPDC shall: <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • generators are fitted with effective silencers • provide adequate enclosures for noise producing equipment • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Compliance Monitoring Reports(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Monitor noise levels • Records of PPE issuance and use 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement records 	<ul style="list-style-type: none"> • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Third party agitation	H	SPDC shall: <ul style="list-style-type: none"> ensure effective consultation with stakeholders ensure commitment and transparent adherence to GMoU programmes and projects. identify and address legacy issues 	M	<ul style="list-style-type: none"> Records of Third Party Grievances Records of work stoppages at locations. Records of GMoU programmes implementation. Minutes of meetings 	Monthly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Wildlife habitat fragmentation	M	SPDC shall <ul style="list-style-type: none"> minimize movement into these sites and respect sacred and historical sites limits land takes to sites that are necessary 	L	<ul style="list-style-type: none"> Fragmentation index, Biodiversity reports, wildlife migration pattern 	Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
Demobilization	Air, water and land pollution arising from improper disposal of cleared materials	M	SPDC shall ensure <ul style="list-style-type: none"> all wastes are properly segregated before disposal all cleared wastes are properly disposed of and monitored from cradle to grave 	L	<ul style="list-style-type: none"> Effluent and groundwater monitoring records Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) Dischargecertificates Waste management records 	Weekly/Monthly/ Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

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Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Impairment of air quality by emissions of air pollutants from vehicular movement	M	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles	L	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Compliance monitoring(cations, anions, organics, heavy metals and microbiology, air quality parameters) 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increase in noise and vibration level	M	SPDC shall <ul style="list-style-type: none"> • use only pre-mobbed and regularly maintained equipment and vehicles • use equipment with low noise level • ensure that appropriate PPEs are provided and used. 	L	<ul style="list-style-type: none"> • Pre-mob certificates • Maintenance records • Compliance monitoring Records of PPE issuance and use 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Increased opportunity for business and employment.	P	SPDC shall <ul style="list-style-type: none"> • Ensure adherence to local content policy • Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement records 	• Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Loss of employment/ income	H	SPDC shall support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities.	M	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community Engagement records 	<ul style="list-style-type: none"> • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Marine/land accident resulting to injuries and fatality	H	SPDC shall ensure <ul style="list-style-type: none"> • compliance with SPDC journey management policy for marine transport • Only pre-mobbed vehicles are used • daily pep talk is carried out for marine transportation • all drivers undertake defensive driving training and are certified • vehicle monitoring and communication devices are installed and tracked 	M	<ul style="list-style-type: none"> • Journey Management Reports • Facility Walk-Through Surveys • Routine health service surveillance 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Opportunities for contracting	P	SPDC shall Ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Register of contractors • Community 	<ul style="list-style-type: none"> • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
					Engagement records		Ministry of Environment and Relevant LGA
	Pirates attack and hostage taking	H	SPDC shall: <ul style="list-style-type: none"> • make adequate security arrangements for the mobilization. • ensure staff are sensitized on the peculiarity of the project environment 	M	<ul style="list-style-type: none"> • Security plan • Record of security orientation 	<ul style="list-style-type: none"> • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Third party agitation	H	SPDC shall <ul style="list-style-type: none"> • ensure effective consultation with stakeholders • ensure commitment and transparent adherence to GMoUprogrammes and projects. • identify and address legacy issues 	M	<ul style="list-style-type: none"> • Records of Third Party Grievances • Records of work stoppages at locations. • Records of GMoUprogrammes implementation. • Minutes of meetings 	<ul style="list-style-type: none"> • Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
Operations and Maintenance	Air pollution from gas flaring, venting, leakage and fire	M	SPDC shall <ul style="list-style-type: none"> • use only pre-mobbed equipment. • ensure that there is controlled use of all equipment and that equipment engines are turned 	L	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) <ul style="list-style-type: none"> • Vehicle/boat 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			off when not in use. • Minimize routine gas venting and flaring • Install scrubbers in their flare stacks		maintenance records • Vehicle/boat pre-mob records		
	Environmental pollution arising from improper disposal of lubricants and oily debris	H	SPDC shall ensure • all oily wastes are properly segregated and contained before disposal • all oily wastes are properly disposed of and monitored from cradle to grave	M	• Effluent and groundwater monitoring records • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Dischargecertificates	• Weekly • Monthly • Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Equipment failure and damage leading to injuries/fatality	M	SPDC shall ensure that • only skilled personnel and certified equipment are used • emergency response procedures are in place • hazard identification has been conducted • Daily pep talks are conducted on identified hazards	L	• Site Inspection Reports • Activity Reports • Routine health service surveillance records • HSE Audits	• Monthly/Annually	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Noise from operational activities (equipment, water & air transport, pumps)	M	SPDC shall <ul style="list-style-type: none"> • Use equipment with low noise level • Use of appropriate PPE such as ear muff • Install acoustic muffler to equipment with high noise level • Regular compliance monitoring • Ensure safe distance to the equipment 	L	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Maintenance records • Vehicle/boat pre-mob records 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Sanitary and domestic wastes	H	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy to the environment • Waste shall be trucked by approved vendors to approved discharge points 	M	<ul style="list-style-type: none"> • Compliance monitoring (cations, anions, organics, heavy metals and microbiology, air quality parameters) • records, sewage volumetric, chlorine dosage data • Waste management records 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
Decommissioning and Abandonment	Air pollution from emissions arising from leaks and trapped oils	M	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy • Contentment of trapped oil and send same to Forcados terminal for treatment/recovery 	L	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) • Vehicle/boat maintenance 	<ul style="list-style-type: none"> • Weekly • Monthly • Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			<ul style="list-style-type: none"> Regular compliance monitoring 		records <ul style="list-style-type: none"> Vehicle/boat pre-mob records 		
	Employment and income generating opportunity	P	SPDC shall <ul style="list-style-type: none"> Ensure adherence to local content policy Introduce and encourage programmes for skills acquisition and personal financial management 	P	<ul style="list-style-type: none"> Employment records Register of contractors Community Engagement records 	<ul style="list-style-type: none"> Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Job-related and traffic accidents resulting from removal of structures from site	H	SPDC shall <ul style="list-style-type: none"> carry out first aid training of workers including casual workers and locals. provide and enforce appropriate use of PPEs (e.g. life vests, hard hats, eye goggles) ensure that work area shall be condoned off as restricted areas with ample warning signals ensure that health talks and awareness and job hazard analysis are carried out prior to work activities 	M	<ul style="list-style-type: none"> Site Inspection Reports Activity Reports Routine health service surveillance records HSE Audits 	<ul style="list-style-type: none"> Monthly Quarterly Annually 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
	Loss of job and project-related economic benefits	H	SPDC shall support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities.	M	<ul style="list-style-type: none"> • Employment records • Community Engagement records • Register of contractors 	• Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Opportunities for contracting	P	SPDC shall ensure adherence to local content policy	P	<ul style="list-style-type: none"> • Employment records • Community Engagement records • Register of contractors 	• Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Restoration of aesthetic value of the environment	P	SPDC shall ensure adequate remediation of all impacted areas	P	<ul style="list-style-type: none"> • Compliance monitoring report(cations, anions, organics, heavy metals and microbiology, air quality parameters) • 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Soil contamination from excavation during removal of well heads	M	SPDC shall <ul style="list-style-type: none"> • Maintain zero discharge policy • Contentment of trapped oil and send same to Forcados terminal for treatment/recovery 	L	<ul style="list-style-type: none"> • Compliance monitoring records(cations, anions, organics, heavy metals and microbiology, air quality parameters) • • Vehicle/boat 	• Weekly/Monthly/Quarterly	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Activity	Description of Impact	Rating Before Mitigation	Mitigation Measures	Rating After Mitigation	Parameters to be Monitored	Monitoring Frequency	Responsible/ Action Party
			<ul style="list-style-type: none"> Regular compliance monitoring 		maintenance records <ul style="list-style-type: none"> Vehicle/boat pre-mob records 		
	Solid wastes from decommissioning activities	H	SPDC waste management policy shall be enforced; SPDC shall <ul style="list-style-type: none"> Maintain zero discharge policy Waste shall be trucked by approved vendors to approved discharge points Regular compliance monitoring 	M	<ul style="list-style-type: none"> Waste inventory/consignment notes Compliance monitoring records(cations, anions, organics, heavy metals and microbiology, air quality parameters) 	<ul style="list-style-type: none"> Weekly/Monthly/Quarterly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA
	Third party agitation	H	SPDC shall <ul style="list-style-type: none"> ensure effective consultation with stakeholders ensure commitment and transparent adherence to GMoUprogrammes and projects. identify and address legacy issues 	M	<ul style="list-style-type: none"> Records of Third Party Grievances Records of work stoppages at locations. Records of GMoUprogrammes implementation. Community Engagement records 	<ul style="list-style-type: none"> Monthly 	SPDC FMEnv, DPR Delta and Bayelsa States Ministry of Environment and Relevant LGA

7.2 Waste Generation and Management

The waste management system of Dodo North is directly linked to that of the larger SSAGS+

Drilling and Other Programme

Table 7.2 Potential Waste expected from the Dodo North Project

Waste Type	Control /Management Measures
Mud	<ul style="list-style-type: none"> Used pseudo oil based mud (POBM) will be re-used in the drilling of other wells. (Standard toxicity will be conducted in DPR approved laboratories on the POBM before they are used) Spent POBM would be incinerated at the Thermal Desorption Unit (TDU) provided in Onne.
Cuttings	<ul style="list-style-type: none"> Bottom hole cuttings drilled with POBM and contaminated with POBM will be incinerated in Onne. POBM cuttings can be also processed by separating the cutting into solid and liquid phases using shaker. The liquid shall be passed through active carbon and filters (carbon & silica) to remove contaminants. The resultant clean water is discharged or re-used. For the solids, they shall be mixed with cement and silicates and used for road tar or as land fill material. The percentage mud on cuttings shall be kept below 10% before incineration through the use of installed high gravity shakers/dryers.
Cement	<ul style="list-style-type: none"> Cement residues and returns (spud mud and cement – contaminated water) generated during the top hole cementation stage will be collected and re-injected.
Brine (NaCl) Discharge	<ul style="list-style-type: none"> Solids free, lightweight, non-toxic completion brine will be used. Excess brines shall be re-injected
Acids	<ul style="list-style-type: none"> Used or spent acids will be diluted and neutralised through the addition of dilute caustic soda. Thereafter it will be disposed off through re-injection.
Sand Consolidation Fluid	<ul style="list-style-type: none"> Used sand consolidation fluids (well fix etc.) will be collected in drums and sent for incineration or re-injected
Sewage	<ul style="list-style-type: none"> It is envisaged that the maximum number of personnel at drilling site at any one time will be about 150 persons. Sanitary sewage produced at site will be treated on the rig sewage treatment plant as per DPR standard. The water can be re-used for flushing the system or disposed in rivers. Regular monitoring will be carried out.
Industrial and domestic wastes	<ul style="list-style-type: none"> 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.
Rig bilge	<ul style="list-style-type: none"> Oily water discharges shall be controlled to less than 20ppm oil in water by the rig oil/water separation system.

Spudding and drilling of wells, well completion and hook up is one of the major activities in addition to site preparation/dredging and flow lines and bulk lines installation. The drilling and completion operations shall be managed at the project sites. Drilling operation requires the use of special drilling fluid (mud).

Drainage Discharges

Drainage discharges upon the drilling rig will occur from a number of sources including:

- Clean area floor drains;
- Deluge drains;
- Machine area floor drains;
- 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 overboard without any treatment. The other discharges may contain oil or chemicals and would be routed to the oily water drainage and treatment system. The expected waste from the drilling activities and their management strategies are tabulated in Table 7.2.

Operation and Maintenance Activities

The wellhead shall 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.

Operations

Facilities Safeguarding Philosophy

Wellhead:

The wellhead will be maintained and safeguarded in accordance with SPDC's HSE policy and guidelines.

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.

Decommissioning/Abandonment

The wellhead and their ancillary installations have a life expectancy of about 25 years. The operation and maintenance procedure shall provide for monitoring the performance and the integrity of the system components. When the performance of the system scales to diminishing returns, SPDC standard procedures for decommissioning shall be invoked. A decommissioning team shall be set up to plan and implement laid down guidelines on decommissioning. The following activities are involved in decommissioning/abandonment:

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

The demolition exercise shall be carried out with skill and diligence to avoid spill of hazardous liquids and damage to the environment. At the end of demolition, various solid wastes shall be segregated according to their types and then disposed of according to SPDC waste disposal guidelines.

Oil Spill Contingency Plan

SPDC's oil spill contingency plan shall be applied to the proposed drilling project. The spill contingency plan shall be based upon the location and volume of potential spill and shall address the possibilities of well blowouts in the drilling 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 labour needed for clean-up work. Finally, the plan shall address the disposal of contaminated waste generated by a spill.

CHAPTER EIGHT DECOMMISSIONING AND ABANDONMENT

8.1: Introduction

The Decommissioning and Abandonment Plan outlines the ways and methods to be adopted for decommissioning and abandonment of the Dodo North surface and subsurface structures (wells, flowlines, bulkline with associated end facilities) at the end of their economic life. This chapter illustrates a logical process of managing abandonment effectively from conception, through execution, to completion stage resulting in an abandoned site that is restored to a clean, safe, usable and environmentally acceptable condition.

8.2: Objectives of Decommissioning and Abandonment

The Objectives of the Decommissioning and Abandonment Plan of the Dodo North NAG Wells facilities includes but not limited to the following:

- To ensure that identified issues have been addressed and that existing wells (surface and subsurface) and field facilities/assets are abandoned in a way that provides a forum for meaningful stakeholder input and ensures that public safety and environmental stability are maintained.
- To minimize impacts to the environment and land use while implementing a cost-effective abandonment system.

8.3: Value Drivers/Critical Success Factors

The value drivers and critical factors for the Dodo North Facilities Decommissioning Plan is presented in Table 8.1.

Table 8.1: Value Drivers/Critical Success Factors

Value Driver	Critical Success factor
Clean Environment	<ul style="list-style-type: none"> • Cleaning pipelines • Efficient oil spill/effluent management • Site reinstatement
Reduce OPEX	<ul style="list-style-type: none"> • Front end loading (Data gathering/design) • Project scoping and framing • Pipeline abandonment strategy • Environmental Evaluation
Improved Reputation	<ul style="list-style-type: none"> • Regulatory compliance • Proactive engagement of key stakeholders • Early involvement of key stakeholders • Community buy-in • Concession of some abandoned materials to community
Health and Safety	<ul style="list-style-type: none"> • Contractor with aligned HSE-MS including Lifesaving rules

Value Driver	Critical Success factor
	<ul style="list-style-type: none"> • Stakeholders proactive engagement • Close contractor supervision

8.4: Reference Standards

For listings and details of Project, Company and International specifications, codes and standards referred to or implied in the detailed engineering of Dodo North wells and associated facilities. However, in the definition of the Dodo North Decommissioning and Abandonment Plan, the following regulations, standards, specifications and procedures have been consulted:

International Standards

The following list of standards and specifications was consulted in developing this pipeline abandonment plan:

- ASME B31.8-2010 - Gas Transmission and Distribution Piping Systems

Shell DEP and SPDC Standards

- DEP 31.40.00.10-Gen - Pipeline Engineering (Amendments/Supplements to ISO 13623)
- DEP 37.19.00.30-Gen - Design of Steel Structures for Fixed Offshore Platforms (Amendments/Supplements to API PR 2ALRFD)
- DEP 80.80.00.10-Gen - Offshore Facilities Life-Saving Appliances Requirements (Amendments/Supplements to SOLAS)
- Well and Field Assets Abandonment and Strategy, September 2000, version 2.
- Pipeline Operations Emergency Response Procedures (SPDC 2004-0044997)

Project Specification

- BDP-BDEP Part II– Design Basis and Design Requirements for Southern Swamp Associated Gas Solutions Projects (SSG-TPD-GEN-AA-7704-00003)
- Dodo North As-Built Deliverables.
- Dodo North Operations and Maintenance Manual

8.5: Order of Precedence

In case of any conflict between the requirements as stated in this decommissioning and abandonment plan, applicable Codes and Standards then the most stringent shall apply. In case of conflict among the documents the following precedence shall be applied:

- This specification
- Other referenced project specifications
- Other specifications, codes and standards referred to within this specification and its attachments

8.6: Decommissioning and Abandonment Strategy

Dodo North Wells with associated wellheads, flowlines, Bulkheader platform and bulkline shall be decommissioned in line with the SPDC Well and Field Asset Abandonment Policy (SPDC 99-064) at the end of its useful design life of ten years. However, the process end facilities at Tunu are designed for twenty five years life to support future NAG productions from adjoining fields which will come on-stream as back fillers to Tunu CPF NAG capacity. Shell Petroleum Development Company (SPDC) Well and Field Asset Abandonment Policy states that “SPDC field assets, including wells, surface facilities, flow lines, trunk lines etc., which have reached the end of their economic life, shall be abandoned, in conformity with SPDC standards, Shell group and statutory requirements. Field sites shall be restored to environmentally safe and clean conditions prior to returning to their original owners”.

The useful design life for Dodo North wells and associated facilities was defined based the best case production forecast for Dodo North Reservoirs which anticipates plateau production of 100MMscf/d from Dodo North over a seven year period (figure 8.1). In reality, Dodo North wells are intended to be swing producers to augment associated gas production volumes from the four Flowstations with the Southern Swamp Node.

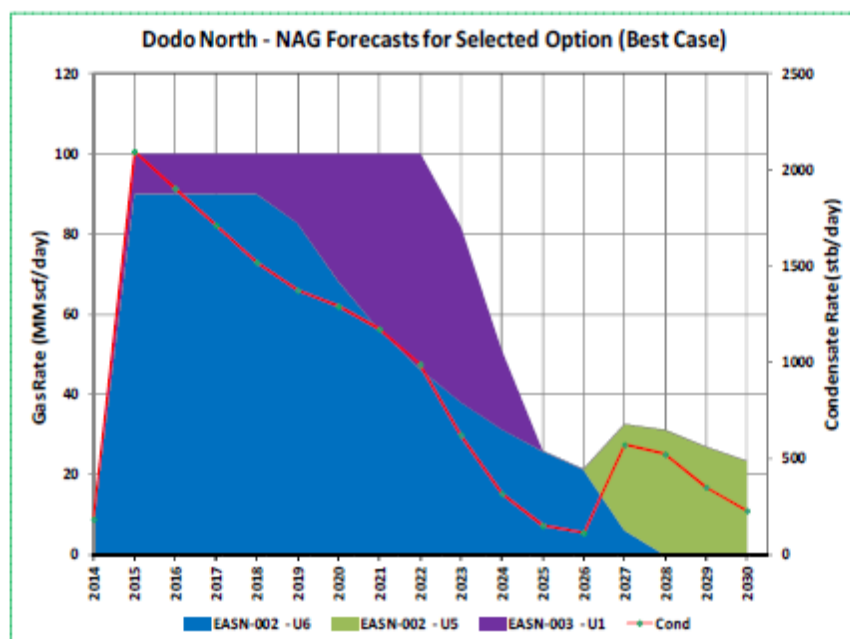


Figure 8.1: Production Profile for Dodo North Wells

Towards the end of the Dodo North field design life, further brownfield formation evaluation and facilities integrity assessment will be performed to confirm if the NAG reserves can still be economically and safely produced using installed facilities. Where it is necessary, further upgrades shall be performed to extend the facilities design life.

In line with the above, if the decision to decommission and abandon the Dodo North facilities is reached, further assessment will be performed to identify equipment or facilities that need to be completely removed, salvaged or abandoned insitu after cleaning and displacement of all residual hydrocarbon in the line. Company shall also, clean and restore items of equipment which may be needed in future and put in place a preservation strategy to make them useful when they will be required. Specific onsite Decommissioning and Abandonment Procedures shall be developed by the specialized contractors to address plans for safe removal of contaminated or potentially dangerous material utilizing environmentally friendly techniques.

Consideration will be given to leaving infrastructure in place if they are agreed to be beneficial to the local communities and confirmed to still have adequate integrity for their (community) intended service. A comprehensive review of the dodo North facilities shall be performed prior to decommissioning with the intension to fully decommission all above ground sections of the wellheads and pipeline end facilities as much as is reasonably practicable. All other buried sections of piles, pipelines, well completions, shall be capped / plugged off at a safe depth and abandoned in-situ after demonstrating to the regulators that it is safe to do so. The redundant pipeline shall be flushed clean of all products to the extent that no more than a thin residual hydrocarbon film can be traced within the pipeline and the effluent water discharge quality is within regulatory limits for discharge into the surrounding environment. The pipeline shall be abandoned in-situ, filled with inhibited water and pressurized to 10psi after being capped or blinded off at a point below the swamp line.

The precise coordinates of the end point of capped sections of buried bulkline shall be maintained as part of the abandonment records. Reusable items recovered during decommissioning and abandonment shall be conditioned, tagged and preserved at SPDC storage facilities at either Kidney Island (KI) or Shell Port Harcourt Industrial area (IA). Scrap items shall be treated according to standard procedures on handling/sales of scrap.

8.7: Decommissioning and Abandonment Scope

Dodo North NAG Wells Project consists of the drilling and completion of two Non Associated Gas (NAG) wells to supplement Associated Gas (AG) from the Southern Swamp fields which will be processed at a new Central Processing Facility (CPF) located at Tunu. As part of this scope a new Bulkheader platform will be installed at Dodo North to bulk wet gas produced from the Dodo North wells (EASN 002 and EASN 003) to Tunu CPF for hydrocarbon and water due pointing before export to the Domestic Gas Market. The Dodo North Bulkline has a design life of ten years based the optimal production forecast for these wells to maintain export of a minimum of 100MMscf/d to the domestic gas market for a period of ten years. The Dodo North Bulkheader Platform is remotely located but in close proximity to the wellhead (150m – 250m). Both the Bulkheader platform and the wellheads are provided with dedicated access slots which will be maintained over the ten years design/service life for these assets.

There is no infrastructure provided to neighbouring communities from the Dodo North Bulkheader platform. However, power will be provided to the communities from the the central processing facility at Tunu. The Dodo North NAG Bulkheader platform has remote monitoring and control capabilities from Tunu Central Control Room (CCR) and shall also be provided with have round the clock security surveillance to mitigate against third party facility interference. All security resources shall be demobilized at the end of the field life during decommissioning.

The scope for the NAG slug catcher and all associated gas processing facilities at Tunu CPF installed as part of the Southern Swamp Associated Gas Solutions Project are excluded from this decommissioning and abandonment plan as these facilities are designed for twenty five years life and covered by EIA approval for Southern Swamp Associated Gas Solutions Project conveyed in letter referenced FMEnv/CONF/EIA/123:208/Vol. III/223 and dated 07th July 2013

8.8: Decommissioning General Requirements

The SPDC Well and Field Assets Abandonment Standards, SPDC 99-064, specifies the general requirements for abandonment of all oil field facilities and shall be used as guidelines for developing detailed abandonment work scope. In the process of decommissioning the Dodo North wells, alternative use will be considered such as recompletion, sidetrack and cuttings re-injection wherever possible.

Where no alternative is found, the wells will be decommissioned according to SPDC well Decommissioning/Abandonment Policy. This requires the field site to be restored to clean, safe and environmentally acceptable condition. Well abandonment decision will be made after a thorough study must have been carried-out on the well and it's economic value/re-use evaluated. The access slots for the Dodo North wellheads and Bulkheader Platform shall be allowed to accrete naturally unless environmental analysis of the soil indicates the requirement for remediation. In that situation, a full remediation and monitoring scheme will be instituted with the collaboration of all stakeholders including the communities and Governmental bodies. There are various options to be considered for decommissioning and abandonment of redundant surface and subsurface. The decision to fully decommission or abandon-in-place any of the surface or sub-surface facilities shall be made on the basis of a comprehensive site-specific assessment. Table 8.2 highlights an array of decommissioning and abandonment alternatives for the Dodo North NAG development Project. However, No option has been chosen.

Table 8.2: Decommissioning and Abandonment Alternatives

Project Activity	Advantages	Disadvantages
<p>Option 1: Leave In-Situ for Future reuse. The bulkline will be isolated, flushed and mothballed and well shut-in and preserved for possible future reuse subject to reserves evaluation and technical integrity verification at time of abandonment. All other installed facilities will be left in-situ. This option involves the least possible intervention</p>	<ul style="list-style-type: none"> • Least energy and CO₂ emissions during execution of all considered options; • Least expensive to execute; • The dodo north bulkline has multiple crossing with existing pipelines in the area This option thus eliminates the risk of unintended damage to other lines thus preventing spills and consequential impact on marine life. • Post Decommissioning hydrocarbon contamination is minimized by line flushing 	<ul style="list-style-type: none"> • Hydrocarbon release hazard with potential impacts on reproductive, developmental and behavioral processes of marine fauna; • Marine transport hazards resulting from the risk of scouring on river crossing sections. Potential source of debris with snagging risk; (Unburied decommissioned pipeline sections have the potential to create debris as they deteriorate. Estimates of the rate of deterioration indicate pipelines will deteriorate over a period of perhaps 100 years)
<p>Option 2: Abandon wells, Reuse Wellhead Platform and Bulkline This option will be considered to produce adjoining fields subject to technical integrity verification at time of abandonment. All other installed facilities will be left in-situ.</p>	<ul style="list-style-type: none"> • Considerably reduced energy and CO₂ emissions during Decommissioning (compared to Option 1) • Optimum use of installed facilities leading to lower cost production • Extended Asset Life and field recovery • Eliminates the risk of unintended damage to third party lines thus preventing spills and consequential impact on marine life. 	<ul style="list-style-type: none"> • Hydrocarbon release hazard with potential impacts on reproductive, developmental and behavioral processes of marine fauna; • Potentially higher operating cost from aging facility • Marine transport hazards

Project Activity	Advantages	Disadvantages
<p>Option 3: Partial Decommission all Topside equipment, and leave buried facilities in Place</p> <p>Set cement plug and abandon wells. Decommission wellhead facilities and pipeline end facilities, cut off risers and pile legs and leave buried lines and reinstate scoured sections, capped and mothballed at with inhibited water at 10barg</p>	<ul style="list-style-type: none"> • Minimizes presence of visible surface structures • Minimise collision and snagging risks on the water ways • Post Decommissioning hydrocarbon contamination to the environment is minimized by line flushing to accepted effluent quality levels • Eliminates the risk of unintended damage to third party lines thus preventing spills and consequential impact on marine life. 	<ul style="list-style-type: none"> • High Decommissioning cost • Considerable CO₂ and noise emissions during decommissioning • Increase environmental disruption during decommissioning and removal of surface facilities • Marine transport hazards
<p>Option 4: Decommission all Topside equipment, and buried bulkline</p> <p>Set cement plug and abandon wells. Decommission wellhead facilities and cut of surface casing to ASAP. Completely decommission bulkline including pipe legs for end facilities.</p>	<ul style="list-style-type: none"> • Post Decommissioning hydrocarbon contamination to the environment is eliminated • Environment is returned to near-virgin state 	<ul style="list-style-type: none"> • Highest Decommissioning cost option • Considerable CO₂ and noise emissions during decommissioning • Increase environmental disruption during decommissioning and removal of buried pipelines along the right of way, wellhead locations and pipeline end facilities in other to achieve complete facilities removal • Damage to third party assets (cables or other utilities not identified from Pre Abandonment Verification

8.9: Decommissioning and Abandonment Activities

The optimal option for Dodo North abandonment and decommissioning will depend on the pre-abandonment evaluations and potential future development of fields around the Dodo North field. The land formally occupied by the old facilities will be returned to its original land owner. The pipeline to be abandoned in place shall be cleaned so that the pipeline shall not constitute a risk to public health or the environment and to minimize the risk of soil and groundwater contamination during decommissioning and abandonment.

The buried sections of pipeline will be cleaned internally until substantially free of hydrocarbon. The line will be filled with inhibited water and pressurized to 10 psi after being capped or blinded off depending on the selected decommissioning and abandonment option. The retention of this pressure depends entirely on the integrity of the line at the time of decommissioning and abandonment. Cleaning of the line shall be done before decommissioning using slugs of surfactant solution, which shall be batched through the trunkline separated by medium density scraper pigs. This process will be repeated to ensure cleaning of any hydrocarbon films, followed by pressurized water to confirm pipeline integrity level at abandonment (Hydrotest) if the line is abandoned in-situ. Effluent swabs shall be collected from the line to analyze concentration of dispersed hydrocarbon.

The cleaning pig train, or trains depending how quickly the line cleans up, will consist of 3 pigs containing 2 surfactant solution slugs as depicted below. Where visual inspection and laboratory assessments verify cleanliness criteria, cleaning of the line shall be considered complete. Effluent water from line cleaning shall be disposed directly into the Trans Remos Pipeline through the surge vessel at Tunu Flowstation

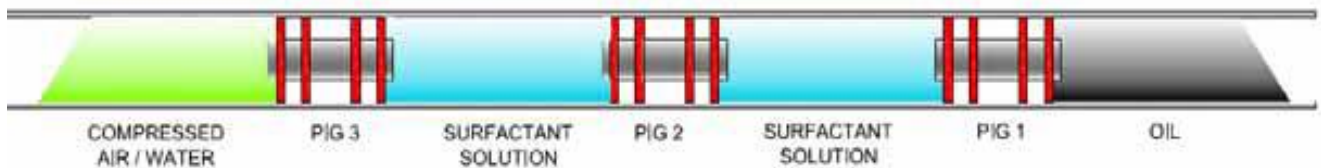


Fig 8.1: Line flushing sequence

The activities to be carried out during the decommissioning and abandonment of Dodo North Facilities includes but not limited to the following:

- Isolate and shut-in the Dodo North wells
- Depressurize the bulkline and associated facilities
- Isolate section to be decommissioned, Purge, water flush and decouple redundant piping loops

- Perform any restoration works required and hook-up new wells (where option 1 or 2 is considered)
- Set concrete plugs on Dodo North wells and abandon in-situ where options 2 and three are considered
- Recover all valves, fittings, and other topside facilities for restoration, reuse or sales where options 3 or 4 is selected
- Dismantle all surface facilities and fencing and recover platform structures for restoration, reuse or sales where options 3 or 4 is selected
- Dig out and flame-cut pipeline risers. Weld end caps buried sections, fill line with inhibited water at 10barg and backfill where option 3 is selected
- Decommission manifold foundation piles to a point 1m below the mud line and cut of pile legs where option 3 is selected.
- Uproot piles completely and remove to a safe disposal site where option 4 is selected
- Decommission CP test posts, fink stations and ground beds as applicable where options 3 or 4 is selected
- Perform site restoration activities including removal of contaminated earth and replacement with uncontaminated top soil from similar environment
- Update drawings to show abandoned sections.

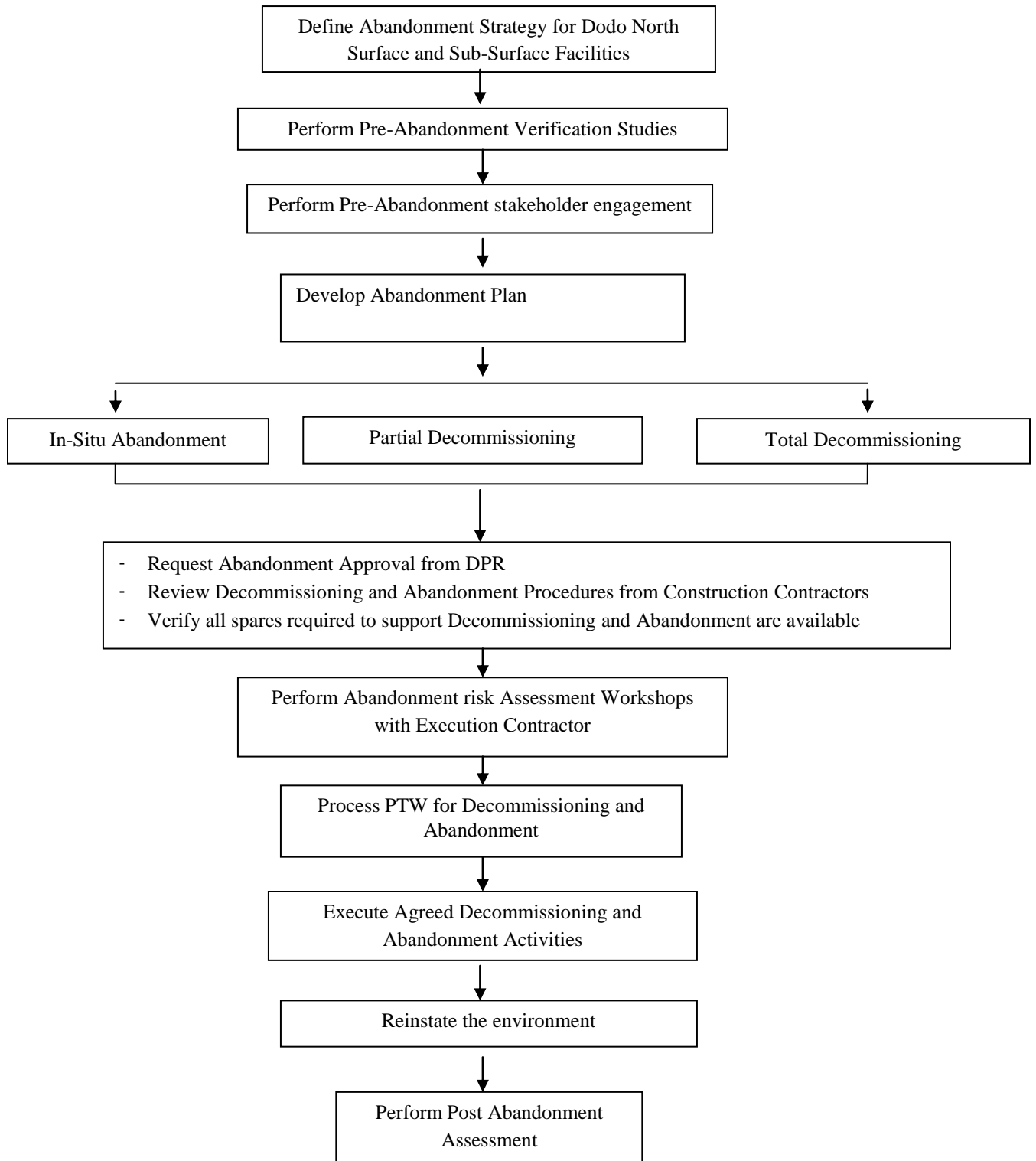


Figure 8.2: Decommissioning and Abandonment Decision Flowchart

8.10: Decommissioning and Abandonment Considerations

The decommissioning and abandonment of the Dodo North surface and sub-surface facilities shall be executed with keen considerations to issues arise from the need to address public safety, legal requirements, environmental protection, and future land use. During the pre-abandonment review a risk assessment shall be performed to identify and closeout all applicable risk issues arising from the abandonment scope, and execution methods and issues identified shall be documented for implementation in the execution contractor's procedures and method statements and tracked for closure by the project team.

8.10.1: Environmental Conditions

The seasonal data gathered in the Dodo North Environmental Impact Assessment Report and environmental impact monitoring reports issued during construction of the Dodo North Facilities shall form input to the pre-abandonment environmental impact assessments. Requirements for environmental reinstatement during abandonment shall be captured in the Environmental Monitoring Plan for abandonment phase.

8.10.2: Land Use Management

The Dodo North Bulkline right of way (ROW) and well access slot land acquisition lease was acquired in 2013 for a 20 years term. Abandonment of this pipeline asset in-situ would imply that the existing Pipeline ROW will need to be maintained and kept under surveillance as long as the pipeline is abandoned in-situ. The pipeline plot alignment as abandoned shall be maintained in SPDC Geomatics database for reference purposes in case of future pipeline designs and crossings.

8.10.3: Ground Subsidence

The long-term structural deterioration of the pipeline abandoned in place may lead to some measure of ground subsidence. This is an issue with potential environmental and safety concerns for the large bore pipeline, which are to be abandoned in-situ in a tidal swamp environment. Ground subsidence could create the potential for water channeling and subsequent erosion, leading to topsoil loss, impact on land use and land aesthetics, and/or pose a safety hazard. The rate and amount of ground subsidence over time depends on a complex combination of site-specific factors, such as the corrosion mechanics in the vicinity of the pipeline, the thickness and diameter of the pipeline, the quality of the pipeline's coating, burial depth, soil type, the failure mechanics of the pipeline material, and soil failure mechanics.

8.10.4: Soil and Groundwater Contamination

Any soil or ground water contamination noted prior to the abandonment activities shall be cleaned up to the applicable regulatory standards prior to commencement of the decommissioning and abandonment work program by the execution contractors, unless it can be demonstrated that environmental damage will not be amplified. The execution contractors work

program shall provide controls to prevent effluent release to the environment or seepage to the ground water table leading to ground water contamination. The quality of pipe coating at abandonment is considered one of the most critical determinants of the abandoned pipeline integrity over time. However, in the event of a leak, the residual contaminants (approx. 10ppm of hydrocarbon) in the abandoned pipeline are unlikely to significantly contribute to soil and ground water contamination.

8.10.5: Water Crossings

The effect of pipelines at water crossings is an important issue at any phase of the asset life cycle due to the social significance of these waterways to local communities for on fishing activities, public use of waterways, cultural and historical feature and marine regulations. River crossing pipeline sections shall also be abandoned in-situ after cleaning to 10ppm residual water quality to minimize the potential for contamination of the water body due to the escape of any internal residues from the eventual failure on the abandoned pipeline. The ends of pipeline segments to be abandoned in-situ shall be cut below the riser section along the pipeline natural centre line and capped consolidated as well as all the buried tie-in connections. Most of the river crossing line pipes have been installed in trenches and buried with a earth cover of over 1.5m and shall be filled with inhibited water to maintain its negative buoyancy and thus mitigate the risk of pipe exposure during the abandonment phase. Damage to any existing bank stabilization structures or destabilization of previously stable banks shall be restored by the execution contractors.

8.10.6: Soil Erosion

Soil erosion is a concern during all phases of the pipeline life cycle, particularly as it relates to slope stability. Leaving a pipeline in the ground may entail a certain amount of activity along the ROW to ensure responsible abandonment, such as excavations to confirm cleaning quality and the installation of caps or plugs. The potential impact of the ensuing ROW disturbance will vary greatly with the geographic location of the activity. If the pipe shall be removed, erosion and slope stability concerns will be similar to those for pipeline construction. For example, traffic, soil compaction, and wind and water erosion of disturbed soil may be of concern. In addition, the pipeline may have become a structural support to many slopes over the time, and its removal may affect the integrity of the slope.

8.10.7: Effluent Management

Effluents from the cleaning and pigging of the Dodo North lines shall be redirected into the surge vessel at Tunu Flows station and evacuated to Forcados Terminal for treatment and disposal. Emergency response facilities including an environmental barge and spill containment booms shall be mobilised to site during decommissioning and abandonment to evacuate any oil or oily-water mixtures recovered from the drain points or retained in headers and other piping spools when disconnected. Oil or oily oil mixture recovered during this process shall be evacuated to the nearest Flowstation, where it shall be pumped via a saver-pit to the terminal.

8.10.8: Site Reinstatement

Right of Way Maintenance for the Dodo North Pipelines shall be provided by SPDC Pipeline Asset Team including surveillance provisions and these requirements shall remain in place for the Pipeline abandoned in-situ. Site reinstatement activities are anticipated around the pigging manifolds where activities around cutting of manifold risers and disconnection of piping spools are planned. The following site reinstatement activities are proposed to be executed post abandonment of the pipeline in-situ:

- Exhume contaminated soil around manifold sites
- Back-fill with appropriate top soil
- Allow two rainy seasons for natural vegetation to sprout and root

8.10.9: Post- Abandonment Responsibilities

Once the pipeline has been abandoned, the Pipeline Asset Team shall continue to maintain a ROW monitoring program (ROW management and surveillance) to ensure that the ROW and any facilities left in place remain free of problems associated with the abandonment. Records shall be kept of all observations on the abandoned pipeline. These records shall be advised to DPR and maintained on the Geomatics database for referencing with respect to future crossing by other SPDC or third party pipelines. All stakeholders (landowners, host community, Government agencies (FMEnv & DPR) will be notified on the abandonment of the Dodo North Facilities. Any input provided by these groups should be recorded in the post-abandonment logbook.

8.10.10: Decommissioning and Abandonment Interfaces

Figure 8.3 shows a cross section of interfaces identified for decommissioning and abandonment of Dodo North surfaces and sub-surface facilities. Prior to and as part of initiation of the decommissioning and abandonment program for Dodo North facilities several stakeholder engagement sessions may be required to secure alignment of interests and relevant stator approvals.



Figure 8.3: Decommissioning and Abandonment Interface Chart

8.10.11: Regulatory Interfaces

Implementation of decommissioning and abandonment of the Dodo North surface and subsurface structures shall be carried out in line with applicable statutory requirements. As a statutory requirement, a letter-of-intent shall be dispatched seeking the consent for abandonment approval from the Department of Petroleum Resources three months before the planned abandonment of Dodo North facilities. This shall be accompanied with the detailed abandonment plan and methods to be adopted in executing the works as well as proposals for restoring disturbed areas on the ROW.

In addition, The Federal Ministry of Environment shall be invited to witness the decommissioning and abandonment activities and a Joint Monitoring Site Visits with Representatives of the Federal Ministry of Environment shall be performed during the abandonment phase. The Department of Petroleum Resources (DPR)' regulatory requirements as contained in DPR guidelines and procedures for the design, construction, operation and maintenance of oil and gas pipeline systems in Nigeria (2007), Petroleum and Gas (Production

and Safety) Regulation 2004 and Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) include the following:

- Issue notice of Abandonment and request DPR Approval of proposed Dodo North Decommissioning / Abandonment Plan
- The need for an Environmental Evaluation (post impact) report if an EIA baseline survey was not done during project implementation.
- A mandatory decommissioning plan specific to the activity. The plan shall contain: peculiarity of the project; the degree of abandonment (partial/complete); installation removal method, verification, disposal of removed structure, debris and waste and environmental protection and monitoring aspects.
- The overarching objective should be to appropriately decontaminate, dismantle and remove structures from decommissioned facilities.
- Decommissioning needs to commence within one year of abandonment and be completed six months after commencement.
- Community consultations.
- Comply with administrative procedures on property divestiture.
- Issue well abandonment report to DPR
- Need for a decommissioning certificate, when works are complete.

Specifically, the DPR guidelines require that buried Process equipment/facilities and pipelines need to be decontaminated, plugged and left buried on site if safe to do so (otherwise it should be excavated and removed) while all surface components are required to be removed. The project team will undertake early engagement of the regulation agencies (DPR) and Federal Environmental Protection Agency (FEPA), as this is essential to obtaining the necessary consents and approvals. Prior to the commencement of abandonment process, a letter-of-intent shall be despatched seeking the consent of the agencies. It will state the company's intention, methods to be adopted in executing the works, restoring the site, amongst others.

8.10.12: Community Interfaces

The decommissioning plan to be adopted shall have minimum negative impact on the community. Community concerns related to SPDC's exit plans for the facilities would be taken on board to ensure successful decommissioning of the facilities.

Community concerns to be addressed include:

- Effect on existing community employment and facility maintenance contracts with host communities.
- Environmental and health risks associated with decommissioning and abandonment of the facility.

- The intended future use of the site.

Before decommissioning of Dodo Facilities, SPDC shall consider alternative uses by the host community. SPDC will seek local authority views on possible uses of the facility being abandoned; these will be taken into account in the abandonment strategy, work scope, and contracting strategy. Abandonment shall be concluded without any liabilities to SPDC. In case of leftover for the host community, the responsibilities shall be duly transferred to the community with a fully documented transfer. All engagements with the Host communities shall be through the Community Development Board. Existing agreements on the engagement and disengagement of skilled, semiskilled and unskilled labour forces from the local communities shall be adopted.

8.10.13: Abandonment Execution Interfaces

Execution the Dodo North Decommissioning scope shall be performed using competent Construction Contractors. Competent NGO and environmental consultants shall be engaged to participate in the pre-abandonment assessment. This shall include all revegetation and site reinstatement works required on disturbed sections of the ROW and Manifold plots. Treatment of spills, contaminated soils and rehabilitation of polluted areas shall be part of the abandonment scope. Polluted soil shall be treated in accordance with SPDC standards. The resulting soil shall be buried under humus topsoil that can sustain vegetation growth. Such treatment may include incineration, mixing with composite, or reinstating at a permanent landfill/waste disposal site. A Pre-Abandonment Evaluation (Abandonment on paper) shall be carried out and report issued ahead of the abandonment kick-off in conjunction with the execution contractors. All decommissioning and Abandonment activities shall be monitored by the Dodo North NAG commissioning and start up team.

8.10.14: Material Handling and Logistics Interfaces

The execution contractors shall make provision for all equipment, powered tools, specialist personnel, skilled, semi-skilled and unskilled engagement from local community required for safe decommissioning and abandonment of the asset. The construction contractors shall advise a mobilisation plan and method statement for abandonment, which ensures that all equipment and tools used within the existing facilities, are intrinsically safe for use within a Zone 1 hazardous Area. All other equipment with energy sources shall be deployed at a safe distance from the facilities.

Decommissioned structures shall be dismantled into manageable modules for transportation to land. All installed piles shall be completely removed to a point at least 4m below the mud line. This is to eliminate anchor damage on vessels and fishing gears around this route. The execution contractor's shall ensure the preservation, handling and packaging of the reusable items by applying a protective film/layer of preservation gel or mothballing, packaging, labelling and storage at designated SPDC store. The execution contractors shall deliver all already conditioned

reusable materials to SPDC stores for preservation and storage. Scrap materials shall be treated in line with SPDC standard procedures on handling/sales of scrap. All reusable items recovered from the decommissioning of Dodo North facilities shall be preserved at SPDC KI and IA stores within Port Harcourt till a time when they are required for any future use.

8.10.15: Asset Owner/Operator

The Pipeline and Production Asset Team shall be engaged to discontinue use of dodo north wells and associated surface facilities. The Asset team shall isolate and line up the Dodo North facilities for final cleaning prior to decommissioning and abandonment in line with the isolation plan documented in the decommissioning and Abandonment Procedure. The asset team shall also provide system isolation prior to decommissioning and removal of all redundant piping loops from site.

8.10.16: Project Team

A decommissioning project team may be set up for the Dodo North facilities or scope assigned to the facilities decommissioning project team. Experienced operations specialists with construction knowledge to perform decommissioning, shall be resourced from Pipeline Asset Integrity Team, Pipeline Operations Team and Western Swamp Operations Teams. The abandonment team shall manage all day-to-day interfaces related to decommissioning and abandonment of the existing asset prior to handover to the asset team.

8.10.17: Remediation Requirements

Prior to the implementation of remediation scope, an investigation of eco-toxicology of the site against its future use will be undertaken. The study will focus on contaminants in soil, sediments, surface water and ground water. A risk-based correction approach (RBCA) will be considered. Soil and sediment samples will be analysed for salinity, Total Petroleum Hydrocarbons (TPH), Metals, Cation Exchange Capacity (CEC), Exchangeable Sodium Percentage (ESP), Polynuclear Aromatic Hydrocarbons (PAHs), Benzene, Toluene, Ethylbenzene (BTEX), Polychlorinated Biphenyls (PCBs), Halogenated Volatile Organic Compounds (VOCs), Extractable Organic Halides (EOX), Radioactivity, Glycol and Amines and Sterilant scan.

Water samples (including ground water) will also be analysed against WHO standard. Parameters analysed will include, Temperature, pH, Dissolved oxygen, Conductivity, Alkalinity, Hardness, Total Dissolved Solids (TDS), Dissolved cations and Anions, TPH, Total phenols, Nitrogen, Phosphorus, Total Organic Carbons (TOC), Dissolved Organic Carbons (DOC), Chemical Oxygen Demand (COD), metal scan, BTEX, PCBs, Homogenate VOCs, Absorbable Organic Halides (AOX), PAHs, etc.

8.10.18: HSE

Prior to implementation a detailed HSE plan shall be prepared to mitigate risks arising from physical, biological and chemical hazards.

8.10.19: Pre-Abandonment Evaluation Report

A Pre-Abandonment Evaluation Report (PAER) shall be prepared approximately three months ahead of the abandonment kick-off. The Environmental Evaluation (EE) is expected to take 2 to 12 weeks based on the scope of Dodo North decommissioning and abandonment. EE shall be carried out using an independent consultants and/or non-governmental organizations (NGO) within the Southern Swamp Area.

8.10.20: Preservation of Re-usable Items

Construction work plan shall address the preservation, handling and packaging of the reusable items. Most reusable equipment shall be preserved by means of applying a protective film/layer of preservation gel or mothballing, packaging, labeling and storage at a designated material store.

8.10.21: Soil Treatment

Treatment of spills and contaminated soils in the well and field facilities are part of normal operation of the facilities. However, rehabilitation of polluted areas shall be an abandonment activity. Polluted soil shall be treated in accordance with SPDC standards. The resulting soil shall be buried under humus topsoil that can sustain vegetation growth. Such treatment may include incineration, mixing with composite, or reinstating at a permanent landfill/waste disposal site.

8.10.22: Scrap Handling

All recovered scraps shall be treated in accordance with standard procedures on handling/sales of scrap. SPDC will investigate the possibility of donation to local government for local projects or to Universities for research works.

8.11: Abandonment Process

A three stage approach (Initiation, Execution and Close-out) will be utilised in the Dodo North wells, flowlines and bulkline assets abandonment implementation plan.

8.11.1: Initiation

Towards the end of the ten years design life, a detailed asset integrity and reserves assessment to confirm if extension of service will be required to support the decision to decommission and abandon the Dodo North Facilities. Where significant integrity concerns or uneconomical reserve

volumes to support further production is identified, further assessment will be required to establish the preferred decommissioning and abandonment alternative in line with Table 8.1.

The asset holders will then initiate abandonment for these facilities based on the outcome of these assessments and recommendations in the Asset Operations Plan (AOP). Subsequently, the Asset Holder shall raise an Asset Abandonment Sheet (similar to Project Proposal Sheet) for consideration and provision of OPEX funding during the programme preparation.

The initiation note shall actuate an Environmental Evaluation that shall be carried out by a team of representatives from Environmental department, Asset Holder department, and executing department. A Pre-Abandonment Evaluation Report (PAER) shall be developed detailing the following:

- Description of well, facility or field to be abandoned.
- Qualitative and quantitative description of impacted areas/environmental resources affected by the facilities installed.
- Community concerns as regards other possible usage of the well or field facilities being abandoned.
- Recommend abandonment strategy.
- Procedure and techniques that would be used in the execution.
- Plans for the removal of contaminated or potentially dangerous material and impacted environment restoration.

Relevant departments and divisional management will approve this PAER. It will form the basis for a letter of intent that will be raised to DPR/FMEnv.

8.11.2: Execution

After passing through the abandonment initiation approval gate, an abandonment work execution plan shall be prepared based on detail engineering design, showing the detail work stages of the facilities to be abandoned. The major activities and responsibilities during decommissioning and demolition/abandonment is presented in Table 8.3.

Table 8.3: Proposed Decommissioning and Abandonment Execution Strategy

Activity	Responsibility
Shutdown of Dodo North Wells	SPDC
Depressurise Dodo North Bulkline	SPDC
Flush degas and inert flowlines, bulkline and end facilities	Contractor
Recover and restore all equipment identified for reuse	Contractor
Recover and transfer to SPDC storage all scrap items to be sold	Contractor

Activity	Responsibility
Cut off surface piles and pipeline risers and mothball buried bulkline	Contractor
Set cement plug to depth and recover redundant wellhead facilities	Contractor
Check and confirm all systems are free of hydrocarbon.	Shell/Contractor

The contractor will prepare, for his work scope a Decommissioning/Abandonment work execution procedure that will detail, among others:

- How the work (Decommissioning/Abandonment) will be carried out.
- CASHES requirements for project execution (including Hazard identification and management during the execution phase)
- Preservation and storage of reusable materials.
- Treatment of wastes and polluted soil.
- Method of site restoration and re-vegetation.
- Logistics

8.11.3: Close-out

For every asset being abandoned, an As-Abandoned drawing shall be prepared.

Land shall be returned to owners after re-vegetation (as necessary) with joint agreement between the company and landowners. Where the asset is converted to an alternative use for the host community a land mark, perhaps a pedestal with Shell shield (Tombstone) shall mark the return of such facilities to the community. The effective date of handover of the facility and an indication that the maintenance of such facility now reverts to the owners shall be clearly stated. Local authorities (Government Land Department) shall be duly involved.

Photographs of the "as-returned" state shall be taken and included in a closeout report. After executing the decommissioning plan, a monitoring programme will be put in place to verify the effectiveness of the implementation. The monitoring programme will seek to verify the preservation, remediation or reclamation effort. The monitoring scope will include:

- Sampling and analysis of soil from possible contaminated zones and adjacent areas.
- Sampling and analysis of sediments and waters from adjacent surface water bodies to verify that contamination has not migrated during the cleanup operations.

8.11.4: Abandonment Cost

Decommissioning and Abandonment Cost estimate shall be prepared for the Dodo North scope to support the decommissioning initiation process.

8.12: Potential and Associated Impacts of Decommissioning and Abandonment activities

The impact assessment methodology for the identification and evaluation of potential and associated impacts of the Decommissioning and Abandonment activities is presented in Chapter five. A detailed Environmental Management Plan for the Decommissioning and Abandonment activities is highlighted in Table 8.4.

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Table 8:4: Detailed Environmental Management Plan for the Decommissioning and Abandonment of Dodo North NAG Wells

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
Premobilization phase	Location preparation for rig re-entry	Impairment of air quality (increase in SPM levels)	M	SPDC shall ensure: -Dust reduction measures such as sprinkling of water during clearing shall be applied. -Regular maintenance of equipment shall be carried out. -Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits. -Compliance monitoring programmes shall be carried out in line with DPR guidelines. -Work procedures and practices that will minimize emission to the barest minimum shall be adopted.	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
		Increase in noise and vibration	M	SPDC shall use only pre-mobbed and regularly maintained equipment	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
		Accidents and injuries	H	SPDC shall ensure <ul style="list-style-type: none"> • daily pep talk is carried out for road transportation • Safety signage shall be 	L	Safety /accident report	Weekly	SPDC/DPR	5000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				deployed at strategic locations. <ul style="list-style-type: none"> • Emergency response plan shall be in place • Use of PPEs by the construction team 					
		Piracy/Kidnapping	H	SPDC shall <ul style="list-style-type: none"> • make adequate security arrangements at the project site • ensure that security orientation and awareness is conducted for workforce • SPDC shall support initiatives and programmes by Government to improve security • A security management plan shall be produced for the project before mobilization • Workers to be educated to be security conscious • Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition employment opportunities for the indigenes 	M	Security report	Daily	SPDC/DPR	15000
		Increase in Waste	H	SPDC shall	L	Environmental	Monthly and	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
		generation		Develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice.		compliance monitoring report	quarterly		
		Alteration of soil fauna community	M	<ul style="list-style-type: none"> Best available technology which entails minimum cost shall be applied. Land take shall be to the minimum. Equipment and machines with low track pressure shall be used. 	L	Site inspection reports	Quarterly	SPDC/DPR	5000
		Employment and income generating opportunity	P	<ul style="list-style-type: none"> Indigenous contractors and resource (qualified) persons shall be used. SPDC shall develop procedure/criteria for indigenous labour sourcing/employment. 	P	Contractor engagement report, employment records	Quarterly	SPDC/DPR	
Mobilization phase	Mobilization of personnel, equipment and materials to the site	Impairment of air quality	M	SPDC shall ensure: -Dust reduction measures such as sprinkling of water during clearing shall be applied. -Regular maintenance of	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				equipment shall be carried out. -Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits. -Compliance monitoring programmes shall be carried out in line with DPR guidelines. -Work procedures and practices that will minimize emission to the barest minimum shall be adopted.					
		Increase in noise and vibration	M	SPDC shall use only pre-mobbed and regularly maintained equipment	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
		Interference with road transport	M	SPDC shall ensure <ul style="list-style-type: none"> • Compliance with journey management policy for road transport. • Only pre-mobbed Vehicles be used • daily pep talk is carried out for road transportation • Safety signage shall be deployed at strategic locations. • Emergency response plan shall 	L	Journey management report.	Monthly	SPDC/DPR	5000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				be in place.					
		Accidents and injuries	M	<ul style="list-style-type: none"> An approved journey management plan shall be applied. All SPDC/contractor drivers shall undergo the driver education program. All project vehicles shall be pre-mobbed and certificate of worthiness issued. Speed limits shall be according to SPDC journey management policy. Appropriate warning signs shall be placed on approved routes. Awareness campaign shall be carried out. 	L	Journey management report Incident register	During the mobilization phase	SPDC/DPR	10000
		Piracy/Kidnapping	H	SPDC shall <ul style="list-style-type: none"> make adequate security arrangements at the project site ensure that security orientation and awareness is conducted for workforce SPDC shall support initiatives and programmes by 	M	Security report	Daily	SPDC/DPR	15000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				Government to improve security <ul style="list-style-type: none"> • A security management plan shall be produced for the project before mobilization • Workers to be made aware to be security conscious • Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition employment opportunities for the indigenes 					
		Increase in waste generation	M	<ul style="list-style-type: none"> • Waste contractors shall be engaged to manage wastes. • Waste containers shall be placed in all strategic points by colour coding or labelling. • Awareness campaigns shall be carried out on the need for improved sanitation and health implications of dirty environment. 	L	Site inspection Compliance monitoring report Waste Inventory log book	Daily	SPDC/DPR	10000
Decommissioning phase	Shutdown of Dodo North Wells	Accidents and injuries	H	SPDC shall ensure: <ul style="list-style-type: none"> • Provision and enforcement of appropriate PPE by worksite personnel at all times. 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				<ul style="list-style-type: none"> • Only competent workers will be employed and used to perform various tasks. • Site nurses and ambulance shall be drafted to each project activities. • Appropriate first aid kits shall be available on site. 					
	Depressurise Dodo North Bulkline	Accidents and injuries	H	SPDC shall ensure: <ul style="list-style-type: none"> • Provision and enforcement of appropriate PPE by worksite personnel at all times. • Only competent workers will be employed and used to perform various tasks. • Site nurses and ambulance shall be drafted to each project activities. • Appropriate first aid kits shall be available on site. 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000
		Air quality impairment from fugitive gas emission	M	SPDC shall ensure: <ul style="list-style-type: none"> -Dust reduction measures such as sprinkling of water during clearing shall be applied. -Regular maintenance of 	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				equipment shall be carried out. -Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits. -Compliance monitoring programmes shall be carried out in line with DPR guidelines. -Work procedures and practices that will minimize emission to the barest minimum shall be adopted.					
		Opportunity for contracting	P	<ul style="list-style-type: none"> Indigenous contractors and resource (qualified) persons shall be used. SPDC shall develop procedure/criteria for indigenous labour sourcing/employment. 	P	Contractor engagement report, employment records	Quarterly	SPDC/DPR	
	Flush degas and inert flowlines, bulkline and end facilities	Accidents and injuries	H	SPDC shall ensure: <ul style="list-style-type: none"> Provision and enforcement of appropriate PPE by worksite personnel at all times. Only competent workers will be employed and used to perform various tasks. Site nurses and ambulance shall 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				be drafted to each project activities. • Appropriate first aid kits shall be available on site.					
		Air quality impairment from fugitive gas emission	M	SPDC shall ensure: -Dust reduction measures such as sprinkling of water during clearing shall be applied. -Regular maintenance of equipment shall be carried out. -Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits. -Compliance monitoring programmes shall be carried out in line with DPR guidelines. -Work procedures and practices that will minimize emission to the barest minimum shall be adopted.	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
		Opportunity for contracting	P	• Indigenous contractors and resource (qualified) persons shall be used. • SPDC shall develop procedure/criteria for	P	Contractor engagement report, employment records	Quarterly	SPDC/DPR	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				indigenous labour sourcing/employment.					
	Recover and restore all equipment identified for reuse	Accidents and injuries	H	SPDC shall ensure: <ul style="list-style-type: none"> • Provision and enforcement of appropriate PPE by worksite personnel at all times. • Only competent workers will be employed and used to perform various tasks. • Site nurses and ambulance shall be drafted to each project activities. • Appropriate first aid kits shall be available on site. 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000
		Increase in waste generation	M	<ul style="list-style-type: none"> • Waste contractors shall be engaged to manage wastes. • Waste containers shall be placed in all strategic points by colour coding or labelling. • Awareness campaigns shall be carried out on the need for improved sanitation and health implications of dirty environment. 	L	Site inspection Compliance monitoring report Waste Inventory log book	Daily	SPDC/DPR	10000
		Opportunity for	P	<ul style="list-style-type: none"> • Indigenous contractors and 	P	Contractor	Quarterly	SPDC/DPR	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
		contracting		resource (qualified) persons shall be used. <ul style="list-style-type: none"> • SPDC shall develop procedure/criteria for indigenous labour sourcing/employment. 		engagement report, employment records			
		Third party agitation	M	<ul style="list-style-type: none"> • SPDC shall ensure management of public expectations by engaging NGOs and CBOs • SPDC shall ensure regular/periodic dialogue sessions with active NGOs and CBOs • SPDC shall ensure adoption of appropriate community entry strategies; 	L	Records of public engagement sessions Records of minutes of meetings Records of Third Party Grievances	Quarterly	SPDC/DPR	
	Cut off surface piles and pipeline risers and mothball buried bulkline	Accidents and injuries	H	SPDC shall ensure: <ul style="list-style-type: none"> • Provision and enforcement of appropriate PPE by worksite personnel at all times. • Only competent workers will be employed and used to perform various tasks. 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				<ul style="list-style-type: none"> Site nurses and ambulance shall be drafted to each project activities. Appropriate first Aid kits shall be available on site. 					
		Increase in waste generation	H	All categories of waste generated shall be carefully collected and treated according to SPDC waste management plan	L	Site inspection Compliance monitoring report Waste Inventory log book	Daily	SPDC/DPR	10000
		Third party agitation	M	<ul style="list-style-type: none"> SPDC shall ensure management of public expectations by engaging NGOs and CBOs SPDC shall ensure regular/periodic dialogue sessions with active NGOs and CBOs SPDC shall ensure adoption of appropriate community entry strategies; 	L	Records of public engagement sessions Records of minutes of meetings Records of Third Party Grievances	Quarterly	SPDC/DPR	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
		Contracting and employment generation	P	<ul style="list-style-type: none"> Indigenous contractors and resource (qualified) persons shall be used. SPDC shall develop procedure/criteria for indigenous labour sourcing/employment. 	P	Contractor engagement report, employment records	Quarterly	SPDC/DPR	
		Air quality impairment (SPM levels) and Noise levels	H	SPDC shall ensure: <ul style="list-style-type: none"> Appropriate use of PPE Regular maintenance of equipment shall be carried out. Compliance monitoring programmes shall be carried out in line with DPR guidelines. Work procedures and practices that will minimize emission to the barest minimum shall be adopted. 	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
		Piracy/ Kidnapping	H	SPDC shall <ul style="list-style-type: none"> make adequate security arrangements at the project site ensure that security orientation and awareness is conducted for 	M	Security report	Daily	SPDC/DPR	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				workforce <ul style="list-style-type: none"> • SPDC shall support initiatives and programmes by Government to improve security • A security management plan shall be produced for the project before mobilization • Workers to be made aware to be security conscious • Engagement of the youths from the area on worthwhile ventures e.g. skills acquisition employment opportunities for the indigenes 					
	Set cement plug to depth and recover redundant wellhead facilities	Potential Brine /cement spills	H	SPDC shall Develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice.	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	5000
		Impairment of air quality (high methane gas)	H	SPDC shall ensure: <ul style="list-style-type: none"> • Appropriate use of PPE • Regular maintenance of equipment shall be carried out. • Compliance monitoring 	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
				<p>programmes shall be carried out in line with DPR guidelines.</p> <ul style="list-style-type: none"> • Work procedures and practices that will minimize emission to the barest minimum shall be adopted. 					
		Accidents and injuries	H	<p>SPDC shall ensure:</p> <ul style="list-style-type: none"> • Provision and enforcement of appropriate PPE by worksite personnel at all times. • Only competent workers will be employed and used to perform various tasks. • Site nurses and ambulance shall be drafted to each project activities. • Appropriate first aid kits shall be available on site. 	L	Incident register	During the decommissioning phase	SPDC/DPR	10000
		Contracting and employment generation	P	<ul style="list-style-type: none"> • Indigenous contractors and resource (qualified) persons shall be used. • SPDC shall develop procedure/criteria for indigenous labour sourcing/employment. 	P	Contractor engagement report, employment records	Bi annual	SPDC/DPR	

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Project Phase	Project Activity	Potential Impacts	Impact Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party	Costs (\$)
		Soil contamination (Spill or lubricants)	H	SPDC shall ensure: <ul style="list-style-type: none"> proper maintenance of equipment mobilized to site; Natural attenuation of impacted soils shall be done. 	L	Environmental compliance monitoring report	Monthly and quarterly	SPDC/DPR	10000
Restoration Phase	Backfilling of existing pits and Levelling of entire drill site	Change in topography	H	<ul style="list-style-type: none"> Care shall be taken to backfill existing pits with excavated materials, in the order of excavation. 	L	Site inspection reports.	Quarterly	SPDC/DPR	10000
		Landscape modification	H	SPDC shall develop and implement landscaping plan in the reinstated site	M	Site Inspection Report	Quarterly	SPDC/DPR	20000
	Spreading of native humus soil and revegetation with native plant species	Disruption of sedges and other emerging plants	H	Where applicable, SPDC shall ensure only indigenous plant species are used to revegetate the site	M	Site Inspection Report	During restoration phase	SPDC/DPR	20000

CHAPTER NINE CONCLUSION

This Environmental Impact Assessment (EIA) report was prepared adopting a multidisciplinary team approach consistent with FMEnvSectoral Guidelines for Oil and Gas Projects and the DPR's Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN, 2002). The EIA study involved detailed literature search, field observation and in situ measurements, field sampling, laboratory analyses/data analyses, impact identification/evaluation, and reporting.

The Dodo North NAG field development was strategically considered a quick win to produce gas essential to meet the domestic gas obligation of 100MMscfd agreed with the Federal Government due to its proximity to the Tunu CPF and the flexibility of drilling new wells on existing location with minimal land-takes. The wells shall have a peak individual production capacity of 100MMscfd which shall be regulated to make up AG volumes, maintain domestic gas obligation of 100MMscfd over the next 10years and maintain effective reservoir management.

The EIA of the project shows that it would have a significant beneficial impact on both local and national economy. The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. Further, an Environmental Management Plan (EMP) has been developed to ensure that the identified potential impacts can be reduced to "as low as reasonably practical" (ALARP). The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components.

It is concluded that the execution of the outstanding activities of the Dodo North NAG Wells Project will not cause serious damage to the environment if the EMP is implemented. The approval of this EIA report for the execution of the proposed project is hereby recommended.

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**APPENDIX I
METHODOLOGY**

1.1: Fieldwork activities

Fieldwork was carried out between 1st and 10th August 2012 for the bio-physical, health and social environment data gathering. The field study involved data acquisition on climate and meteorology, air quality and noise, soil, vegetation, aquatic, wildlife, geology/geophysics/hydrogeology, socio-economic and health status of persons in the localities within and around the fields.

Table 1: Proposed Sampling Locations/Co-ordinates

AIR		
CODE NAME	EASTING	NORTHING
AQ4	360005	104520
AQ40	362670	101394
AQ41	361470	101365
AQ42	361819	102395
AQ43	361970	100893
AQ44	363681	101299
AQC4	366811	107390

SURFACE WATER		
CODE NAME	EASTING	NORTHING
SW1	363199	104253
SW2	365053	103074
SW3	365543	100583
SW4	367277	104510
SW5	363515	106043
SW6	362471	101138
SW7	362963	101687
SW8	361451	100619
SW9	360966	100103
SW10	361101	101356
SW11	361829	102944
SW12	359696	101188
SW13	358383	99689
SW14	355544	97879
SW15	363142	100846

SURFACE WATER		
CODE NAME	EASTING	NORTHING
SWC1	366166	107806
SWC2	335917	87894

SEDIMENT		
CODE NAME	EASTING	NORTHING
SD1	363199	104253
SD2	365053	103074
SD3	365543	100583
SD4	367277	104510
SD5	363515	106043
SD6	362471	101138
SD7	362963	101687
SD8	361451	100619
SD9	360966	100103
SD10	361101	101356
SD11	361829	102944
SD12	359696	101188
SD13	358383	99689
<i>SD14</i>	355544	97879
<i>SD15</i>	363142	100846
SDC1	366166	107806
SDC2	335917	87894

SOIL		
CODE NAME	EASTING	NORTHING
SS1	359937	104151
SS2	362011	104929
SS3	363648	103251
SS4	365285	103688
SS5	347010	109714
SS6	362982	101318
SS7	362367	101951
SS8	362150	101290

SOIL		
CODE NAME	EASTING	NORTHING
SS9	362651	101772
SS10	362859	100883
SS11	363520	100543
SS12	364040	99957
SS13	363946	102008
SS14	364503	101554
SS15	361432	99951
SS16	361451	100619
SS17	361498	101195
SS18	361224	101620
SS19	361252	102140
SS20	362519	102386
SS21	361110	103019
SS22	371275	100798
SS23	360175	102981
SS24	359787	102254
SS25	360077	101519
SS26	359637	100434
SS27	354310	97658
SS28	357923	108623
SS29	358458	110270
SS30	368151	102504
SS31	371992	101572
SS32	356748	99274
SS33	355994	99316
SS34	352037	102020
SS35	355732	105350
SSC1	366811	107390
SSC2	355505	112389

VEGETATION		
CODE NAME	EASTING	NORTHING
VG1	359937	104151
VG2	362011	104929
VG3	363648	103251
VG4	365285	103688

VEGETATION		
CODE NAME	EASTING	NORTHING
VG5	347010	109714
VG6	362982	101318
VG7	362367	101951
VG8	362150	101290
VG9	362651	101772
VG10	362859	100883
VG11	363520	100543
VG12	364040	99957
VG13	363946	102008
VG14	364503	101554
VG15	361432	99951
VG16	361451	100619
VG17	361498	101195
VG18	361224	101620
VG19	361252	102140
VG20	362519	102386
VG21	361110	103019
VG22	371275	100798
VG23	360175	102981
VG24	359787	102254
VG25	360077	101519
VG26	359637	100434
VG27	354310	97658
VG28	357923	108623
VG29	358458	110270
VG30	368151	102504
VG31	371992	101572
VG32	356748	99274
VG33	355994	99316
VG34	352037	102020
VG35	355732	105350
VGC1	366811	107390
VGC2	355505	112389

BOREHOLE		
CODE NAME	EASTING	NORTHING
BH1	365858	102102
BH2	362490	101318
BH3	361299	101223
BH4	358654	100375
BHC1	366811	107390
BHC2	360251	104752

1.1.1: Topography

Topography studies the relative positions, and elevations of natural and man-made features of a particular landscape, such as mountains, rivers, valleys, and human settlements, etc. A systematic sampling technique was adopted as a scheme to extrapolate data evenly about the area for the study. The distribution and pattern of the physical features defining the terrain of the entire study area were used as common approach to landscape description and assessment. Physiographic or land system approach were used to identify the units forming the terrain.

1.1.2 Meteorology, Air Quality & Noise

The climatic information was based on data collected from the study area during the field work and analysis of long term historical data collected from NIMET, Oshodi for Bayelsa and Warri. With the aid of the field map for easy identification, air quality, noise and other data were acquired with reference to specific sites. Measurements were then undertaken at the locations specified on the Map provided for the air quality and noise. Properly calibrated digital portable handheld meteorology, air quality and noise sampling equipment were used to measure the level of each of the parameters.

Table 1: Meteorology, Air Quality and Noise Parameters studied as well as Equipment used for measurement during fieldwork for the EIA of Dodo North NAG Wells Project

Environmental Component	Parameter	Equipment	Unit
Meteorology	Wind Turbulence, speed and direction	Extech Mini Themo-Anemometer	m/s
	Relative Humidity	Extech Mini Themo-Anemometer Plus Humidity	%
	Air temperature	Thermometer	°C
Air Quality	Total Suspended Particles	Gassella monitor	ug/m ³
	Nitrogen Oxides	Zenon , Z-1200	ppm
	Sulphur Oxides	Zenon ; Z-1300	ppm
	Carbon Oxide	Zenon ; Z-1500	ppm
	Ozone	Zenon ; Z-1000	ppm

Environmental Component	Parameter	Equipment	Unit
	Ammonia	Zenon ; Z-800	ppm
	VOC	Dragger tube & GC	ug/m ³
Noise	Decibel level	Noise meter TES 1351 Type 2	d(B) A

Various sound events contribute to sound level measured by any instrument. Besides, the measured wave energy depends on both frequency and amplitude of the sound event. Emphasis is often placed on the sound intensity that is determined only by the amplitude. Therefore, it is only when a loud noise source, which more often than not is intermittent, far exceeds ambient levels that it becomes a source of worry. In practice, it is often preferred to specify the percentage of measurement time that a specified sound level is exceeded. This is implemented in noise measuring instruments as equivalent sound levels in $L_{Aeq,T}$ dB(A). This is thus read as the equivalent sound level in dB containing the same amount of energy of the fluctuating sound energy over a period T. The parameter measured in this study is $L_{Aeq,90}$. An Integrating Sound Level meter was used for measurement at a height of 1.5m above ground level.

1.1.3 Vegetation studies

Vegetation studies are important to understand the existing state of the vegetation including the species composition, diversity, and population (density) of plant species as well as their health status (plant pathology). This is useful for assessment of environmental impacts due to the operations of facilities. Cleared vegetation normally lead to environmental impacts, such as loss of ecologically important plant species and habitats for some animals as well as enhancement of soil erosion. The present study has been carried out to determine the nature of the existing vegetation within the study area.

The vegetation studies were carried out at the same sampling stations with soil studies. Random quadrant sampling technique was employed in the field at predetermined geo-referenced locations.

At each sampling location, two quadrants measuring 10m x 10m and 1m x 1m were used to study trees and shrubs, and herbs respectively. The plant community structure was generally observed and the plant species within each quadrant were identified. The floral and vegetative parts of unidentified plant species were collected, pressed in the field with herbarium press, and taken to the laboratory for herbarium studies and identification. The dominant species are being worked out.

The population of the dominant plant species in each quadrant was determined by counting (Kershaw, 1973). The density of the key tree species and the herbaceous layer including grasses were determined while rare and endangered plant species and all those significant to the ecosystem and the local economy were categorized (Oosting, 1956). The species diversity of the plants are being calculated as the ratio between the number of species and “importance value”

which, for the purpose of this study, is being taken as the number of individuals per quadrant (Odum, 1971). Both general and specific characteristics of the vegetation were assessed by determining its floristic composition, life form and biological spectrum.

The life form spectra of the various plant communities within each of the sampling locations was analysed using the Raunkiaerian life form classification scheme (Raunkiaer 1934, Kerskaw 1973) which divides the life form into the following:

PHANEROPHYTES (Woody Plants)

- Megaphanerophytes (Mgp) - Trees over 30m high
- Mesophanerophytes (Mep) - Trees from 8 - 30m high
- Microphanerophytes (Mip) - Trees and shrubs 2 - 8m high
- Nanophanerophytes (Nanop) - Shrubs under 2m high

EPIPHYTES (Epi)

- Air plants with no roots in the soil.

CHAMAEPHYTES (Cha)

- Plants with surviving buds close to the ground surface. In this study, climbers were included in this class.

HEMICRYPTOPHYTES (Her)

- Plants with surviving buds at the ground level.

CRYPTOPHYTES (Cry)

- Plants with surviving buds below the ground level. This includes rhizomes, corms, tubers and geophytes.

THEROPHYTES (The)

- These are annual plants.

Mature leaves of the commonest plants were collected from the same sampling positions with soil studies for plant tissue analyses.

Pathological investigations were carried out by moving across each of the various micro ecotypes and farms/gardens within and around the sampling locations. This was aimed at determining as well as listing the pests and diseases of crops. Disease severity for each crop was determined by the use of standard disease severity index expressed as infection indices similar to those of Alasoadura and Fajola (1970) and Emua (1980).

Table 2 Infection indices for different levels of disease severity

Infection Index	Description
0	No infection
1	Very light infection
2	Moderate infection
3	Severe infection
4	Very severe infection

Diseased plant/crop parts were aseptically collected using a sharp knife into sterilized polythene bags for further pathological studies in the laboratory. Photographs were taken of the key vegetation types and other features of interest.

1.1.4 Wildlife/Animal Ecology

Assessment of the wildlife fauna of the Dodo North NAG Wells Project area was carried out. At each study location, the invertebrates and vertebrates population were observed in their natural habitat. This was corroborated with data collected from interviews with hunters, trappers and reference to specialist institutions and experts both local and international. Specimens or photographs taken in the field were identified using taxonomic guides in the Zoology Museum, University of Benin. Identification and nomenclature are based on the field guide of birds of Nigeria and West Africa (Elgood, et al., 1994; Serle et al., 1977), Mammals of Nigeria (Happold, 1987).

1.1.5 Soil Studies

A total of one hundred and twenty nine soil sample sites located in different fields of SSAGS+ Project area and its environs within the mangrove swamp ecosystem were investigated. Surface (0 -15 cm) and subsurface (15 – 30 cm) depths were critically examined at each sampling points with the aid of a probe auger. A total of 129 soil samples were collected. Soil colour, texture, consistency, presence or absence of roots and degree of wetness were the major parameters determined in the field.

1.1.6 Aquatic Studies

Aquatic parameters considered includes

- Physico-chemistry of surface water
- Physico-chemistry of bottom sediment
- Phytoplankton
- Zooplankton
- Macrobenthic fauna
- Fisheries Studies

- Hydrology studies

Physicochemical Parameters

At each water sampling station, composite water samples were taken from the surface of the water body diagonally and mixed. The resulting sample was poured into appropriate sample containers, preserved as appropriate (acidified with HNO₃ to a pH of 1.5 for heavy metal analysis, Oil and Grease preserved with 1ml H₂SO₄, and kept at 4°C in ice-packed cooler and then transported to the laboratory for analysis.

Water temperature was measured *in situ* using mercury-in-glass thermometer. Hydrogen-ion concentration (pH), electrical conductivity, total dissolved solids (TDS), dissolved oxygen (DO), salinity and turbidity were measured *in situ* using HACH portable digital meters. Samples for BOD determination were collected in black 250ml reagent bottles and taken to the laboratory for a five-day incubation, fixing and analysis. The other samples were taken to the Thermosteel laboratory in Warri for analysis.

Aquatic Ecology

Phytoplankton and Zooplankton

Composite samples were taken quantitatively by filtering 100 litres of water through 55µm Hydrobios plankton net. All samples were preserved in 4% buffered formaldehyde in labeled polyethylene bottles and taken to the laboratory for analysis.

Fisheries Studies

Fisheries studies investigated fish species composition, diversity, economic importance, harvest methodology, fishing activities and fish sales. These were carried out through artisanal fishing using appropriate gears, inspection of catches by local fishermen both in the field and in fishing camps, interviews of fishermen in camps regarding catch composition and methodology, survey of the fishes on sale in market places within the OML 42 environment, and interview with the fisheries middlemen about the source of their fishes, landing/income per fishing.

Bottom Sediment Physico-chemistry

These samples were taken from the bottom sediment by using an Ekman grab. A total of 82 sediment samples were collected for physico-chemistry, kept in plastic bags and transported to the laboratory for analysis.

Benthic fauna

The Ekman grab or light dredge was used in taking composite samples of profoundly benthic fauna. The grab samples were sieved at the station using 250 - 500µm set of Tyler sieves and preserved in wide-mouthed containers using 4% buffered formaldehyde. All the labeled samples were taken to the laboratory for analysis.

1.1.7 Geophysics and Hydrogeology

The geophysical investigation was carried out with the vertical electrical resistivity sounding method (VES) using the Abem SAS 300B Terrameter in the measurement of the resistance. VES stations were strategically located alongside with a borehole in each site of the study area. The VES stations were near the shallow boreholes which were drilled to provide both strategic and hydro geologic data set that could be extrapolated to cover the entire area under investigation.

The Schlumberger configuration was adopted in the array spread, and a spread length of $AB/2 = 100$ m was achieved as the maximum current electrode separation for all the VES stations. A crew of four (4) persons was involved in the survey which lasted for the same duration as the drilling processes described below. All the VES stations had similar terrain which is that of the boreholes described above. The table below shows the summary of the field survey.

Environmental Borehole Drilling

Equipment used

- One casing bit of 3ft long
- Seven casing string/pipe of 5ft long
- Hand auger and pipe attachment of 10ft long
- Monkey jack/wooden platform
- 16 feet PVC pipe, gravel, cement, gum etc.
- Water pumping machine

The percussion drilling work commenced with a crew of six personnel. A hand auger was used to open a spot and subsequently enlarge the hole to a depth of about $1\frac{1}{2}$ ft, to enable the shoe-casing run through the hole for drilling, while two of the men poke the soil with a hand auger of length 10ft long, which was passed or run through the casing pipe. As the drilling proceeded, the casings were added at different intervals of 5ft respectively. At intervals of every 3ft, borehole formation samples were collected.

1.1.8 Socio Economics/Social Impact Assessment (SIA)

In line with the objectives of the Dodo North NAG Wells Project Social Impact Assessment study of the communities within the area (Table 1.1) was conducted. The methodological design of the study involved descriptive or survey research, which attempts to describe and explain conditions of the present by using many subjects and questionnaires to describe a phenomenon. Primary data were largely used in the study and the research utilized a variety of information gathering tools to maximize data obtained. These tools or data gathering methods included questionnaire administration, focus group discussion, key informant interviews as well as observation. The field engagement was supported with photographic and video documentation of pertinent socio-economic attributes. The data gathering instruments i.e. the questionnaire and FGD guide, were validated by consulting with other experts in sociological issues as well as SPDC representatives to ensure its relevance.

The question instruments covered the following pertinent features:

- Demography
- Livelihood
- Social Infrastructures: availability of infrastructures such as electricity, water, waste management systems etc.
- Cultural Properties e.g. norms and taboos, shrines and religions
- Natural Resources and Land Use pattern e.g. farming type, land acquisition patterns etc
- Perception of the project: perceived risks, benefits, fears and expectations
- Status of vulnerable groups such as women, children & the physically Challenged
- Social Structure and Organization
- Social ills e.g. youth militancy, leadership conflict, inter-community conflict, commercial sex workers etc.
- Education and social services as well as
- Economy e.g. personal income level and employment sources

Survey duration lasted seven (7) days beginning from 1st to 10th August, 2012. The primary data were obtained from community members using different data collection techniques as mentioned above. A total of 260 questionnaires were administered in the 13 communities visited at the rate of 20 per community in order to capture the wide views of the study area. This number was considered as a representative sample for the purpose of this exercise. For respondents that could not read or write, an interpreter was used to facilitate the filling of such questionnaires. In addition FGDs were held in the communities. Membership of the FGD included representatives of the community leadership including men, youths and women as well as non-office holders. This FGD design was adopted to capture and incorporate the divergent views and interest of the sexes and age groupings.

Data obtained were analyzed using descriptive statistics comprising of frequency distribution, percentages and graphs. The Statistical Package of Social Sciences (SPSS) version 20 was used to analyze the data.

1.1.9 Health Status

Health impact assessment is traditionally one of the components of an Environmental Impact Assessment study. The information required for the Health Impact Assessment is usually derived from demographic data and routine health services data, and complemented with data collected from the communities. The field study was mainly to collect data peculiar to each of the communities affected by the gas gathering project, especially:

- Data required for the assessment of the health status of members of the community
- Those required to ascertain the presence and prevalence of risk factors to health; and
- Those required assessing the quality of health services in the communities; and testing the robustness of the health system.

These data are necessary to establish the baseline levels of various risk factors to health, and the health status of members of the impacted communities, for future reference. They are also needed for the assessment of the possible health impact of the gas gathering project on members of the affected communities. The information would also be used to propose possible mitigation measures for the identified hazards of the project, even as efforts are made to further boost the benefits of the project.

Data collection methods

The field study took place between 1st and 10th August, 2012, some of the communities could not be visited during the field study for logistic reasons, while some of the communities were actually satellites of some of the bigger impacted communities. Information on these communities would be acquired through the desktop review of relevant literature, especially the previous EIA studies, carried out in the impacted communities, as listed in the Terms of Reference (TOR).

The field study was carried out using mainly rapid appraisal methods, because they are recommended by the Regulators, to ensure the inputs of members of the impacted communities. They have also been found to be a rapid way of getting valid data. The following rapid appraisal methods were used during the field study:

- Focal Group Discussion, especially with the women of the communities
- Key informant interviews, especially with health workers in the communities and community leaders; and
- On-the-spot observations

These rapid appraisal methods were complemented by the use of a self-administered semi-structured questionnaire. The anthropometric measurements of under-five children and the blood pressure readings of participants at the various discussions held during the field study were also taken. The Focus Group Discussions were held in the house of the Community Chairman, Community Hall, or any convenient place, chosen by members of the community; and conducted using the standard methods. The discussion sessions were mainly with women groups in the communities. Women were chosen because they are the main custodians of the health of members of their households. The discussions were held using a discussion guide (please find attached). At least one session of focus group discussion was held in all the communities visited.

The key informant interviews were held with:

- Key members of the Community Development Committee
- Community health workers posted to the health centers that serve the communities
- Traditional medicine practitioners in the communities, especially Traditional Birth Attendants
- Owners of private health facilities in the communities; and
- Other opinion leaders in the communities, chosen for their ability to provide the needed information

The interviews were held in all the communities visited; and were conducted in an environment that guarantees valid responses.

The interviews of the opinion leaders in the communities were to get a detail view of:

- The living conditions in the communities
- Presence of risk factors in the communities
- Health seeking behaviour; and
- To explore the interviewee's view on the possible health impact of the gas gathering project on the community.

The interviews of health workers and traditional medicine practitioners in the area were to assess the quality of health services in the communities, and the health seeking behaviour of members of the communities.

An average of four key-informant interviews were conducted in each of the communities visited, during the field study.

Direct observations were used to assess:

- The quality of health services in the health facilities serving the communities, using a checklist
- The practices of patent medicine dealers and Traditional Birth Attendants in the communities; and
- The environmental health conditions in the communities, especially:
 - i. The layout of the buildings
 - ii. The source of drinking water
 - iii. Method of refuse disposal
 - iv. Sanitation facilities

The HIA team, assisted by a local guide moved round the communities, taking note of these and taking photographs where possible. Questionnaires were distributed to all heads of household present at the meeting between the communities and the EIA team. To prevent bias, efforts were also made to administer the questionnaire to other heads of household in the communities that were not present during the meeting. The questionnaire was self-administered, and an average of twenty (20) questionnaires was administered in each of the communities.

The anthropometric measurements of randomly selected under-five children in the community were taken during the field study. The measurements taken include:

- Weight for age – To assess short-term malnutrition
- Height for age – To assess chronic malnutrition; and
- Mid-upper arm circumference (MUAC) – An easy measure of malnutrition that can predict the immediate risk of death.

Emphasis was however put on the Mid Upper Arm Circumference, because of time and logistics constraints.

Appendix II

Air Quality Characteristics of Dodo North

S/N	SAMPLE IDENTITY	NOISE LEVELS (db)	WIND SPEED (m/s)	TEMP. °C	RELATIVE HUMIDITY (%)	SO ₂ (ppm)	NO ₂ (ppm)	NO (ppm)	CO (ppm)	NH ₃ (ppm)	H ₂ S (ppm)	SPM (µg/m ³)	VOC (µg/m ³)
1	DODO AQ 1	46.50	0.30	25.50	92.80	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	1.22	0.84
2	DODO AQ 2	40.20	0.80	25.70	94.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.01	0.20
3	DODO AQ 5	42.30	0.50	26.50	90.30	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.72	0.03
4	DODO AQ 4	31.40	1.50	27.10	80.10	<0.01	<0.01	<0.01	<0.01	<0.10	<0.70	2.20	0.08
5	DODO AQ 3	39.60	2.40	27.90	82.20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.94	<0.001
6	DODO AQ 6	32.40	0.30	28.40	78.50	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	1.80	0.04
7	DODO AQ 7	20.50	2.30	24.40	74.20	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.10	<0.001
8	DODO AQC1	31.80	0.70	26.30	77.30	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.10	0.01
9	DODO AQC2	31.40	3.20	31.30	84.50	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.8	0.10

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Appendix: III

Soil Physico-chemical properties (wet season)

PARAMETERS	DN SS 1		DN SS 2		DN SS 3		DN SS 4		DN SS 5		DN SS 6		DN SS 7	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
pH	4.12	3.38	3.28	4.13	4.42	4.04	4.96	5.1	4.29	4.20	4.01	3.28	4.56	4.32
Temperature, °C	27.1	27	27.5	26.6	26.6	26.8	27.9	27.8	27.8	27.3	27.1	26.2	25.46	25.98
Cation Exchange Capacity cmol/kg	40.69	27.6	43.8	29.7	18.26	20.81	32.7	27.6	45.12	46.34	41.69	25.6		
Sodium, mg/kg	581.45	431.25	681.07	522.1	693.11	384.26	974.3	884	656.98	680.10	519.45	450.25	532.87	531.21
Calcium, mg/kg	210.32	52.3	99.97	53.82	188.26	183.33	43.32	36.04	31.26	32.18	230.31	72.2	56.34	56.89
Potassium, mg/kg	640.21	496.51	800.51	251.53	443.14	430.22	163.75	149.85	620.18	610.98	610.22	596.52	321.12	321.78
Cadmium, mg/kg	3.31	1.311	3.09	0.817	3.26	2.81	5.282	1.213	6.102	6.234	3.32	1.311	4.50	4.32
Zinc, mg/kg	13.12	22.41	26.04	18.14	14.08	10.99	25.81	16.869	11.11	11.23	13.13	22.45	29.17	29.80
Iron, mg/kg	1581	971.1	1441	1012	1323	1318	598.3	251.25	920.17	914.29	1516	981.3	456.23	478.91
Magnesium, mg/kg	187.41	121.11	172.05	99.2	122.3	119.44	125.61	32.535	145.87	145.23	167.47	155.11	112.89	112.34
Copper, mg/kg	36.21	18.11	17.72	8.37	38.88	21.05	25.67	16.89	16.24	16.98	37.29	19.91	32.18	33.12
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	30.21	18	4.01	1.371	26.14	20.05	18.35	10	14.35	14.89	31.26	17	35.42	35.67
Nickel, mg/kg	24.11	21.21	13.48	10.41	11.6	9.45	52.13	30.08	19.23	19.87	21.14	22.24	45.12	45.23
Lead, mg/kg	18.01	22.41	19.15	9.48	15.33	14.01	35.48	27.77	25.66	25.15	19.03	21.44	25.18	25.43
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic														
TPH, mg/kg	2.41	<0.001	4.5	2.82	8.32	3.56	4.65	0.33	2.99	0.79	2.18	<0.001	4.98	0.99
Total Organic Carbon, g/kg	4.1	1.2	14.9	0.7	11.03	1.09	8.5	0.4	10.18	0.34	5.9	1.2	9.9	0.91
Microbiology														
Total Heterotrophic Bacteria (HUB), cfu/g x10 ⁵	2.91	2.41	3.2	3.06	3.84	3.3	3.26	3.1	2.99	2.89	2.36	2.13	2.31	3.35
Total Fungi count (THC), cfu/g x10 ⁴	3.81	3.51	3.71	3.21	2.66	2.44	3.98	3.72	2.18	2.29	3.28	3.45	3.21	3.13
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.41	2.11	2.79	2.9	2.14	2.2	2.57	2.44	3.12	3.08	2.43	2.23	2.91	2.16
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ²	2.21	2.01	2.36	2.16	2	1.55	2.15	2	2.0	1.99	2.27	2.08	1.32	1.46

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (wet season) Cont'd

PARAMETERS	DN SS 8		DN SS 9		DN SS 10		DN SS 11		DN SS 12		DN SS 13		DN SS 14	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
pH	4.26	5.11	4.63	3.74	3.21	4.13	5.7	5.18	3.85	4.11	4.55	4.18	3.37	4.13
Temperature, °C	26.9	26.8	26.7	25.8	27.1	26.6	27.6	27.6	26.6	27.3	26.6	26	27	26.6
Cation Exchange Capacity cmol/kg	32.7	27.6	42.6	27.8	42.8	18.7	21.52	34.34	37	18.15	26.11	23.13	46.8	19.7
Sodium, mg/kg	971.3	881	681	461.53	628.07	412.1	499.81	625.24	781.03	411.33	682.04	426.14	681.07	421.1
Calcium, mg/kg	43.31	36.01	131	86.1	101.97	45.82	11.94	35.2	131.12	47.01	189.33	188.01	100.91	42.82
Potassium, mg/kg	163.71	149.81	730.41	481	800.51	241.53	242.18	271.71	411.1	211	428.04	426.1	901.51	221.51
Cadmium, mg/kg	5.212	1.211	8.11	3.12	3.09	0.887	7	6.574	4.11	2.11	3.05	2.61	3.17	0.891
Zinc, mg/kg	25.21	16.81	52.1	12.41	25.14	19.24	7.755	15.5	18.91	11.21	15.26	11.11	26.11	18.21
Iron, mg/kg	591.3	251.21	1431	1131	1631	1042	980.44	799.16	781	368.11	1318	1315	1611	1051
Magnesium, mg/kg	121.61	32.531	147.11	63.91	172.05	99.2	106.81	441.35	122.1	35.11	143.22	138.05	181.05	98.1
Copper, mg/kg	25.17	16.19	31.11	18.3	17.92	8.77	27.83	17.81	33.71	17.21	40	26.05	17.81	8.21
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	18.31	11	44.11	25.51	4.01	1.541	16.46	22.93	27.4	23.01	18.45	10.05	4.1	1.511
Nickel, mg/kg	52.11	30.18	27.81	18.31	13.53	10.41	5.75	19.22	16.11	17.21	12.26	10.88	13.51	10.11
Lead, mg/kg	35.41	27.71	22.51	11.71	19.16	9.28	23.9	4.453	24.81	13.71	10.05	9.67	19.44	9.31
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic														
TPH, mg/kg	4.61	0.36	20.18	0.91	4.7	2.93	9.35	1.7	1.63	<0.01	7.35	2.64	4.1	2.91
Total Organic Carbon, g/kg	8.6	0.9	9.6	0.8	14.5	0.7	1.6	1.4	29.1	0.7	11.01	1.07	14.1	0.3
Microbiology														
Total Heterotrophic Bacteria (HUB), cfu/g x10 ⁵	3.21	3.12	2.81	2.61	3.10	3.07	2.89	2.71	3.14	3.14	3.14	3.05	3.2	3.06
Total Fungi count (THC), cfu/g x10 ⁴	3.91	3.71	3.61	3.41	3.72	3.32	3.14	3.08	3.61	3.51	3	2.14	3.71	3.32
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.51	2.41	2.81	2.21	2.93	2.5	2.45	2.33	2.71	2.61	2.51	2.03	2.91	2.7
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ³	2.12	2.0	1.41	1.31	2.24	2.11	1.51	1.3	2.1	1.81	1.96	1.83	2.21	2.11

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (wet season) Cont'd

	SS 15		SS 16		SS17		SS 18		SS 19		SS 20		SS 21	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
pH	4.26	5.11	4.63	3.74	3.21	4.13	5.7	5.18	3.85	4.11	4.55	4.18	3.37	4.13
Temperature, °C	26.9	26.8	26.7	25.8	27.1	26.6	27.6	27.6	26.6	27.3	26.6	26	27	26.6
Cation Exchange Capacity cmol/kg	32.7	27.6	42.6	27.8	42.8	18.7	21.52	34.34	37	18.15	26.11	23.13	46.8	19.7
Sodium, mg/kg	971.3	881	681	461.53	628.07	412.1	499.81	625.24	781.03	411.33	682.04	426.14	681.07	421.1
Calcium, mg/kg	43.31	36.01	131	86.1	101.97	45.82	11.94	35.2	131.12	47.01	189.33	188.01	100.91	42.82
Potassium, mg/kg	163.71	149.81	730.41	481	800.51	241.53	242.18	271.71	411.1	211	428.04	426.1	901.51	221.51
Cadmium, mg/kg	5.212	1.211	8.11	3.12	3.09	0.887	7	6.574	4.11	2.11	3.05	2.61	3.17	0.891
Zinc, mg/kg	25.21	16.81	52.1	12.41	25.14	19.24	7.755	15.5	18.91	11.21	15.26	11.11	26.11	18.21
Iron, mg/kg	591.3	251.21	1431	1131	1631	1042	980.44	799.16	781	368.11	1318	1315	1611	1051
Magnesium, mg/kg	121.61	32.531	147.11	63.91	172.05	99.2	106.81	441.35	122.1	35.11	143.22	138.05	181.05	98.1
Copper, mg/kg	25.17	16.19	31.11	18.3	17.92	8.77	27.83	17.81	33.71	17.21	40	26.05	17.81	8.21
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	18.31	11	44.11	25.51	4.01	1.541	16.46	22.93	27.4	23.01	18.45	10.05	4.1	1.511
Nickel, mg/kg	52.11	30.18	27.81	18.31	13.53	10.41	5.75	19.22	16.11	17.21	12.26	10.88	13.51	10.11
Lead, mg/kg	35.41	27.71	22.51	11.71	19.16	9.28	23.9	4.453	24.81	13.71	10.05	9.67	19.44	9.31
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic														
TPH, mg/kg	4.61	0.36	20.18	0.91	4.7	2.93	9.35	1.7	1.63	<0.01	7.35	2.64	4.1	2.91
Total Organic Carbon, g/kg	8.6	0.9	9.6	0.8	14.5	0.7	1.6	1.4	29.1	0.7	11.01	1.07	14.1	0.3
Microbiology														
Total Heterotrophic Bacteria (HUB), cfu/g x10 ⁵	3.21	3.12	2.81	2.61	3.10	3.07	2.89	2.71	3.14	3.14	3.14	3.05	3.2	3.06
Total Fungi count (THC), cfu/g x10 ⁴	3.91	3.71	3.61	3.41	3.72	3.32	3.14	3.08	3.61	3.51	3	2.14	3.71	3.32
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.51	2.41	2.81	2.21	2.93	2.5	2.45	2.33	2.71	2.61	2.51	2.03	2.91	2.7

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

	SS 15		SS 16		SS17		SS 18		SS 19		SS 20		SS 21	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
Hydrocarbon Utilizing Fungi (HUF) , cfu/g x10 ²	2.12	2.0	1.41	1.31	2.24	2.11	1.51	1.3	2.1	1.81	1.96	1.83	2.21	2.11

Soil Physico-chemical properties (wet season) Cont'd

PARAMETERS	DN SS 22		DN SS23		DN SS24		DN SS25		DN SS26		DN SS27		DN SS28	
	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
pH	3.95	4.1	4	3.48	4.99	4.89	3.59	3.79	3.73	3.79	3.5	3.62	3.99	3.68
Temperature, °C	27.6	25.3	28.1	28	25.8	25.6	27.6	25.8	27.3	27.4	27.7	25.4	26.8	26.2
Cation Exchange Capacity cmol/kg	37	18.15	40.69	27.6	35.2	36.4	34.1	34.9	34.5	34.7	25.98	23.81	29.80	11.11
Sodium, mg/kg	783.03	412.33	589.45	430.25	534.29	550.67	1013	469.55	1021	451.55	415.23	424.38	872.37	329.12
Calcium, mg/kg	134.12	47.08	210.31	52.2	109.13	102.54	82.32	59.76	81.31	54.71	89.63	64.48	28.17	13.25
Potassium, mg/kg	441.1	231	640.22	496.52	620.08	615.19	783.21	684.65	791.21	691.65	267.14	258.31	89.15	33.26
Cadmium, mg/kg	4.81	2.41	3.34	1.351	5.23	5.46	6.2	3.098	7.1	3.021	5.18	5.5	4.367	1.36
Zinc, mg/kg	18.92	11.22	13.11	22.43	31.27	32.18	37.11	19.89	38.12	15.81	16.89	15.22	15.67	9.28
Iron, mg/kg	788	368.15	1586	971.3	872.19	789.23	902.2	648.9	901.2	448.1	1401	1331	435.1	234.1
Magnesium, mg/kg	122.3	35.71	187.47	125.11	101.23	98.70	341.33	168.97	361.13	178.17	101.26	81.55	46.16	23.78
Copper, mg/kg	33.74	17.23	36.29	18.91	25.44	25.68	10.89	4.85	10.41	4.85	82.51	78.65	22.37	15.78
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	28.4	23.03	30.26	19	28.56	28.70	30.16	18	30.21	20	19.64	16.99	16.17	7.99
Nickel, mg/kg	16.51	17.25	24.14	21.24	35.12	35.76	24.13	21.14	24.15	21.14	17.51	15.82	7.34	2.38
Lead, mg/kg	24.82	13.75	18.03	22.44	32.12	32.19	18.06	22.14	18.13	22.41	19.95	16.33	11.67	4.37
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic														
TPH, mg/kg	1.61	<0.01	2.48	<0.001	18.15	0.45	7.42	6.34	7.18	6.12	3.22	2.1	0.11	0.01
Total Organic Carbon, g/kg	29.3	0.6	4.9	1.1	28.78	0.7	4.3	0.7	4.2	0.9	10.01	11.04		
Microbiology														
Total Heterotrophic Bacteria (HUB) , cfu/g x10 ⁵	3.18	3.11	2.96	2.43	2.55	2.33	2.95	2.44	2.91	2.41	3.24	3.08	2.16	2.11
Total Fungi count (THC), cfu/g x10 ⁴	3.63	3.57	3.88	3.55	3.13	3.76	3.82	3.74	3.81	3.71	3.27	3.19	2.89	1.26
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.76	2.62	2.44	2.13	2.46	2.37	2.64	2.46	2.61	2.41	2.5	1.89	1.98	1.04
Hydrocarbon Utilizing Fungi (HUF) , cfu/g x10 ²	2	1.88	2.23	2.09	1.67	1.71	2	1.51	2.1	1.51	1.19	1.20	1.22	1.67

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (wet season) Cont'd

PARAMETERS	DN SS 29		DN SS 30		TUNU SS 31		DN SS 32		DN SS 33		DN SS 34		DN SS 35	
	TOP	BOTTO M	TOP	BOTTO M	TOP	BOTTO M	TOP	BOTTO M	TOP	BOTTO M	TOP	BOTTO M	TOP	BOTTO M
pH	4.63	3.74	5.53	4.55	4.09	4.41	4.2	3.18	4.44	5.05	4.88	4.6	3.82	4.3
Temperature, °C	26.7	27.8	27.3	27.7	26.8	25.9	28.2	27	27.5	27	28.1	27.1	26.5	26.4
Cation Exchange Capacity cmol/kg	41.6	26.8	32.34	20.8	24.5	18.2	40.29	28.6	22.8	17	20	13.71	24.1	18.5
Sodium, mg/kg	639	493.53	470.07	364	548.23	398.01	529.45	440.25	537.46	434.24	493.15	325.22	532.4	525.07
Calcium, mg/kg	127	99.1	110.2	82.41	71.04	58.33	250.31	59.2	19.33	12	68.33	41.04	52.83	43.24
Potassium, mg/kg	720.42	478	539.87	249.02	153.11	178.41	630.22	486.52	212.46	132.41	147.21	108.72	211.47	122.11
Cadmium, mg/kg	8.71	3.92	2.35	1.07	5.13	4.02	3.35	1.311	4.07	2	4.073	2	7.02	5.43
Zinc, mg/kg	54.1	12.45	26.95	17.52	14.25	17.07	13.14	21.43	15.45	10.82	13.82	11.41	16.41	13.03
Iron, mg/kg	1414	1114	1584	648.2	125.02	918	1576	961.3	1184	899	343.29	288.2	514.39	445.31
Magnesium, mg/kg	127.21	93.92	173.53	124.4	173.63	101.4	177.47	135.11	153.85	142.01	90.03	73.33	101.2	99.28
Copper, mg/kg	32.61	17.3	12.7	14.21	14.48	10.72	36.23	18.95	15.19	9.83	18.1	16.51	14.12	16.1
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	42.31	25.48	12.75	7.33	14.8	8.21	30.16	18	7.18	5.21	13.1	8.43	17.3	17.18
Nickel, mg/kg	27.52	18.47	26.63	18.85	15.73	19.12	24.24	21.34	12.46	10.33	19.83	17.32	13.19	20.22
Lead, mg/kg	22.44	11.58	24.42	20.12	12.44	12.14	18.13	21.44	10.87	11.14	12.1	10.23	14.73	15.34
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic														
TPH, mg/kg	20.41	0.83	2.46	1.19	2.5	1.56	2.42	<0.001	1.32	0.19	1.27	1.05	2.15	1.28
Total Organic Carbon, g/kg	9.5	0.9	11.4	0.2	8.4	2.1	4.6	1.2	0.99	0.09	9	4	2.5	3
Microbiology														
Total Heterotrophic Bacteria (HUB), cfu/g x10 ⁵	2.81	2.63	2.98	2.7	3.11	2.75	2.91	2.42	3.01	2.87	2.94	3.05	3.04	2.79
Total Fungi count (THC), cfu/g x10 ⁴	3.65	3.48	2.63	2.41	3.1	2.56	3.87	3.52	3.58	3.52	2.38	2.29	2.84	2.54
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.87	2.25	2.45	2.09	2.87	2.53	2.45	2.15	2.43	2.43	2.48	2.15	3.0	2.52
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ²	1.46	1.32	3.01	1.45	3.01	2.94	2.28	2.08	1.86	1.75	1.67	1.44	1.66	1.48

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (wet season) Cont'd

PARAMETERS	AYAMA SS C1		DN SSC2	
	0-15cm	15-30cm	0-15cm	15-30cm
pH	3.96	3.8	4.85	5.15
Temperature, °C	27	27.4	27.6	27.8
Cation Exchange Capacity cmol/kg	27.11	29.04	31.62	12.74
Sodium, mg/kg	818.34	722.44	1094	443.12
Calcium, mg/kg	98.63	79.38	30.83	14.53
Potassium, mg/kg	430.05	421.15	92.51	37.33
Cadmium, mg/kg	5.24	4.06	5.585	2.45
Zinc, mg/kg	25.16	20.43	16.64	10.12
Iron, mg/kg	1428	1422	519.7	341.32
Magnesium, mg/kg	146.51	122.09	47.55	24.64
Copper, mg/kg	35.06	22.14	23.28	16.3
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001
Chromium, mg/kg	21.44	19.38	17.07	8.18
Nickel, mg/kg	28.33	16.51	8.78	3.48
Lead, mg/kg	20.08	12.15	12.16	5.42
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001
Organic				
TPH, mg/kg	6.28	2.08	0.32	0.04
Total Organic Carbon, g/kg	11.04	1.08	11.8	0.3
Microbiology				
Total Heterotrophic Bacteria (HUB) , cfu/g x10 ⁵	3.14	3.1	3.14	3.1
Total Fungi count (THC), cfu/g x10 ⁴	3.26	3.04	3.88	2.51
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	3.15	2.85	2.59	2.04
Hydrocarbon Utilizing Fungi (HUF) , cfu/g x10 ²	2	1.88	2.22	2.1

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (Dry season)

PARAMETERS	Dodo1	Dodo2	Dodo 3	Dodo 4	Dodo5	Dodo6	Dodo7	Dodo8	Dodo9	Dodo10	Dodo11	Dodo C ₁	Dodo C ₁
Calcium, mg/kg	1603	149.07	2436	894	2311	926.04	412.13	154.33	1115	1696	506.45	2303	2238
Sodium, mg/kg	1524	2521	1213	2871	3171	2819	3116	1987	2465	2754	3091	1304	1257
Magnesium, mg/kg	800.13	602.65	174.73	949	592.85	787.21	582.09	432.90	805.74	1132	832.87	816.42	174.95
Potassium, mg/kg	1064	526.12	1274	614	1178	1144	865.89	1187	1176	696.51	687.33	1099	1403
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/kg	20.48	18.69	21.16	18.41	14.90	15.23	21.11	20.19	21.17	15.62	15.45	19.42	22.99
Cobalt, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel, mg/kg	14.52	10.15	10.75	13.66	20.06	14.21	18.78	28.79	29.25	16.25	30.90	13.67	11.34
Lead, mg/kg	<0.002	<0.002	15.33	<0.022	33.73	12.97	27.67	16.59	15.11	<0.022	32.79	18.24	16.34
Chromium, mg/kg	23.35	25.33	15.00	21.15	18.78	26.82	16.71	24.36	14.30	25.50	10.78	21.70	13.365
Zinc, mg/kg	32.69	30.60	28.96	17.82	15.66	20.00	27.66	18.55	18.53	18.32	80.90	21.23	29.60
Cadmium, mg/kg	1.519	0.251	7.00	0.272	1.655	6.363	1.459	1.543	3.838	<0.005	0.765	2.036	3.13
Iron, mg/kg	276.40	172.30	228	144.45	290.60	150.99	230.12	190.88	119.60	179.28	250.18	210.88	275.72
manganese, mg/kg	793	134.52	857.15	774.64	490.19	576.13	350.44	671.98	157.15	598.19	652.21	793.00	801.27

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Soil Physico-chemical properties (Dry season)

PARAMETERS	Dodo 12	Dodo 13	Dodo 14	Dodo 15	Dodo 16	Dodo 17	Dodo 18	Dodo 19	Dodo 20	Dodo 21	DODO NORTH 22	DODO NORTH 23	DODO NORTH 24	DODO NORTH C 2
Calcium, mg/kg	418.45	745.89	311.53	2470	700.56	2259	1580	643.81	1171	604.68	1797	646.46	2153	2226
Sodium, mg/kg	2529	2787	1457	531.12	1224	2675	2392	2487	3103	1281	1781	3187	2335	2979
Magnesium, mg/kg	805.09	778.49	179.51	175.06	175.61	841.93	797	621.98	1146	177.90	783.19	798.74	762.29	816.77
Potassium, mg/kg	885.34	714.44	1313	1153	1258	1176	1144	789.37	793.34	1192	1217	1137	1259	817.55
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/kg	12.53	16.84	21.60	13.74	23.18	16.17	18.22	17.23	10.46	22.51	21.13	10.42	15.96	18.60
Cobalt, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aluminium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel, mg/kg	37.28	8.97	15.69	20.00	19.05	31.24	12.37	25.08	9.44	14.52	24.30	11.97	37.20	43.51
Lead, mg/kg	<0.002	16.81	17.83	19.04	17.18	14.162	14.95	30.18	<0.002	15.27	<0.002	<0.002	28.03	13.312
Chromium, mg/kg	14.43	25.55	11.10	14.13	23.52	9.56	25.37	11.43	14.20	12.33	19.95	28.22	21.57	18.60
Zinc, mg/kg	22.43	17.63	30.48	11.34	19.98	83.93	21.37	75.89	19.30	22.34	16.43	18.22	26.65	14.09
Cadmium, mg/kg	2.072	2.04	2.599	5.94	1.799	2.955	1.55	1.321	0.359	1.629	<0.001	1.084	0.661	2.423
Iron, mg/kg	174.85	160.49	281.64	204.01	185.89	332.88	150.13	143.22	178.62	226	295.70	217.10	216.00	400.56
Manganese, mg/kg	330.23	506.31	994.24	12.98	417.208	238.11	813.00	432.18	514.31	323.44	340.50	1251	1048	926.59

Appendix: V

Physicochemical and Microbiological Properties of Groundwater

PARAMETERS	Dodo North BHC1	Dodo North BHC2	Dodo North BH 1	Dodo North BH2	Dodo North BH 3	Dodo North BH 4	Dodo North BH24	Dodo North BH23
pH	6.54	6.14	6.54	4.2	6.58	6.7	6.7	6.58
Temperature, °C	27	26	26.4	27	26	26.1	26.1	26
Electrical Conductivity, µS/cm	173.1	200	17.6	558.1	30	12	12	30
Colour, pt-Co	5	5	5	5	5	10	10	5
Dissolved Oxygen (DO), mg/l	6.38	2	2	6.42	2.6	2.5	2.5	2.6
Chemical Oxygen Demand (COD), mg/l	7.24	8.2	8	27.85	8	8.1	8.1	8
Total Dissolved Solids (TDS), mg/l	91.74	125	9.33	295.74	17.2	10.2	10.2	17.2
Total Suspended Solids (TSS), mg/l	4	9	9	1	4.8	9.1	9.1	4.8
Biochemical Oxygen Demand (BOD), mg/l	5.66	6.6	5.65	5.73	6.7	6.75	6.75	6.7
Turbidity, NTU	6	6.58	6.5	6	5.2	6.06	6.06	5.2
Alkalinity, mg/l	9.99	5.99	1.99	<0.01	1.99	1.99	1.99	1.99
Hardness, mg/l	48	12	8	200	12	8	8	12
Salinity, mg/l	10.64	35.45	3.33	14.18	6.38	6.03	6.03	6.38
Nitrate, mg/l	0.32	2.16	0.09	2.73	1.22	1.05	1.05	1.22
Sulphate, mg/l	<0.001	27.72	0.93	24.82	8.43	1.1	1.1	8.43
Carbonate, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate, mg/l	0.19	1.39	2.13	0.04	0.06	0.6	0.6	0.06
Calcium, mg/l	12.83	7.87		42.59			9.542	11.58
Magnesium, mg/l	3.87	3.075	2.056	9.62	11.58	9.542	4.714	4.95
Hydrogen Sulphide, mg/l	<0.001	<0.001	0.983	<0.001	4.95	4.714	<0.001	<0.001
Phenol, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrite, (NO ₂),mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyanide,mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.311	<0.001
Ammonia,mg/l	4.04	<0.001	<0.001	1.04	<0.001	0.311		
Heavy metals								
Cadmium, mg/l	<0.001	<0.005	0.101	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc, mg/l	0.216	0.222	<0.005	0.208	0.212	0.135	0.135	0.212
Iron, mg/l	2.061	2.238	0.308	3.519	0.385	0.76	0.76	0.385
Manganese, mg/l	0.105	0.241	1.374	0.022	0.018	0.057	0.057	0.018
Silver, mg/l	<0.001	<0.001	0.378	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/l	0.104	0.129	<0.001	0.024	0.128	0.131	0.131	0.128
Chromium, mg/l	<0.001	0.067	0.16	0.028	0.09	0.076	0.076	0.09
Nickel, mg/l	<0.002	<0.002	0.15	<0.002	<0.002	<0.002	<0.002	<0.002
Lead, mg/l	<0.002	0.009	<0.002	<0.002	0.008	0.008	0.008	0.008
Vanadium, mg/l	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

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PARAMETERS	Dodo North BHC1	Dodo North BHC2	Dodo North BH 1	Dodo North BH2	Dodo North BH 3	Dodo North BH 4	Dodo North BH24	Dodo North BH23
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Microbiology								
Total Heterotrophic Bacteria (THB), cfu/ $\mu \times 10^4$	3.04	5.13	4.1	2.6	4.58	4.41	4.41	4.58
Total Fungi count (THF), cfu/ $\mu \times 10^3$	3.14	4.44	3.85	3.01	3.96	4.00	4	3.96
Hydrocarbon Utilizing Bacteria (HUB) , cfu/ $\mu \times 10^2$	1.8	1.55	2.66	1.22	2	2.26	2.26	2
Hydrocarbon Utilizing Fungi (HUF) , cfu/ $\mu \times 10^2$	1.22	1.00	1.11	1.05	1.45	1.44	1.44	1.45

Appendix VI

Physico-chemical and Microbiological Properties of surface waters (wet season)

	Dodo North 1	Dodo North SW 2	Dodo North 3	Dodo North SW 4	Dodo North 5	Dodo North SW6	Dodo North 7	Dodo North SW 8	Dodo North SW 9	Dodo North 10	Dodo North 11	Dodo North 12
pH	6.43	6.70	6.93	6.80	6.90	6.23	6.12	7.70	6.14	6.15	6.54	6.90
Temperature, °C	28.20	24.1	27.7	26.1	27.3	27.2	27.2	28.5	26.4	23.87	27.0	26.2
Electrical Conductivity, µS/cm	50.00	56.1	32070	49.1	27600	20.23	23500	54.80	20.41	1340.25	40.00	45.6
Colour, pt-Co	5.00	4.90	10.00	5.12	5.00	10.00	15.00	10.00	5.00	8.55	5.00	5.00
Dissolved Oxygen (DO), mg/l	3.93	3.51	8.25	3.61	7.55	3.68	8.24	3.60	3.71	4.67	3.40	3.55
Chemical Oxygen Demand (COD), mg/l	8.88	7.99	5.33	7.16	6.21	7.12	5.00	8.26	7.05	7.96	7.20	8.15
Total Dissolved Solids (TDS), mg/l	27.30	34.10	16997	34.30	14628	15.3	12455	27.20	15.4	13098	22.60	24.17
Total Suspended Solids (TSS), mg/l	8.00	8.34	3.00	8.00	5.00	10.00	4.00	12.00	16.00	6.00	8.00	9.00
Turbidity, NTU	5.55	5.95	2.45	6.75	3.15	7.10	2.88	8.65	7.89	2.15	6.00	6.00
Alkalinity, mg/l	1.99	7.89	7.99	7.92	7.99	1.99	5.99	1.99	1.99	7.89	1.99	3.99
Hardness, mg/l	12.00	9.80	3360	11.50	3400	10.00	3160	12.00	11.00	3360	20.00	16.00
Biochemical Oxygen Demand (BOD), mg/l	7.20	6.35	2.25	5.55	2.95	4.90	2.26	6.65	5.03	2.34	5.10	6.95
Salinity, mg/l	8.87	10.54	7038	11.00	7100	9.39	6989	8.87	9.27	3638	7.09	7.09
Nitrate, mg/l	1.21	0.56	0.153	0.76	<0.001	0.80	0.017	1.51	0.91	1.11	1.73	1.37
Sulphate, mg/l	2.06	3.04	98.54	3.24	96.23	1.89	103.34	0.35	1.95	76.67	0.94	<0.001
Carbonate, mg/l	<0.01	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.01	<0.001
Phosphate, mg/l	0.24	0.15	0.06	0.17	0.05	0.07	0.06	0.58	0.27	0.05	0.023	0.06
Sodium, mg/l	5.232	7.046	4176	5.026	3160	1.346	2796	4.51	1.232	3387	3.182	2.493
Calcium, mg/l	3.210	6.570	2819	4.570	2484	3.167	2449	6.077	3.511	128.90	5.372	354.294
Magnesium, mg/l	0.968	2.356	1689	1.456	1009	1.708	1441	2.079	1.719	1686	1.613	2.375
Phenol, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrite, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ammonia, mg/l	0.409	0.53	0.12	0.43	<0.001	1.72	0.03	2.50	1.71	0.05	1.137	0.47
Hydrogen Sulphide, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyanide, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heavy metals												

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	Dodo North 1	Dodo North SW 2	Dodo North 3	Dodo North SW 4	Dodo North 5	Dodo North SW6	Dodo North 7	Dodo North SW 8	Dodo North SW 9	Dodo North 10	Dodo North 11	Dodo North 12
Cadmium, mg/l	<0.005	<0.002	<0.005	<0.005	<0.005	<0.005	1.701	<0.005	<0.005	<0.005	<0.005	<0.005
Vanadium, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, mg/l	0.133	0.190	<0.001	0.299	0.077	0.152	12.42	0.139	0.161	<0.001	0.339	0.220
Lead, mg/l	0.009	0.033	0.032	0.033	0.111	0.009	6.68	0.007	0.008	2.01	0.008	0.009
Iron, mg/l	0.801	0.601	0.876	0.631	1.074	1.536	2.140	1.394	1.608	1.12	0.589	1.057
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese, mg/l	0.128	0.103	0.144	0.100	0.141	0.162	0.140	0.229	0.164	0.150	0.246	0.385
Asernic, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/l	0.072	0.253	0.072	0.323	0.108	0.061	15.36	0.080	0.060	0.100	0.094	0.056
Chromium, mg/l	0.213	0.014	0.094	0.013	0.091	0.098	28.67	0.101	0.096	0.220	0.048	0.089
Nickel, mg/l	<0.002	<0.002	0.181	<0.002	0.293	<0.002	24.44	<0.002	<0.002	<0.001	<0.002	<0.002
Barium, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organics												
Oil & grease, mg/l	0.03	0.77	0.23	0.87	0.10	1.11	0.61	0.63	1.12	0.56	0.22	0.50
TPH, mg/l	0.01	0.73	0.22	0.52	0.003	1.13	0.45	0.51	1.10	0.030	0.16	0.35
PAH, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
THC, mg/l	0.04	0.50	0.25	0.30	0.11	1.15	0.68	0.64	1.13	0.34	0.023	0.58
TOC, g/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.002	<0.001	0.001	<0.001
Microbiology												
Total Heterotrophic Bacteria (THB), cfu/μ x 10 ⁴	4.78	2.87	3.89	1.88	4.15	4.50	3.26	3.92	5.05	4.30	4.88	6.05
Total Fungi count (THF), cfu/μ x 10 ³	2.22	2.53	2.33	3.07	2.06	3.17	2.14	2.44	3.16	2.34	3.69	2.00
Hydrocarbon Utilizing Bacteria (HUB), cfu/μ x 10 ²	1.00	2.25	1.85	1.89	1.77	2.10	1.59	2.61	2.05	1.23	1.10	1.05
Hydrocarbon Utilizing Fungi (HUF), cfu/μ x 10 ²	0.39	1.00	1.00	1.05	1.21	1.02	1.02	1.61	1.09	1.02	0.59	0.66

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Physico-chemical and Microbiological Properties of surface waters (wet season) Cont'd

PARAMETERS	Dodo North 13	Dodo North SW 14	Dodo North 15	Dodo North 16	Dodo North 17	Dodo North SW C1	Dodo North SW C2
pH	6.19	6.70	6.45	6.62	6.63	6.50	6.51
Temperature, °C	25.67	26.5	24.15	27.60	28.00	25.0	28.00
Electrical Conductivity, µS/cm	1006.00	60.0	1110.20	38.10	31.80	57.1	34.00
Colour, pt-Co	10.55	5.00	7.89	10.00	10.00	4.99	10.00
Dissolved Oxygen (DO), mg/l	4.56	3.20	5.60	5.15	4.58	3.55	4.33
Chemical Oxygen Demand (COD), mg/l	6.56	7.06	7.12	7.14	8.14	8.20	8.44
Total Dissolved Solids (TDS), mg/l	15997	31.8	14628	20.40	19.40	34.10	18.60
Total Suspended Solids (TSS), mg/l	4.00	10.00	7.00	8.00	8.00	8.10	10.00
Turbidity, NTU	3.88	6.50	2.15	5.45	5.66	5.85	7.25
Alkalinity, mg/l	4.56	1.99	6.99	1.99	1.99	8.59	1.99
Hardness, mg/l	4200	12.00	2098.00	16.00	12.00	11.00	8.00
Biochemical Oxygen Demand (BOD), mg/l	1.99	5.12	4.50	5.65	6.65	6.65	6.70
Salinity, mg/l	5100	7.09	209.00	10.64	5.32	11.64	7.09
Nitrate, mg/l	1.01	1.706	1.24	0.84	1.76	0.67	1.71
Sulphate, mg/l	86.89	0.32	56.89	1.88	1.38	2.64	0.16
Carbonate, mg/l	<0.001	<0.01	<0.001	<0.01	<0.01	<0.001	<0.01
Phosphate, mg/l	0.05	0.154	0.11	0.26	0.36	0.12	0.20
Sodium, mg/l	4166	6.245	120.00	3.110	3.441	5.006	3.314
Calcium, mg/l	219.99	4.810	45.66	3.210	5.082	5.470	1.60
Magnesium, mg/l	1001	1.009	125.00	0.970	2.359	2.326	0.970
Phenol, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrite, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ammonia, mg/l	0.04	0.400	0.60	1.983	0.258	0.43	2.096
Hydrogen Sulphide, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyanide, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heavy metals							
Cadmium, mg/l	<0.005	<0.005	<0.003	<0.0015	<0.005	<0.007	<0.005
Vanadium, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, mg/l	0.067	0.139	0.123	0.199	0.187	0.303	0.144
Lead, mg/l	3.56	0.012	0.23	0.007	0.008	0.010	0.008

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

PARAMETERS	Dodo North 13	Dodo North SW 14	Dodo North 15	Dodo North 16	Dodo North 17	Dodo North SW C1	Dodo North SW C2
Iron, mg/l	1.05	1.395	1.23	0.876	1.234	0.711	0.905
Mercury, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese, mg/l	0.150	0.229	0.121	0.200	0.018	0.122	0.157
Asernic, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/l	0.100	0.080	0.006	0.133	0.129	0.298	0.108
Chromium, mg/l	0.091	0.101	0.799	0.044	0.081	0.024	0.043
Nickel, mg/l	0.44	<0.002	0.145	<0.002	<0.002	<0.002	<0.002
Barium, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organics							
Oil & grease, mg/l	0.12	0.38	0.30	0.43	0.31	0.66	0.47
TPH, mg/l	0.230	0.45	0.23	0.38	0.26	0.63	0.33
PAH, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
THC, mg/l	0.50	0.50	0.40	0.44	0.31	0.80	0.47
TOC, g/l	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Microbiology							
Total Heterotrophic Bacteria (THB), cfu/μ x 10 ⁴	5.10	4.99	3.56	3.96	4.00	3.88	4.45
Total Fungi count (THF), cfu/μ x 10 ³	2.05	3.33	2.34	1.44	3.66	3.57	3.26
Hydrocarbon Utilizing Bacteria (HUB) , cfu/μ x 10 ²	1.22	1.18	1.14	1.01	2.03	2.11	1.30
Hydrocarbon Utilizing Fungi (HUF) , cfu/μ x 10 ²	1.23	0.60	1.00	1.00	1.88	1.10	1.00

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

Physico-chemical and Microbiological Properties of Sediment

PARAMETERS	Dodo North 1	Dodo North SD C1	Tunu SD C2	Dodo North SD 2	Dodo North SD 3	Dodo North SD 4	Dodo North 5	Dodo North 6	Dodo North 7	Dodo North 8
pH	5.20	5.21	6.12	3.62	4.44	4.57	4.26	4.99	4.75	5.10
Temperature, °C	26.81	27.04	27.00	27.12	26.9	26.91	26.90	26.81	27.10	26.54
Electrical Conductivity, µS/cm	113.90	113.93	20.60	138.81	350	115.32	82.70	38.45	54.00	121.45
Total Nitrogen, g/kg	3.86	3.87	10.41	2.08	11.08	2.16	14.08	16.78	12.68	2.98
Phosphate, (PO ⁴) mg/kg	2.14	2.13	0.92	0.98	8.88	1.16	2.99	3.12	0.84	1.19
Sodium, mg/kg	93.88	93.87	13.43	95.30	217.20	94.01	21.28	39.10	14.33	94.87
Exchange Acidity, cmol/kg	1.28	1.29	0.98	1.18	0.98	1.26	1.12	1.01	0.84	1.21
Calcium, mg/kg	4.29	4.28	8.32	6.33	7.20	4.47	7.64	11.89	10.11	5.89
Cation Exchange Capacity, cmol/kg	1.51	1.52	1.61	1.51	1.44	1.11	1.70	1.50	1.37	1.49
Potassium, mg/kg	7.14	7.11	8.18	4.22	63.63	6.13	5.11	8.09	3.18	6.34
Cadmium, mg/kg	3.423	3.422	4.001	3.187	5.411	4.122	2.552	5.38	8.639	5.128
Zinc, mg/kg	17.44	17.42	27.470	22.51	413.965	18.24	16.457	17.23	17.789	20.19
Iron, mg/kg	530.24	530.23	438.212	428.42	20.32	430.11	334.381	390.68	521.330	489.01
Magnesium, mg/kg	6.20	6.21	4.84	5.16	2.85	5.87	3.14	4.21	2.00	5.99
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/kg	21.68	21.67	21.13	15.26	15.81	20.91	13.95	21.34	13.723	17.23
Chromium, mg/kg	26.11	26.12	27.41	19.77	10.85	25.13	30.57	25.32	8.12	24.37
Nickel, mg/kg	19.80	19.81	26.00	13.53	13.53	15.44	15.12	13.24	10.60	17.56
Lead, mg/kg	15.57	15.58	18.82	22.92	8.26	21.81	13.48	19.17	18.14	18.36
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic										
TPH, mg/kg	6.30	6.31	4.22	4.52	8.32	5.51	9.41	8.90	7.22	4.99
Total Organic Carbon, g/kg	4.90	4.92	4.90	5.11	1.80	5.06	2.60	8.83	5.20	5.08
Microbiology										
Total Heterotrophic Bacteria (THB), cfu/g x10 ⁵	3.84	3.83	5.26	1.22	2.73	3.13	3.70	4.50	3.16	1.99
Total Fungi (THF) , cfu/g x10 ⁴	3.62	3.63	3.26	3.37	3.03	3.41	3.45	3.68	3.04	3.48
Hydrocarbon Utilizing Bacteria (HUB) , cfu/g x10 ³	2.77	2.79	2.00	2.01	2.22	2.53	1.59	1.32	2.21	2.66
Hydrocarbon Utilizing Fungi (HUF) , cfu/g x10 ²	1.55	1.57	1.65	1.61	1.51	1.58	1.27	1.77	1.44	1.58

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

	Dodo North 9	Dodo North 10	Dodo North 11	Dodo North 12	Dodo North SD 13	Dodo North SD 14	Dodo North 15	Dodo North 16	Dodo North 17
pH	5.09	3.63	5.10	5.21	4.80	4.74	5.83	5.31	5.41
Temperature, °C	27.06	27.02	26.8	26.8	26.90	26.89	27.09	26.5	27
Electrical Conductivity, µS/cm	120.89	138.80	130.10	28.43	630	470	120.89	158.7	180.3
Total Nitrogen, g/kg	3.19	2.09	2.89	15.23	8.12	9.39	17.12	10.12	15.23
Phosphate, (PO ⁴) mg/kg	2.10	0.99	2.00	2.75	8.24	8.64	0.99	4.17	3.59
Sodium, mg/kg	95.01	95.33	95.12	35.12	205.23	111.45	25.43	22.13	18.17
Exchange Acidity, cmol/kg	1.23	1.19	1.26	0.89	0.76	0.94	1.11	1.07	1.13
Calcium, mg/kg	6.20	6.32	6.00	12.34	6.21	5.20	8.83	11	7.13
Cation Exchange Capacity, cmol/kg	1.25	1.53	1.35	1.78	1.55	1.15	1.49	1.73	1.88
Potassium, mg/kg	4.98	4.20	7.01	7.12	73.40	52.81	3.56	7.16	5.07
Cadmium, mg/kg	5.187	3.185	6.098	4.89	6.939	3.574	7.23	4.13	3.9
Zinc, mg/kg	19.81	22.50	21.01	17.45	375.69	527.156	23.12	25.06	19.22
Iron, mg/kg	520.87	428.43	450.11	389.12	27.45	30.48	423.19	31.28	34.07
Magnesium, mg/kg	5.20	5.18	6.20	3.45	2.58	3.81	2.99	5.8	3
Barium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/kg	19.80	15.25	18.79	15.23	14.23	14.267	14.58	23.13	16.2
Chromium, mg/kg	22.10	19.78	23.49	24.32	4.89	7.00	24.12	13.12	12.43
Nickel, mg/kg	14.22	13.52	16.90	25.00	21.47	13.20	17.68	15.32	18.16
Lead, mg/kg	20.11	22.90	18.12	15.32	12.98	10.60	16.43	10.08	11.3
Vanadium, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Organic									
TPH, mg/kg	5.01	4.51	4.89	8.33	7.23	9.32	5.12	4.92	2.13
Total Organic Carbon, g/kg	5.05	5.10	4.99	7.84	1.80	2.40	4.58	2.37	3.32
Microbiology									
Total Heterotrophic Bacteria (THB), cfu/g x10 ⁵	2.90	1.24	1.89	5.30	4.00	3.00	5.50	3.36	3.23
Total Heterotrophic Fungi (THF), cfu/g x10 ⁴	3.49	3.38	3.60	3.44	2.18	2.15	3.12	1.67	2.07
Hydrocarbon Utilizing Bacteria (HUB), cfu/g x10 ³	2.55	2.00	2.11	1.99	2.81	2.44	2.19	2.9	1.89
Hydrocarbon Utilizing Fungi (HUF), cfu/g x10 ²	1.61	1.62	1.56	1.87	1.87	2.01	1.55	1.38	1.02

Aquatic Studies

Benthic fauna composition of the study area

	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14	SW 15	SWC 1	SWC 2
MOLLUSCA																	
BIVALVIA																	
<i>Egeria paradoxa</i>	2			2							8					1	6
<i>Pisidium abditum</i>						2				4							
<i>Sphaerium occidentale</i>	3									2						4	4
GASTROPODA																	
<i>Thais callifera</i>		3								2			7				6
<i>Thais haemastoma</i>	4		3		1	1	5	14		2		4		21			4
<i>Pachymelania aurita</i> Muller										3						2	4
<i>Tympanotonus fuscatus</i>	1	2	9	8									5				
<i>Tympanotonus fuscatus</i> var. <i>radula</i>																1	1
<i>Crassostrea gasar</i>									22								5
<i>Pila ovata</i>						3											
<i>Onchomelania hypensis</i> <i>hypensis</i>		2													16		
<i>Potamopyrgus ciliatus</i>						6											2
Taxa_S	4	3	2	2	1	4	1	1	1	5	1	1	2	1	1	4	8
Individuals	10	7	12	10	1	12	5	14	22	13	8	4	12	21	16	8	32
Shannon_H	1.28	1.079	0.562 3	0.500 4	0	1.199	0	0	0	1.565	0	0	0.679 2	0	0	1.213	1.979
Margalef	1.303	1.028	0.402 4	0.434 3	0	1.207	0	0	0	1.559	0	0	0.402 4	0	0	1.443	2.02
Equitability_J	0.923 2	0.982 1	0.811 3	0.721 9	0	0.864 8	0	0	0	0.972 4	0	0	0.979 9	0	0	0.875	0.9518

Zooplankton composition of the study area

TAXA	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14	SW 15	SWC 1	SWC 2
PROTOZOA																	
<i>Paramecium aurelia</i>											2						
<i>Monostyla lunaris</i>														1			
<i>Microthorax unguulatus</i>																1	
<i>Colpidium campylum</i>												1					
Unidentified Type 1											1						
Unidentified Type 2												1					
Unidentified Type 3												2					
PLATYHELMINTHES																	
Planaria	2																
ROTIFERA																	
<i>Chromogaster testudo</i>																1	
<i>Trichocerca enlongata</i>																1	
<i>Lecane luna</i>																1	
<i>Notholca caudata</i>																1	
<i>Argonotholca species</i>									2								
<i>Monostyla bulla</i>													1				2
<i>Keratella cochlearis</i>			3														
OSTRACODA																	
<i>Cypris subglobosa</i>					2	2	3	1		2			1				8
<i>Cypris species</i>																3	
Unidentified species														1			
CLADOCERA																	
<i>Chydorus ventricosus</i>													1				
<i>Chydorus latus</i>			1					2					1	1			
<i>Chydorus gibbus</i>				7			3	4				1	1	7			5
<i>Argonotholca foliaceac</i>													1				1

Environmental Impact Assessment (EIA) of Dodo North NAG Wells Development Project

TAXA	SW 1	SW 2	SW 3	SW 4	SW 5	SW 6	SW 7	SW 8	SW 9	SW 10	SW 11	SW 12	SW 13	SW 14	SW 15	SWC 1	SWC 2
Unidentified (larval) Stage																4	
Kantra sp																1	
CYCLOPOIDA																	
<i>Thermocyclop scptifer</i>				1													
<i>Microcyclops varicans</i>		1								1					3		
<i>Copepod nauplius</i>																1	
CALANOIDA																	
<i>Thermodiaptomus sp</i>																	3
ARACHNIDA																	
Water mite					1	2	2	1								1	
Larval stage					1												
Taxa_S	1	1	2	2	3	2	3	4	1	2	2	4	6	4	1	10	5
Individuals	2	1	4	8	4	4	8	8	2	3	3	5	6	10	3	15	19
Shannon_H	0	0	0.5623	0.3768	1.04	0.6931	1.082	1.213	0	0.6365	0.6365	1.332	1.792	0.9404	0	2.119	1.399
Margalef	0	0	0.7213	0.4809	1.443	0.7213	0.9618	1.443	0	0.9102	0.9102	1.864	2.791	1.303	0	3.323	1.358
Equitability_J	0	0	0.8113	0.5436	0.9464	1	0.9851	0.875	0	0.9183	0.9183	0.961	1	0.6784	0	0.9201	0.8692

