The Shell Petroleum Development Company of Nigeria Limited

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

OF THE

ISENI WELLS EARLY HOOKUP TO DOMESTIC GAS PROJECT IN SAGBAMA, EKEREMOR AND PATANI LOCAL GOVERNMENT AREAS OF BAYELSA AND DELTA STATES

FINAL REPORT

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Abbreviations and Acronyms

ALARP	As Low As Reasonably Practicable
APHA	American Public Health Association
ASME	American Society of Mechanical Engineers
BOD5	Biochemical Oxygen Demand
BTEX	Benzene, Tuolene, Ethylbenzene, Xylene
CAS	Catch Assessment Survey
CBO	Community Based Organisation
CBR	Crude Birth Rate
CDR	Crude Death Rate
CEC	Cation Exchange Capacity
COD	Chemical Oxygen Demand
CPF	Central Processing Facility
DO	Dissolved Oxygen
DPR	Department of Petroleum Resources
EC	Electrical Conductivity
EGASPIN	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
FTO	Freedom To Operate
GEM	Gender Empowerment Measure
GDT	Gas Down To
GIIP	Gas Initially In PlacePVT
HAZID	Hazard Identification
HAZOP	Hazard Operability
HB	Heterotrophic Bacteria
HDI	Human Development Index

HF	Heterotrophic Fungi
HIA	Health Impact Assessment
HPI	Human Poverty Index
HSE	Health, Safety, Environment
IFC	International Finance Corporation
ISO	International Organisationfor Standardization
JV	Joint Venture
LGA	Local Government Area
MEDEVAC	Medical Emergency Evacuation
NGO	Non-Governmental Organisation
NIWA	National Inland Waterways Authority
NO_2^-	Nitrite
NO_3^-	Nitrate
NTU	Nephelometric Turbidity Unit
OML	Oil Mining Lease
PAH	Polycyclic Aromatic Hydrocarbon
PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
PO_4^-	Phosphate
PVT	Pressure Volume Temperature
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
RoW	Right of Way
RWD	Recyclable Waste Depot
SCD	Sustainable Community Development
SD	Sustainable Development
SIA	Social Impact Assessment
SO_4^{2-}	Sulphtae ion
SMART	Specific, Measurable, Achievable, Realistic and Time- based
SPDC	Shell Petroleum Development Company of Nigeria Limited
SWL	Static Water Level

TDS	Total Dissolved Solid
ToR	Terms of Reference
TSS	Total Suspended Solids
TEG	Tri-Ethylene Glycol
THC	Total Hydrocarbon Content
TPH	Total Petroleum Hydrocarbon
V	Vanadium
WRD	Waste Recycling Depot

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Executive Summary

ES 1.0: Background information

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of its Joint Venture Partners (Nigerian National Petroleum Corporation, Total, and Nigeria Agip Oil Company) intends to drill a single well for appraisal of hydrocarbon reserves within the western part of OML-35 located in Ekeremor Local Government Areas (LGA) of Bayelsa State. It additionaly proposes to re-enter, complete and hook-up three existing wells to supply gas into Nigerian domestic gas market, through a 3rd party offtaker. It also proposes to embark on location preparation and construction of a camp site, access road, Compact Ramp and Jetty in the Iseni field to support hydrocarbon production. It will assist the company in contributing to Nigeria's desire to expand her Hydrocarbon Reserves Base, domestic gas market expansion and local content capability development. The Iseni appraisal well is required firm up hydrocarbon type and discovered volume in Iseni field.

ES 2.0: Objectives of the EIA

The objectives of the EIA are to:

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

ES 3.0: Project Location

The Iseni field is located in Sagbama, Ekeremor and Patani Local Government Areas (LGA) of Bayelsa and Delta States in the Niger Delta area of Nigeria. The Iseni field is adjoined by the Ogara field in the Northern part of (OML-35) and lies roughly between grid coordinates 125326mN; 394191.59mE and 118392mN; 389940., approximately 28km SW of Sagbama. The Ofoni community is the major settlement in the Iseni field, lying on the Southern bank of the Forcados River, one of the two major distributaries of the River Niger. The Ofoni community is bounded by River Forcados, Lalagbene, Angalabiri and Ayamasa in the North, South, East and West respectively. Vegetation in the area is fresh water swamp high forest. Land take shall be 44.2774HA for Iseni well-1& 2 and its access from Ofoni waterside. There is also additional **2.8481Ha** to be acquired for the access from Odorubu to New Odorubu Jetty.

ES 4.0: Legal and Administrative Framework

The EIA was carried out in accordance with the Mineral Oil (Safety) Act CAP 350 LFN 1990, 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 CAP E12 LFN 2004 (FMEnv), FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999), FEPA (Now FMEnv) National Policy on the Environment (1989), Territorial Waters Act CAP 428 LFN 1990, Water Resources Act CAP W2 LFN 2004, National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007. Others include: Bayelsa State Environmental and Development Planning Authority Law 1998; Bayelsa State Pollution Compensation Tax Law 1998 and Bayelsa State Forestry Law 1998.

ES 5.0: Need for the Project

The Federal Government of Nigeria through its joint venture participation is determined to earn more revenue from its hydrocarbon resources. The Project is one of such efforts being planned by SPDC to enable development decisions to be taken on monitise hydrocarbon resource and Nigeria’s domestic gas market growth aspiration. The appraisal well will enable the establishment of the extent and readiness for development of the gas, as well as reducing the subsurface uncertainties.

ES 6.0: Benefits of the Project

The Iseni Project (appraisal and completion), when successfully completed, will provide justification for full filed development of the expected gas reserves in the field. This will entail the drilling of gas development wells and boost the potentials of SPDC as a major player in the development of Nigeria oil and gas resources. If the readiness and extent of the gas volume of the reservoir is proven by the results of drilling the appraisal well, it will enhance SPDC’s capacity to meet the growing demand for gas. The outcome of this well will increase SPDC hydrocarbon reserves and gross production levels as well as improve the revenue base of the country and be a catalyst to further promote partnership withlocal participation in the country’s midstream petroleum sector and industrialization efforts. Furthermore, the drilling activities will lead to the creation of many business and employment opportunities through direct and indirect involvement of communities, consultants, contractors, supplies and other professionals at different stages of the project

ES 7.0: Value of the Project

The estimated cost of the project is about 30 million USD. The project at this stage will be helpful in getting required information/data for further development.

ES 8.0: Envisaged sustainability

Environmental Sustainability

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

Technical Sustainability

The re-entery and hook-up three existing wells to supply gas to 3rd party gas offtaker, the drilling of an additional appraisal well and the construction of camp site, access road, Compact Ramp and Jetty is technically sustainable because of SPDC's proven oil and gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable shall be utilized in the execution of the proposed project.

Economic Sustainability

There is an opportunity to re-enter and complete three existing wells (ISENI-1, -2 and 4) to deliver about 100MMscf/d to a 3rd party customer as soon as possible in order to complement existing supply and meet domestic gas commitment. The 3rd party gas off taker receiving facility is expected to be ready by Q2 - 2019 for commissioning. The Iseni field has proven reserves of gas that can economically and commercially support the project thereby contributing to the revenue accruing to Nigeria and SPDC.

Social Sustainability

The commencement of the Iseni field operations has the potential of increasing number of expatriates and other skilled and unskilled labour force into the community. This has the likelihood of altering the socio-cultural lives of the people. This may lead to youth restiveness and some other social vices. The EIA is expected to identify and categorize the likely negative impact of the field operations on the community. The expected mitigation programme will include human capital development, with the establishment of training institutions, skills acquisition centres and functional guidance and counselling programmes for the youths and other adults. Every effort will be made to preserve the cultural lives of the people and ensure that the community is self-sustaining. The proposed project will in addition:

- 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.

ES 9.0: Project Options/Alternatives

The concept that holds the most value for the opportunity was selected. The project options are as follows:

No Project Option

Advantage: No impact on Environment and No new risks

Disadvantages: Stakeholders (third party offtakers) will not be able to increase their gas target; the Economic opportunities (commerce, employment, etc.) for the communities will be lost and Huge investments that have already been committed into preliminary activities would be lost.

Remarks: Not recommended

Delayed Project Option

Advantage: More time to plan and assess risks

Disadvantages: This will lead to a delay in achieving FID; Loss of expected revenue for the period of delay.

Remarks: Not recommended

Develop the Iseni field:

Advantages: Increase the earnings of SPDC/Nigerian government; Meet SPDC gas obligation to third party gas offtakers; Boost local economy of communities within the Iseni field and Provide Technology transfer to locals.

Disadvantages: Increase SPDC environment footprint and High Unit Technical Cost (UTC).

Remarks: Recommended

Project Alternatives for Drilling

The project options for the drilling of the appraisal well were considered on the basis of technical feasibility, environmental and economic considerations.

Vertical Appraisal Well Option

The option of drilling a vertical appraisal well through the objective sequence expected to be penetrated was considered but dropped. This is because vertical well option will require the acquisition of a new portion of land for drilling whereas the deviated well option is to be drilled from an already acquired location, thereby conserving land. The second factor was the fact that a vertical well would not have allowed optimal penetration of the objective sequence thereby stalling the objectives of the appraisal well.

Deviated Appraisal Well Option

This is the preferred option because it will allow the drilling of the appraisal well from one of the four existing locations, thus reducing land take and minimizing associated environmental impacts (biodiversity). This acquired location is also ideal for efficient and optimal drilling of a deviated well that will penetrate the sequence in order to achieve the appraisal objectives.

Project Options for Construction of Camp site, access road, Compact Ramp and Jetty
The project options for the location preparation and construction of camp site, access road, Compact Ramp and Jetty considered for accessing the Iseni Field location include the following;

Option 1: 12km Road from Odorobu to Iseni 01 location
- Construct 3.5km Surface dressed road from Odorubu to waterside.
- Construct Ramp/Jetty at Odorubu water side.
- Construct Ramp/Jetty at Ofoni water front
- Construct 8.5km Surface dressed road from Ofoni to Iseni-001 location.
- Reconstruction of Iseni 01 Location Platform
- Construction of 1.5Km access road from Iseni 1 location to Iseni 02 location.
- Reconstruction of Iseni 02 Location Platform.
- Construction of Drilling campsite in Iseni Field

Options 2: Odorobu Junction - New Odu Jetty- Bomadi River - Iseni LAUY - Iseni 02 New Jetty
- Construct 3.5km surface dressed road from Oduboro to waterside
- Construct Ramp/Jetty at Odorobu water side.
- 32Km Mtce. Dredging from Odorobu water side to Iseni –LAUY Loc.
- 2.0Km Capital Dredging from Iseni LAUY Loc. To Iseni 02 Ramp/Jetty.
- Construct Ramp/Jetty at Iseni 02
- Construct 1.5km surface dressed road from Iseni 2 to Iseni 01 Location.

Project Options 3 – Ogunu- Burutu-Okwagbe-FOC River - Iseni LAUY - Iseni New 02 Jetty
- Sail from I.A Ogunu Jetty- Burutu -Okwagbe- Gbaregolo –Forcados River – ISENI LAUY Slot.
- 2.0Km Capital Dredging from Iseni Lauy Loc. To Iseni 02 Ramp/Jetty.
- Construct Ramp/Jetty at Iseni 02 Ramp/Jetty
- Construct 1.5km surface dressed road from Iseni 2 to Iseni 01 Location.

ES 8.0: Proposed Project Scope (Iseni Appraisal Well, Hook up of Existing wells, Access Road, Camp site, Ramp/Jetty)
The proposed project scope is as follows:
1. The drilling of an appraisal well within the Iseni Field area. Sidewall coring, wire line logging, pressure and fluid sampling will be done during the drilling of the appraisal well. The well is planned to appraise the 3 reservoirs; E1000, E6000 and F1000 reservoir in Iseni field. The appraisal well is planned to penetrate the structurally down-dip of these hydrocarbon-bearing reservoir to achieve the following:

- To establish fluid type in the undifferentiated 30ft of E1000 reservoir
- To establish F1000 fluid contact and typing beneath the proven Gas-Down-To (GDT) of the reservoir.
- The planned well will also provide additional structural and stratigraphic control.

2. Re-enter and hook-up three existing wells to supply gas to 3rd party gas offtaker.

The Project is focused on early hook-up of existing wells in the cluster to deliver early gas to western domestic market (OSD 2019) with a 3rd party commercial solution. The Iseni Appraisal Well Development is mainly to enter existing Iseni wells number 1, 2 and 4 (Iseni well 3 was side tracked as Iseni-4), recomplete these wells as viable gas producers and produce the wells. The project scope involves laying of NAG flow lines from the individual wellheads to an infield manifold situated on one of the two wells pad which will be tied in a 3rd party pipeline that is expected to deliver the gas to either Utorogu Gas plant or a new gas processing facility near existing Utorogu plant. The scope includes:

- Re-enter, Complete and hook up 3 existing Iseni NAG wells from Iseni 1 and 2 Locations
- Install an infield manifold with metering, well control and data acquisition equipment at the iseni location
- Install 2 Nos of 6” X 0.2km flowline from Iseni-2 location to transport wells fluids to the Infield manifold
- Install 1 No of 6” x1.5km flowline from Iseni – 1 location to transport well fluid to the infield manifold
- 3rd party to lay bulkline to Utorogu gas plant or new CPF by Utorogu Gas plant

3. Location preparation and construction of Camp site, Access road, Compact Ramp and Jetty
   - Odorubu Junction – New Odorubu Jetty- across the river-new Ofoni Jetty- Iseni road-Iseni location
   - Campsite
   - 3.5km access Road (Odorubu to waterside) - dressing
   - 8.5Km main access road (Ofoni to iseni 1) - dressing
   - Iseni 01/02 Location box -(Retrievable Durabase Mats for Surfacing)
   - 1.5km Iseni Location access road
   - Compact ramp/Jetty at Odorubu waterside (Marine berth)
   - Compact ramp/Jetty at Ofoni Waterside (Marine berth)

4. Pipelaying and Manifold
   - 4”/6” X 1.5Km flowline
   - 4”/6” X 0.5Km flowline
   - 4”/6” X 1.5Km flowline

- Shut Down Valves, Sampling points ,HIPPS
- 10"/12" (#1500/#2500) Infield Manifold (3 Nos inlet connection + 1 spare, and one 10"/ 12" outlet) including instrumentations
- infield Manifold Platform

5. Power Transmission
    - 11kvA composite cable to Iseni Infield manifold from Utorogu
    - 50KVA Transformer; 11/0.42kv
    - 400A LV Switchboard
    - LV XLPE cables to wellheads
6. Fiscal Metering
    - 100MMscfd gas Fiscal meter
    - Multiphase /wet gas meter/Test separator for custody transfer metering
    - SPDC field auxiliary room

ES 10.0: Project Activities

A summary of the Project activities include the following:

Premobilization and Mobilisation

- Stakeholder Engagement
- Pre-drilling activities such as reconnaissance visit;
- Movement and transportation of equipment, personnel and materials.

Site Preparation for drilling

- Vegetation clearing within the existing Right-of-Way and additional land acquired.

Site Preparation for Access Road and Camp site Ramp/Jetty

- Setting Out
- Vegetation clearing

Construction of Campsite

- Excavation
- Earthworks (Sand filling)
- Concrete Works
- Perimeter Block wall
- Installation of Gates

Construction of Access Road

The construction of the Odorubu Junction – New Odu Jetty- across the river-new Ofoni Jetty road is divided into the following:

- 3.5km access road (Odorubu to waterside)
- 8.5km main access road (Ofoni to Iseni 1)
- Iseni 01/02 Location box - (Retrievable Durabase Mats for Surfacing)
- 1.5km Iseni Location access road.

The construction activities will involve the following:

- Sub-grade excavation
- Earthworks (Sand filling)
- Base Preparation (Soil-Cement Stabilization and crushed rock filling)
- Extension of one of the existing well pads to accommodate manifold and flow line tie-in
- Bituminous Surfacing
- Installation of culverts

Construction of Concrete Jetty and Concrete Ramp

The Construction of Concrete Jetty and Concrete Ramp will be in two (2) folds:

- Compact ramp/Jetty at Odorubu waterside (Marine berth)
- Compact ramp/Jetty at Ofoni Waterside (Marine berth)

This will involve the following activities:

- Piling Works
- Mobilise piling rig to site
- Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel schedule 40 casing)
- Steel works
- Reinforced Concrete works
- Steel works (hand rails etc.)
- Installation of Bollards & Fenders
- Dredging Works (Depending on siltation levels)

Construction, laying of three (3) flowlines of total length (3.5km) and hook-up to the infield manifold

The description of the flowlines and manifolds are:

- 4”/6” X 1.5Km flowline
- 4”/6” X 0.5Km flowline
- 4”/6” X 1.5Km flowline
- Shut Down Valves, Sampling points, HIPPS

- 10"/12" (#1500/#2500) Infield Manifold (3 Nos inlet connection + 1 spare, and one 10"/ 12" outlet) including instrumentations
- infield Manifold Platform

The activities involved will include but not limited to the following:

- Trenching
- Stringing
- Cleaning, bevelling and Pipeline bending
- Welding
- Radiography
- Field Joint Coating
- Lowering
- Inspection, testing and NDT of welds
- Cathodic Protection
- Backfilling
- Hydrotesting
- Manifold works
- Site Reinstatement

Hook-up of Existing Wells to Manifold

The specific project activities to be carried out include:

Well Operation, Flow line and infield manifold Construction

- Well reentry and completion operation
- Excavation / trenching
- 11.7km of access road preparation
- Wells and manifold location preparation- e.g. landfills
- Ramp/Jetty construction
- Pipe welding, coating and testing
- Pipe laying
- Pressure testing
- Backfilling
- Commissioning of Pipelines
- Well maintenance and operation activities
- Rig interventions

Rig movement, positioning and set up

Drilling

Only one appraisal will be drilled. The activities involved in the drilling process include:

- Drilling
- Casing logging, cementation and completion of well
- Well testing and Hook-up
- Well handover Operations

Operation and Maintenance
Demobilization

Decommissioning and abandonment;

- Demolition and site clean-up;
- Disposal of wastes; and
- Site remediation and monitoring

ES 11.0: Waste Management

Wastes will be generated from the various project activities. However, the bulk of waste generated will be from logistics, construction and drilling activities. The anticipated wastes from these activities include domestic wastes (e.g. food and trash), sanitary wastes, batteries, cabes and scraps. The waste management strategy will involve Recycle or reuse of batteries and cables, composting and incineration.

Drilling Waste

The drilling waste management principles in this project will focus on waste minimisation and recycling. The wastes that will be generated during the drilling operations are:

Drill cuttings / excess

Spent drilling mud and completion fluids

- Rig wash (Detergent) water.
- Cementing waste.
- Discarded consumables.
- Domestic waste (solid and sewage).
- Drilling effluents (waste water)

Non Drilling Waste

Discarded consumables include unused drilling chemicals, chemical/material bags, scrap metals used in constructions etc. All these will be trucked back to Kidney Island base in Port Harcourt for recycling. A strict inventory control of all chemicals in use shall be maintained. All chemicals, lubricating oils and fuels will be stored in containers and safely placed in a sheltered area on the rig. Appropriate Safe Handling of Chemicals (SHOC) cards will be provided for every chemical on board the rig for the safety of personnel and the environment.

Dredging Works

Depending on the siltation levels at the approaches to the Ramp/Jelly, maintenance dredging of the area shall be carried out to provide the required draft for vessel to birth safely. Approved personnel flotation devices (PFD) are to be deployed and used daily on the project by all personnel. Life Lines (with small floating rings), Life buoy & Rescue Stick shall be available on site. In line with safety consciousness and alertness, workers shall be advised to shout for help should there be an event of man overboard for the deployment of probing/rescue stick for the victim to grab if he is within reach.

ES 12.0: Project Schedule

Access Road construction and location preparation is scheduled to be concluded Q2, 2018. However, Well Re-Entry/Workover, Pipeline construction and Hookup/commissioning of the Wells activities will be completed in Q3 2018. The Hookup/commissioning of the Wells is scheduled for Q3 2019.

ES 13.0: Description of the Existing Environment

The purpose of the environmental 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 project. The environmental data presented in this chapter is a representative of the status of the biophysical, social and health profile of the people in the Iseni field. A multi-disciplinary approach was adopted for data acquisition and ecological characterization which include Climate and Meteorology, Air quality and Noise, Soil quality and Land use, Vegetation and Wildlife, Hydrobiology and Fisheries, Geology, Social and Health Profile. Data were also generated through literature review of existing environmental studies report in the area, consultations with stakeholders, Field study, Laboratory and Statistical data analysis. The current report represents an integration of the Environmental Impact Assessment (EIA) of Iseni Appraisal Well Project (2015) in which data was obtained from the approved one season field study carried out between 29th October and 5th November 2013 and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty and Access Road) Project, 2016 in which data was obtained from an approved one season field study from 18th to 23rd of July, 2016

Literature Review

Some information used for the description of the environment in this report was obtained from the following documents:

- Environmental Impact Assessment of Iseni Appraisal Well Project, 2013 in which data was obtained in February 2008.
- Scientic documents.

Description of Sampling Location

The sampling points were geo-referenced by means of Global Positioning System (GPS). Two sets of data were obtained. Field data gathering exercise for the one season study of Iseni Appraisal Well Project, 2015 was conducted from 29th October to 5th November 2013 and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty and Access Road) Project, 2016 from 18th to 23rd of July, 2016 respectively. The study covered a spatial boundary of 2km radius of the proposed well locations in the Iseni field. The stratified sampling design protocol was adapted for the study. In stratified sampling, the target population or study area was separated into non-overlapping strata, or subpopulations that are known or thought to be more homogeneous (relative to the environmental sensitivities or contaminants). This allowed for less variation among sampling units in different strata. The strata were chosen on the following bases:

- Vegetation type;
- Surface water bodies and other environmental components and sensitivities;
- Existing well location;
- Human presence and population density;
- Proposed development area (such as well locations and flowlines);
- Professional judgment.

All samples were analysed in Tudaka Laboratory Limited, Warri, Delta State. The summary of sampling points for various environmental spheres in 2013 and 2016 field data gathering exercise is as follows:

- Air Quality and Noise quality: 12+3 controls; 4 +2 controls
- Soil quality: 18+3 controls, 7 +2 controls
- Vegetation/Wildlife: 18+3 controls, 7 +2 controls
- Surface water quality: 6+3 controls, 2 +2 controls
- Sediment quality: 6+3 controls, 2 +2 controls
- Ground water quality: 6+3 controls, 3 + 2 controls
- Social and Health Profile: Odorubu and Lalagbene communities; Ofoni (Pougelle) community.

ES 14.0: Quality Assurance/Quality Control

The quality assurance/control programme covered all aspects of the study, including sample collection, handling, laboratory analyses, data coding, statistical analysis, presentation and communication of results. The Federal Ministry of Environment (FMEnv) and the Department of Petroleum Resources (DPR) Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) Part VIII D (2) on sampling and handling were strictly adhered to in the course of field sampling. Where these were not possible due to logistics or safety reasons, other proven scientific and standard methods were used. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory were also implemented. The following precautions were also observed:

- Samples were collected in bottles that have been thoroughly washed with detergent (nutrient free) and rinsed with distilled water;
- All sampling equipment were properly protected and maintained in accordance with manufacturers' manuals;
- Sampling bottles were adequately labeled with masking tapes and indelible markers to avoid mistaken identity;
- Only analytical grade (Analar) chemicals were used and where applicable redistilled;
- Automated equipment were calibrated prior to field sampling.

Basic information was recorded together with results of analysis, in a sample register. With proper, sustained calibration of the instrument and the use of standardized observational procedures, equipment errors were brought to acceptable minimum.

Statistical Analysis

All data generated in this study were subjected to statistical analysis to test for spatial variation between sampling stations and control stations during sampling periods 2013 and 2016 separately; data could not be compared with data obtained in 2008 in the Iseni Appraisal Well EIA (2013) because the latter was obtained in the dry season February while data obtained in 2013 and 2016 were both obtained in the wet season. The Dunnett's test was used to identify stations responsible for the variations. Other tools employed in this study included descriptive statistics (range, mean, standard deviation, coefficient of variation, frequency and percentages) and *chi square goodness of fit test* ratio 1:1 and SPSS 15.0 packages as applicable. One level of significance ($p<0.05$) was considered in the results interpretation. Bar and pie charts, and line graphs were also used in comparing the results. The analytical results were also compared with local and international standards where applicable and also with data from previous studies on the area.

ES 15.0: Results

Climatic Conditions

The project area is characterized by two dominant seasons (wet and dry seasons) on the basis of the rainfall pattern. The wet season (Rainfall) peaks in June and September and the drier period, between November and February. The high annual total rainfall is in excess of 2500 mm and its pattern of distribution influences other environmental parameters including ambient temperature and relative humidity. The temperatures recorded in the area are typical of its tropical location. The *in-situ* temperatures measured during the study ranged from 28.9 - 33.4 ^{o}C, while the humidity was from 62.1 - 80.3%. The wind pattern over the study area shows that the wind flow pattern is predominantly south westerly with average speed ranging from 0.10 m/s and 1.40 m/s

Air Quality

The concentrations of Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2) in the proposed well, existing wells area and un-impacted/community area and control stations (Iseni Wells EIA 2013) were generally low. Similarly, the concentration of these gaseous pollutants (SO_2 and NO_2) for the around the proposed Camp, access road, Jetty/Ramp area and the control stations (Iseni wells Addendum EIA 2016) compared favourably with the 2013 data as the concentrations were below the equipment detection limits (<0.001ppm). Statistical Analyses showed that there was no significant difference ($p>0.05$) in the gaseous pollutants when compared to the control stations. These values complied with the DPR limits of 0.04-0.06ppm and 0.08ppm for daily average/mean values and FMEnv limits of 0.01 and 0.04 to 0.06ppm. The mean concentration of VOCs in the proposed well, existing wells area and un-impacted /community area and control stations (Iseni Wells EIA 2013) were 0.22±0.01 ppm, 0.20±0.03 ppm, 0.21±0.06 ppm and 0.19±0.12ppm respectively. These values were lower than the concentrations of VOCs around the proposed Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) 4.85±3.89 ppm, 8.05±1.06 ppm and 4.05±0.21ppm respectively. This may be attributed to the influence of emissions from automobile exhausts and generators from the nearby Ofoni community.

Statistical analyses showed that SPM levels in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) 12.65±6.58 $\mu g/m^3$, 17.45±0.78 $\mu g/m^3$ and 7.2±0.57 $\mu g/m^3$ were higher ($p=0.001$) than levels of in the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) 2.88±0.26 µg/m3, 3.37±0.48 $\mu g/m^3$, 3.4±0.81 $\mu g/m^3$ and 2.29±1.46 $\mu g/m^3$ respectively. The SPM levels complied with the DPR and FMEnv limits of 60 to 90 $\mu g/m^3$ and 250 $\mu g/m^3$ for daily average/mean values. The Noise levels measured at the Proposed Iseni Appraisal Well, Existing Wells, Unimpacted area/Community and control stations were 48.03±0.90 dB(A), 51.35±1.95 dB(A), 49.86±4.65 dB(A) and 36.34±24.96 dB(A). No significant variation ($p>0.05$) was observed across the sampling stations including the control stations for the Iseni Appraisal Well Project, 2013. Similarly, there was no spatial variation ($p=0.497$) in the noise levels when compared to the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 as the mean values were 42±0.42 dB(A), 42.75±4.88 dB(A) and 41.3±1.13 dB(A) for Proposed access road, Proposed Jetty/Ramp and Control stations. The noise levels complied with the DPR and FMEnc limits of 85 dB(A) and 90 dB(A) for 8 hour exposure.

Soil Characteristics

Texture

Sand dominated the textural class across the sampling stations in the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013). No significant variation was observed in the clay ($p=0.889$), silt ($p=0.695$) and sand ($p=0.152$) composition when compared to the control stations. Similarly, in the the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016), clay dominated the textural class. The dominance of clay maybe attributed to weathering processes of soils around the area. The clay ($p=0.128$) and silt ($p=0.866$) composition compared favourably with those around the control stations except sand ($p=0.000$). Local variation in the geologic conditions may also contribute.

Bulk Density

The bulk densities in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) did not show any variance ($p>0.05$) when compared to values obtained from sampling stations in the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013).

pH

The pH values were generally acidic in the top and bottom soils within the study area. There was no significant difference ($p=1.000$) in the pH values across the sampling stations including the control stations in the top and bottom soils. The mean pH of the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) were 4.88±0.4, 4.51±0.37 (proposed Iseni Appraisal Well); 4.85±0.62, 4.51±0.36 (existing Iseni Wells), 4.78±0.49, 4.45±0.38 (Unimpacted area/community) and the control stations (4.55±2.51, 4.24±2.32). Similarly, the mean pH values in the top and bottom soils of the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) were 3.68±0.38, 3.73±0.44 and 4.25±2.25, 3.93±1.97 respectively.

Electrical Conductivity

The Electrical conductivity (EC) levels around the existing Iseni Wells were significantly different ($p=0.000$) when compared to the proposed Iseni Appraisal Well , Unimpacted area/community and the control stations in the (Iseni Appraisal Well Project 2013). The mean EC values in the top and bottom soils were 146±30.25 µS/cm, 142.8±43.59 µS/cm (proposed Iseni Appraisal Well), 230.55±4.88 µS/cm, 209±16.97 µS/cm (Existing Iseni Wells), 184.67±33.84 µS/cm, 141±32.45 µS/cm (un impacted area/community) and the control stations (166.26±94.72 µS/cm, 158.48±89.30 µS/cm). The variance in the EC levels may be attributed to local variation in the soil minerals and nature of parent rock materials around the proposed Iseni Appraisal Well. The EC levels in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) were significantly lower ($p<0.05$) when compared to the data obtained proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013).

Nutrients

No significant variation ($p=1.000$) in ammonium, nitrates phosphates, Na, K and Ca concentrations were observed in all the sampling stations in the study

Trace Elements (Heavy Metals)

Concentration of V, As, Hg, Ba, Co, Al and Ag in the top and bottom soils of the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) were below the equipment detection limits (<0.001mg/kg). Similarly, Cr ($p=0.934$), Pb ($p=0.881$), Cu (1.000), Zn ($p=0.919$), Ni ($p=0.753$) and Cd ($p=1.000$) were generally within background levels and compared favourably with the control stations except Iron ($p=0.000$).

Concentrations of V, As, Pb, Hg and Ba concentrations in the top and bottom soils around the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016)were below the equipment detection limits ($p<0.001$). There was no significant variation in the concentration of Cr ($p=0.074$), Cu ($p=0.705$), Ni ($p=0.782$) and Cd ($p=0.096$) when compared to the control stations.

Organics

The concentration of TPH, PAH, BTEX, Oil and Grease in the top and bottom soils of the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) and Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) were below the rquipment detection limits (<0.001mg/kg). The soil was relatively pristine with regards to organics.

Soil Microbiology

The THB and TF counts were in the order of 10^5cfu/g and 10^3 cfu/g in the top and bottom soils of the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) and compared favourably ($p=0.801$, $p=1.000$) with those in the control stations. Similarly, the THB and TF counts were higher (THB 10^7cfu/g)) in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) compared to the Iseni Appraisal Well Project, 2013(THB 105cfu/g). The THB ($p=0.564$) and TF ($p=1.000$) counts suggest high microbial activity and may be attributed to the presence of utilizable organic substrates in the soils within the area. The proportion of the hydrocarbonoclastic counts in the top and bottom soils was <1% in both the proposed well, existing wells, un-impacted /community and control stations (Iseni Wells EIA 2013) and Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016).This suggests the near-pristine nature of the soils in the Iseni field as the analytical results of TPH, PAH, BTEX, Oil and Grease also lends credence to this findings.

Land Use

Land use in Iseni community comprises residential, schools, recreational facilities, health center and worship centers. Also, the area is surrounded by forests which provide arable lands for agricultural purposes. Agricultural lands host agricultural activities including crop cultivation and artisanal fish ponds which are localised mostly within farm settlements.

Geology, Stratigraphy, Geomorphology and Hydrogeology

The proposed project location is within the Niger Delta Basin of Nigeria. It is situated on the West African continental margin at the apex of the Gulf of Guinea, which formed the site of a triple junction during continental break-up in the Cretaceous. It is informally divided into three gross lithofacies: (i) marine claystones and shales of unknown thickness, at the base; (ii) alternations of sandstones, siltstones and claystones, in which the sand percentage increases upwards; (iii) alluvial sands, at the top. The area constitutes an extensive plain open to periodic inundation by flood resulting in flood plains and levees at the River banks. The geomorphology of the Niger Delta is that of a wave-dominated delta, with a smoothly seaward-convex coastline crisscrossed by distributary channels. Geologically, the proposed Iseni Appraisal Well Project area is underlain by three main lithological units the Akata Formation, Agbada Formation and the Benin Formation. Prolific Hydrocarbon reserves are found in the Agbada Formation. The Benin Formation represents the best aquifer unit in the area, although shallow aquifers are found in the recent Alluvium deposits. Borehole yields are generally very good, with production rates of about 20,010 l/h and borehole success rate is usually high. Groundwater movement and flow direction is controlled by hydraulic gradient (flow direction is usually from areas of higher gradient, i.e., water level, to areas of lower gradient). Groundwater flow direction in the area was found to be from North to South, which is in conformity with the regional groundwater flow direction in Nigeria and the Niger Delta.

Vegetation

The study area is located in the Niger Delta Swamp forest ecoregion [5] of the Lower Guinean forests of Nigeria. Its terrain is seasonally flooded and its vegetation cover is differentiated into two basic types of rain forest communities namely the freshwater swamp forest ecotype referred to as the Niger Delta Flood Forest, and the Raffia Swamp Forest(which is a vegetation community delineated based on *Raphia* species dominance). Agricultural farmlands and fallows present form an artificial vegetation cover. These three vegetation categories in ratio of percentage coverage are: Fresh Water Swamp (75%) > Raffia Swamp (16%) > Artificial Vegetation Cover (8%). Vegetation in the first two vegetation systems is mostly secondary forest (at climax stage) and predominantly mesophanerophytic. Average height of vegetation across the habitats in decreasing order is 28 meters > 13 meters > 3.5 meters. The vertical profile of the fresh water swamp vegetation shows that it is fairly stratified into two layers of trees: the canopy layer of trees between 21-30 meters in height, and the emergent layer of trees between 30 – 40 meters in height. Total tree density in mature areas ranges between 549 (– 650) – 723 trees per hectare. Open forest canopy areas in Secondary forest regrowths occur as a result of deforestation activities especially logging. A diversity of plant forms were identified which include Trees, Shrubs, Herbs, Lianes and Climbers, Epiphytic Ferns and Orchids; and also a few grasses. Dominant families include Fabaceae and Euphorbiaceae with 4 species each; and Apocynaceae, Palmae, Asteraceae, and Orchidaceae with 3 species each. A total of 62 species belonging to 41 plant families are enumerated from the study area. There was no sign of invasive species or abnormal disease conditions within the plant population. Agriculture is organized into farm camps, non-mechanized, and dominated by small subsistence plantation (typically less than an acre) holdings of Plantain. Cocoyam and Cassava are also cultivated on a much smaller scale. Traditional Palm oil mills occur on the farms where palm fruit harvested from the wild is stored and processed into palm oil in commercial quantity. Tissue analysis revealed that there was no incidence of phytotoxicity as most of the nonessential heavy metals were absent while the others occurred at normal concentrations.

Wildlife

A total of thirty three (33) species of wild life have been identified. The wildlife of the Iseni field is dominated by mammals with a total of twenty (22) species belonging to 14 different animal families. The species diversity and composition by families, in decreasing order is Mammals (21) > Reptiles (7) > Aves (5). Important locally threatened species include the West African Manatee, Mona monkey, Putty/white nosed monkey, African Civet, Crested genet, White bellied pangolin, and Walter's duikers. These species are seriously under hunting pressure from a few artisanal hunters in Iseni. Hunting is carried out mostly by gun wielding hunters and setting of traps. Forest buffalo and crocodiles were not known to occur in the area although they are present in nearby Bomadi overside and Aiyemaibeni communities respectively.

Surface Water Quality

Generally, most of the parameters determined showed no significant difference ($p>0.05$) across the sampling stations (proposed well, existing wells and Ramp/Jetty areas, except TDS, conductivity, total alkalinity nitrate and hardness.

Colour

The colour of the surface water around the proposed Iseni Wells compared favourable with the control stations as the mean values were 5.25±1.26 Pt/Co units and 5±3.06 Pt/Co units. Similarly, the mean values around the proposed Jetty/Ramp were not significantly different ($p=0.615$) when compared to the 2013 values. The similarity maybe attributed to the fact that both samples were obtained during the Wet season.

Temperature

The mean temperature values around the proposed Iseni Appraisal Well, Existing Iseni Wells and control stations (2013) were not significantly different ($p=0.998$) when compared to the values around the Jetty/Ramp (2016). In the Iseni Appraisal Well Project, 2013, the mean values were 29.43±0.78 ºC, 28.95±16.72 ºC and compared favourably ($p>0.05$) with the control stations (28.63±14.33 ºC). Similarly, the mean temperature values in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were 27.8±0.26 ºC and 27.5±15.88 ºC around the proposed Jetty/Ramp and Control stations respectively.

Electrical Conductivity, Total Dissolved Solids and Salinity

The levels of Electrical conductivity, Total Dissolved Solids (TDS) and Salinity around the Iseni Appraisal Well Project, 2013 were 82.19±0.18 µS/cm, 48.35±0.10 mg/l, 10.16±1.48 mg/l (Proposed Iseni Appraisal Well); 68.6±42.18 µS/cm, 40.35±24.82 mg/l, 7.895±4.60 mg/l (Existing Iseni Wells) and 69.40±39.94 µS/cm, 40.83±23.49 mg/l, 7.05±3.83 mg/l (Control). There were significant differences in the levels of electrical conductivity ($p=0.000$) and TDS ($p=0.000$) when compared to the levels around the Jetty/Ramp in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The variance maybe attributed to the influx of salinity related materials from the Forcados river. The mean values around the Jetty/Ramp and control stations were: 39.27±1.08 µS/cm, 19.63±0.54 mg/l¸10.61±2.35 mg/l; 38.35±22.15 µS/cm, 19.18±11.08 mg/l ¸ 11.03±6.37 mg/l.

Total Suspended Solids and Turbidity

The mean Total suspended solid (TSS) around the proposed Iseni well and existing wells were 8.96±0.27mg/l and 8.77±5.07mg/l respectively. No significant variation (p=0.861) was observed when compared to the TSS values around the Jetty/Ramp as mean values were 5.67±1.15mg/l. The TSS values in the control stations compared favourably with the study area (Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016).

Turbidity, which defines the clarity of water is a function of the suspended solids concentration. Turbidity values measured around the proposed Iseni well and existing wells were 69.26±20.90 mg/l and 7.11±4.16 mg/l and were significantly different (p<0.05) from values in the control station (32.90±27.31mg/l). Similarly, the turbidity levels around the proposed Jetty/Ramp and control stations were significantly lower (p=0.000) compared to the Iseni Appraisal Well Project, 2013. The variance maybe attributed to influx of materials from the Forcados river to surface water bodies around the proposed Iseni well and existing wells.

pH

The pH of the surface water was slightly acidic in the proposed well area and existing well area and slightly alkaline in the Ramp/Jetty area. The values were 6.48±0.16 in the proposed well area, 6.02±3.48 in the existing well area and 8.00±0.2 around the proposed Ramp/Jetty area. No significant variation (p=0.903) was observed in the ph of surface water bodies around the proposed well area and existing well area and around the Ramp/Jetty area. The control stations however compared favourably in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016.

Alkalinity

The alkalinity in the proposed well and existing wells area was higher (p=0.000) than that of the Ramp/Jetty area. The mean alkalinity values were 17.93±3.29 mg/l and 11.76±6.99 mg/l around the proposed appraisal well and existing wells respectively. The control stations compared favourably (p>0.05) with the study area. Furthermore, the mean alkalinity values around the proposed Jetty/Ramp and control stations were 0.34±0.04 mg/l and 0.29±0.17mg/l.

Total Hardness, Calcium and Magnessium

The hardness of the surface water around the proposed appraisal well and existing wells were at variance (p=0.051) with the levels around the Jetty/Ramp. The mean values in the Iseni Appraisal Well Project, 2013 were 5.04±0.50mg/l and 6.36±3.79mg/l for the proposed appraisal well and existing wells. Similarly, the mean hardness levels were 9.33±1.15mg/l and 14±8.33mg/l around the Ramp/Jetty and control stations. The levels in the control stations in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were generally similar and showed no variation.

Hardness in water comprises the determination of calcium and magnesium as the main constituents with magnesium ions contributing more to the measured hardness in this study. The mean calcium concentrations in the proposed well and existing wells area was 1.18±0.19mg/l and 1.96±1.21 mg/l. The calcium concentration compared favourably ($p=0.392$) with the concentrations around the Jetty/Ramp as mean values were 2.58±0.20mg/l and 3.6±2.14mg/l around the Jetty/Ramp and control stations. These values corroborated with the levels of hardness in the surface water bodies. The concentration of magnesium followed the same trend as no significant variation ($p=0.200$) were observed around the proposed appraisal well and existing wells compared to the Ramp/Jetty.

Sulphate (SO_4^{2-})

The concentration of sulphates in surface water bodies around the proposed appraisal well and existing wells were 1.88±0.3mg/l and 2.88±1.89mg/l. The concentration in the control stations (2.2±1.15mg/l) did not differ significantly ($p>0.05$). There was no significant variation ($p=0.881$) in the concentration of sulphates in surface water bodies around the Jetty/Ramp.

Phosphate (PO_4^{3-})

Phosphate concentrations within the study area were similar. Phosphate concentrations for the proposed well and existing wells area was 0.03±0.01mg/l and 0.05±0.03mg/l. The concentration of phosphates in surface water bodies around the Jetty/Ramp and control stations were not significantly different ($p=0.651$) when compared to those around the proposed appraisal well and existing wells. The observed level of phosphate in the water body indicates that the water was not contaminated with this plant nutrient. High concentration has been implicated in excessive nutrient enrichment (eutrophication) of surface water body, with the attendant unrestricted growth of water weeds.

Nitrate (NO_3^-)

Nitrate is the most completely oxidised state of nitrogen commonly found in natural water and all natural ecosystems need it as an essential nutrient for primary production. Nitrate concentrations in the surface water around the proposed well and existing wells was 0.74±0.19mg/l and 1.00±0.58mg/l. The concentration in the surface water bodies around the Ramp/Jetty were lower ($p=0.012$) compared to the proposed appraisal well and existing wells. The mean concentration of nitrates was 0.05±0.03mg/l and 0.07±0.05mg/l around the Jetty/Ramp and control stations. In the study area, NO_3^- was higher than NH_4^+, indicating an oxidation reaction with little or no anthropogenic pollution and organic matter decomposition. This also agrees with the observed positive OPR values.

Other Anions

Other anions determined in the water samples were sulphide (S^{2-}) and cyanide (CN^-) with concentrations below instrument detection limits (<0.001 mg/l).

Dissolved Oxygen (DO)

The mean DO levels in the surface water bodies around the proposed well and existing wells area were 5.25±0.44mg/l and 5.05±2.92mg/l. No significant variation (p=0.901) was observed in the DO levels around the Jetty/Ramp as mean values were 4.33±0.74mg/l and 4.2±2.50mg/l around the Jetty/Ramp and control stations. The control stations compared favourably (p>0.05) with the study area. Typically, the concentration of DO in surface water is usually less than 10 mg/L.

Biochemical Oxygen Demand and Chemical Oxygen Demand

The mean BOD_5 was 0.81±0.10mg/l around the proposed well and 0.84±0.48mg/l around the existing wells area. Similarly, the BOD_5 levels around the Jetty/Ramp were generally similar (p=1.000) to the levels around the proposed well and existing wells. The mean BOD_5 levels around the Jetty/Ramp were 1.42±0.18mg/l and 1.05±0.61mg/l. Furthermore, the COD levels around the proposed appraisal well and existing wells were 2.03±0.24mg/l and 2.09±1.21mg/l. No significant variation (p=0.801) was observed in the COD levels around the Jetty/Ramp. Under normal environmental conditions, the background COD values are expected to be higher than the BOD_5 for any given sample because COD includes both biodegradable and non-biodegradable substances.

Oil and Grease and Hydrocarbons

Oil and grease, THC, BTEX and PAHs were very low and below the equipment detection limits (< 0.001).

Metals

The concentrations of these metals determine in surface water in the study area were generally very low, below instrument detection limit (<0.001), except Fe, Cr and Zn that showed values which are below their maximum allowable concentrations in potable water.

Surface water Microbiology

The mean THB population in the surface water samples was $3.7 \times 10^3 \pm 0.63 \times 10^3$ cfu/ml for the proposed well and existing wells area and $3.1 \times 10^7 \pm 6.0 \times 10^5$ cfu/ml for the proposed Ramp/Jetty area. The mean percentage HUB for the proposed well and existing well area was 5.1% and for the proposed Ramp/Jetty was 0.006%. This result suggested that the heterotrophic bacterial population within the proposed well and existing well area had been exposed to hydrocarbons of petroleum origin though in very small amounts. However the heterotrophic bacterial population within the proposed Ramp/Jetty area had not been exposed to hydrocarbons of petroleum origin. The low TPH, PAH, BTEX oil and grease concentrations give support to these observations. The total coliform counts of the proposed Ramp/Jetty area were higher than that of the proposed well and existing wells area. This result showed the influence of human activities in the latter area compared with the former. The coliforms include the fecal coliforms which are indicators of human fecal contamination of water. The predominant bacteria isolated from the surface water were; *Esherichia coli*, *Bacillus* sp, *Pseudomonas* sp, *Streptococcus* sp, *Klebsiela* sp, *Staphylococcus* sp *Enterobacter* sp and *Micrococcus* sp

Hydrobiology

Phytoplankton

The phytoplankton flora comprised seventeen taxa distributed into three divisions namely Bacillariophyta (diatoms), Chlorophyta (Green algae) and Cyanophyta (Blue green algae). The Phytoplankton community was dominated by the Bacillariophyceae (47.1%), followed by Chlorophyceae (35.2%) and Cyanophyceae (18.6%) each represented by six and three species respectively. The Bacillariophyta, comprising both pinnate and centric forms of which Coscinodiscus dominated in both density and ubiquity, followed by *Flagillaria* sp and *Surirella elegans*. The least occurring species was the *Fragillaria javanica*, *Eudorina elegans*, *Spirogyra dubia* and *Lyngbyia majuscule*. The green algae were dominated by *Closterium* and *Spirogyra*, while Microcystis aeruginosa was the dominant species among the blue-green algae. Species diversity and distribution show that Stations 1, 3 and 2 had the highest diversity of 1.9625, 1.8082 and 1.8077 respectively, while stations 7, 4 and 5 had the least diversity (0.9303, 1.0609 and 1.3216) respectively.

Zooplankton

The zooplankton comprised the Copepods (45.5%) in occurrence followed by the Cladocerans and Rotifers contributing 27.2% each. Among the Cladocerans, the families Chydoridae, Daphnidae and Moinidae were represented, of which Moinidae was the most dominant, while Chydoridae was the least dominant. The preponderance of Copepods species in the water body, both in occurrence and distribution, may be due to the intrusion of brackish water into the environment. The water body were composed of cosmopolitan species dominated by the cyclopoid Copepods. Nauplius larvae were found in all the stations. Diversity and species distribution assessment showed Stations 3 and 1 with the highest diversity of 1.802 and 1.5292, while stations 4 and 9 had the least diversity of 0.6365 and 0.8664 respectively.

Macrobenthic Fauna

The benthic fauna are the bottom dwelling organisms and their distribution and abundance help to delineate water types and indicate shifts in water quality. The benthic invertebrate fauna were made up of 17 species comprising 9 species of Arthropoda, 4 species of Annelida, 2 species of Nematoda and 2 species of Mollusca. The percentage contribution by species composition of the major macrofaunal taxonomic groups to benthic faunal diversity showed that the Arthropods were the dominant species in terms of distribution and abundance accounting for 56% of the entire macrobenthic fauna, followed by the Annelids (34%), Mollusca (9%) and Nematods (1%). High disparity in the distribution of these organisms among the different stations was observed. Species diversity was high for Stations 1, 2 and 6 but low for Station 3, whilst the species distribution for all the stations was generally low.

Fisheries

Species composition in the area was identified during sampling. Secondary information from fisher-folk as well as from recent studies carried out around the area was used to provide a comprehensive list. The list shows that 34 species belonging to 16 families were found in the aquatic ecosystem in the study area. Dominant fish families identified in catches in the area include Bagridae, Characidae, Clariidae and Mochokidae. The Bagrid species included *Chrysichthys nigrodigitatus*, and *Clarotes macrocephalus*, while the Characidae, Clariidae and Mochokidae are made up of *Alestes macrolepidotus, A. longipinis, A. nurse, Clarias anguillaris, C. gariepinus, Parauchenoglanis* sp., *Synodontis omias, Synodontis clarias and Synodontis nigrita*. Other common species include *Gnathonemus abadi, Labeo senegalensis, Heterotis niloticus, Citharinus latus, and Gymnarchus niloticus*.

Sediment Quality

pH

The pH values of the sediment samples were in the acidic range with mean values for the proposed Iseni appraisal well (5.12±0.24) existing Iseni wells (4.88±0.04) and Jetty/Ramp area (5.52±0.16).The mean pH of the control stations for the proposed Iseni appraisal well, existing Iseni wells was 5.42±2.77 and the Jetty/Ramp was 5.85±3.38. There was no significant difference between the pH of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). High sediment acidity has been attributed to combination of possible oxidation of pyrite (FeS2) in the sediment to produce sulphuric acid, depleted calcium level or increased aluminium concentration in sediment.

Redox Potential

The redox potential was high and positive indicating aerobic nature of the sediments. There was no significant variation between the redox potential of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean redox potentials of the sediment samples for the proposed Iseni appraisal well (123.5±12.02mV) existing Iseni wells (122.5±4.95mV) and Jetty/Ramp (95±7.55mV).

Total Organic Carbon

Total organic carbon contents of the sediment samples were low in spite of the high silt content. There was no significant variation between the total organic carbon (TOC) of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean TOC of the sediment for the proposed Iseni appraisal well (0.425±0.06%), existing Iseni wells (0.47±0.17%) and

Jetty/Ramp (0.99±0.77%) was low. The mean TOC of the control stations in proposed Iseni appraisal and the existing Iseni wells was 0.31±0.16 and in the Jetty/Ramp area was 1.1±0.65.

Nutrients

There was no significant variation between the nitrate concentration of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean nitrate concentration of the sediment for the proposed Iseni appraisal well(1.145±0.25mg/kg), existing Iseni wells (0.06±0.01mg/kg) and Jetty/Ramp (1.08±0.21mg/kg). The mean nitrate concentration of the control stations in proposed Iseni appraisal and existing wells was 0.05±0.03mg/kg while the control station values for the Ramp/Jetty area was 1.12±0.68mg/kg.

Exchangeable Cations

Exchangeable cations (Na, K, Ca, and Mg) were higher in the Ramp/Jetty area than the proposed and existing wells area. The observed cations values reflect a freshwater environment. The exchangeable acidity and cation exchange capacity of the sediment samples ranged from 1.32 - 2.57 cmol/kg and 3.47 - 6.46 cmol/kg respectively.

Oil and Grease, and Hydrocarbons

The oil and grease concentration, THC and TPH contents of the sediment samples were very low indicating that their sources were probably biogenic. The mean THC of the sediment was greater in the proposed Iseni appraisal well (0.36±0.25mg/kg) and the existing Iseni wells area (0.23±0.06mg/kg) than the Jetty/Ramp area (<0.001mg/kg). The mean oil and grease was greater in the proposed Iseni appraisal well (0.48±0.29/kg) and the existing Iseni wells area (0.32±0.10 mg/kg) than the Jetty/Ramp area (<0.001mg/kg).The values for the control stations were 0.29±0.15 mg/kg and <0.001mg/kg for the proposed well/existing wells area and Jetty/Ramp area respectively. The mean TPH in the proposed Iseni appraisal well (0.105±0.04mg/kg) and the existing Iseni wells area (0.07±0.01mg/kg) than the Jetty/Ramp area (<0.001mg/kg). PAHs recorded very low concentration from <0.01 – 0.02 mg/kg and BTEX concentrations were below instrument detection limits (<0.001 mg/kg) in all the sampled areas.

Heavy Metals

The order of concentrations of the heavy metals with measurable concentrations in the sediment samples were: Fe >> Zn >> Pb > Cr > Mn > Ni > Cd > Cu.

Some heavy metals were higher in the Ramp/Jetty area (Fe, Zn, Cu and Cd) than the proposed wells and existing wells area. Other metals (Hg, V, Co and As) did not show any significant variation between the proposed well and existing wells area and the Ramp/Jetty area.

Sediment Microbiology

There was no significant spatial differences between the microbial counts (THB,TF, HUB and HUF) of the proposed Iseni well area and existing wells area and Ramp/Jetty area.Control values in both areas (wells and Ramp/Jetty) showed no significant differences in values with sample stations.The mean percentage HUB for the proposed well area, existing wells area and Ramp and Jetty were 0.008%, 0.004% and 0.00005% respectively. The control values for well area and Ramp/Jetty area were 0.003% and 0.00005%. The results indicated that the percentage HUB populations were very low and suggestive of an environment that had little exposure to hydrocarbons of petroleum origin. The very low concentrations of TPH, PAH and BTEX compounds in the study area supports this observation. The predominant bacteria species isolated from the sediments included *Staphylococcus* sp, *Bacillus* sp., *Pseudomonas* sp, and *Escherichia coli*. The predominant fungi isolated from the study area included *Mucor* sp. *Penicillium* sp, *Cladosporum* sp.

Ground Water Quality

pH

The mean pH of the groundwater in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community (Iseni wells EIA,2013)were slightly acidic and compared favourably with the pH in the control stations ($p>0.05$). Similarly, no significant differences ($p=0.289$) was observed in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016)as the mean values were 6.13 ± 0.70 and 5.65 ± 3.31 around the proposed access road and control stations respectively. The pH values were lower than the DPR/FMEnv/WHO limits of 6.5 to 9.2 for substances and characteristics affecting the acceptability of water for domestic use. This may be ascribed to the geology of the Niger Delta werethe ground water is acidic

Turbidity

The turbidity levels in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community (Iseni wells EIA,2013) were significantly higher ($p=0.000$) than the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016). This was attributed to the composition/nature of the aquifer and regular aquifer recharge. The turbidity levels were above the WHO limits of 5NTU.

Salinity related parameters

The concentration of Total Dissolved Solids (TDS) ($p=0.000$), Electrical Conductivity (EC) ($p=0.000$) and Salinity ($p=0.000$) were higher in the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) compared to the the proposed Iseni Appraisal Well, Existing Iseni Wells and Community (Iseni wells EIA,2013).The levels of the salinity related parameters suggest a freshwater bearing aquifer. Local variation in aquifer composition, hydraulic pressure and source of aquifer recharge may be responsible for the variance.

Nutrients

The concentration of nutrients (Nitrate, Phosphate and Sulphate) in the Iseni Appraisal Well Project, 2013 were generally low as the values compared favourably with the control stations.

There was no significant difference in the concentration of nitrates, phosphates and sulphates ($p=0.881$) when compared to the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016). The sulphate concentration complied with the 400mg/l limits for the acceptability of water for domestic use.

Calcium, Sodium, Potassium and Magnesium

The concentration of Calcium ($p=0.000$), Sodium ($p=0.721$), Potassium ($p=1.000$) and Magnesium ($p=0.475$) concentrations in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community area (Iseni wells EIA,2013) were not significantly different when compared to the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) except for calcium. This result maybe attributed to the mineral composition of the aquifer. These minerals (Ca and Mg) also influence the levels of Hardness in the groundwater.

Heavy metals

The concentration of As, Ag, Co, Mn, Cr, Cd, Ni, Pb, Hg, V, Al and Ba were generally below the equipment detection limits (<0.001mg/l) in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community area (Iseni wells EIA, 2013)and the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016).Other heavy metals (Zn, Fe and Cu) were withn background levels and complied with the DPR/FMEnv/WHO maximum permissible limits for the acceptability of water for domestic use.

Organics

The concentration of THC, TPH, PAH and BTEX were generally very low and below the equipment detection limits (<0.01mg/l) in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community area (Iseni wells EIA, 2013) and the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) . The concentrations of organics were within the DPR/FMEnv/WHO maximum permissible limits for the acceptability of water for domestic use.

Groundwater Microbiology

The mean THB and TF counts in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community area (Iseni wells EIA, 2013)were in the order of 10^4 cfu/ml and 10^2cfu/ml and compared favourably with the control stations. The microbial count suggests the presence of organic substrates in the groundwater. Similarly, the THB ($p=0.000$) and TF ($p=0.000$) counts were higher than those obtained in Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016) as the mean microbial counts were in the order of 10^2cfu/ml. The hydrocarbon utilizing organisms (HUB and HUF) were generally low in the groundwater of the and also higher in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community area (Iseni wells EIA, 2013) compared to the Camp/access road, Jetty/Ramp and control stations (Iseni wells Addendum EIA 2016. The HUB and HUF composition in the groundwater were <1% suggesting the low hydrocarbon burden of the groundwater (Atlas, 1981). The analytical data obtained from the groundwater physicochemistry also supports this finding. The mean coliform counts (p=0.000) in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were 66.67±25.17MPN/100ml and 30±20MPN/100ml.. Predominant bacterial genera *Pseudomonas* sp, *Micrococcus* sp. *Arthrobacter*, *Bacillus* sp., and fungal genera were *Candida* sp., *Mucor* sp.

Social Profile

Ofoni community

The socioeconomic study conducted showed that the households' composition was typically pyramidal. Hence, the children and youth constituted 71% of the population, while the middle aged and the elderly constituted the remaining 29%. This shows a population that is young and growing, with a huge number of the unemployed. Sex distribution revealed that the males were more in number than the females, although the difference was not significant. High proportions (75.5%) of the sampled respondents were married, with 95 % of them having formal education. While 42.5% of them had secondary school education, 15.1% possessed vocational/technical training certificate.

Odorubu and Lalagbene communities

These two communities are from two major ethnic groups. While Odorubu is of the Urhobo ethnic nationality, Lalagbene is of Ijaw ethnic nationality. Each of the community is autonomous with distinct historical attributes. While Odorubu community is under the local government jurisdiction area of Patani Local Government Area and is uniquely the only Urhobo speaking community in the Patani LGA of Delta State; Lalagbene is Ekeremor Local Government Area of Bayelsa State.

Occupation/Employment and Income Generating Activities

Ofoni

A vast majority (78%) of the respondents derived their livelihood from agriculture, with fishing as the major agricultural occupation. It is interesting to note that women and children were involved in fishing. About 40% of the fisher folks were women, implying that there was no gender discrimination in fishing. Women fisher folks owned their canoes and earned their income. Crop production was another major aspect of their agricultural activities and the major crops grown were cassava, plantain, sweet potatoes, maize, yam and pepper. Farming is done at subsistence level with the traditional hoe and cutlass as farm implements. Income in the community was low, with the average income being ₦12, 000per month and only16.2% of them earned above ₦ 50,000 per month. The field study showed that the community generally had access to some basic social amenities, many of which were provided by SPDC, NDDC and MDG office.

Odorubu and Lalagbene communities

Formal sector employment , trading, business/contracting, artisanship also forms part of the economic mainstay of the adult inhabitants (male and female). The average response shows that farming/fishing/hunting account for 47.65% of the primary occupation of the people. Also, 5.8%

of the populations are student/apprentice, and 5.95% engages in business/contracting. Other economic activities include technical/artisan 10.9% and full housewives 5.6%. Also 5.15% of the sampled population are civil servants, 17.05% are said to be unemployed and others 1.85%. The 17.05% unemployed rate in the studied communities shows that employment issues are of serious concern in the project affected communities. The income levels found to be meagre and variable had majority (34.65%) earning N10, 001–20,000 in a month, 34.45% of the population had income in the bracket of N20,001-50,000, and 14.5% earn less than N10,000. Meanwhile 10.6% earn between N50001-N80000 and 5.8% earn N80000 and above.

Infrastructure Quality of Life

Ofoni community

There were four primary schools in the community, one Secondary school and a College of Agriculture being built by the State Government. Ofoni community did not have electricity power from the national grid but had a solar energy power supply provided by the State Government. Power from this source was provided for some stipulated hours daily. To augment the power from the general solar source, some individuals also had private generating sets for their use. Access to and from the community was only through water transportation, using boats and canoes. The population is served by a mix of transportation modes – speed/paddle boat, motorcycle (Okada), bicycle, and foot. Access to public communication facilities like the telephone and postal services in the community was not adequate.

Odorubu and Lalagbene communities

The two project affected communities have government owned primary and secondary school except Lalagbene which have only primary school but no secondary school. The Lalagbene community children and wards go for their secondary education at the neighbouring communities and town like Ofoni, Sagbama and Bomadi etc. However, these primary schools need upgrading and staffing with appropriate incentives to enable the staff put in their best in educating the pupils. There is no post primary institution in Lalagbene community. The low number of educational institutions or facilities in the area may be responsible for the generally low level of literacy in the community as well as high school drop-out.

Health Profile

The main factors influencing the health status of people in Nigeria include poverty, nutrition, lifestyle, infectious or communicable diseases, immunization status, inadequate social and health infrastructure, housing, unsanitary environmental conditions and high abundance of disease vectors with little or no local capacity to achieve acceptable levels of control.

Morbidity Status:

The commonest causes of ill health in the Iseni community in the study area were found to be malaria, typhoid fever, upper respiratory tract infections, skin diseases and diarrheal diseases.

Health issues discussed at focused group discussions (FGDs) are similar to the pattern obtained from the public health facilities that serve the community and consistent with the diseases seen in other communities in Nigeria.

Immunization Status

About 36% of the children in the communities have been immunized against polio and measles. This immunization coverage was below national average of 77%.

Access to safe drinking water

Water is a basic human need and access to safe water is critical for health and survival. It is also one of the Millennium Development Goals. The government, its agencies and the oil companies that operate in the area provided most of the water borehole facilities. In previous studies, there was no municipal water supply to Iseni community. However, because of operational and maintenance problems of the community's water facilities, several members of the community fetch the water used for cooking, bathing and other cleaning purposes from the river or depend on rain water. Drinking water was obtained from private boreholes and sachet water.

Waste Disposal and Access to Sanitation Facilities

Waste disposal in the project area is mostly by open dumping on land or directly into the river. Some members of the community had toilet facilities within the recommended 50m distance from their houses. However, due to proximity to the river, defeacation into the river was common practice. A number of flush toilets were, however, noticed in some of the modern houses. This situation may be responsible for the high coliform count recorded in the surface water of the study area.

Nutritional Status

Pregnant and lactating women, children below the age of three and the old are the most vulnerable/susceptible to the effects of malnutrition on health and well-being. Malnutrition is known to be an associated risk factor in deaths in children below the age of five years. Malnutrition among children less than five years was used as the proxy for assessing malnutrition. Out of 43 under-five children whose anthropometric measurements were taken during the survey, 7 (16.27%) were found to be under-weight. This level of malnutrition is higher than the average for communities in the south-south zone, but better than the national averages. The prevalence of malnutrition is, however, not only a reflection of the diet and socio-economic status of the people, but also points to the environmental conditions in the communities.

Sexual Behaviour

The sexual behaviour of members of the community can encourage the transmission of sexually transmitted infections, including HIV/AIDS. Polygamy is common, most adult males having multiple sexual partners. Marital infidelity is culturally tolerated for men.

Knowledge about Sexually Transmitted Diseases, Life Style and Habits

Risk factors found in the communities include alcohol consumption and tobacco use.

Smoking is common in Ofoni, especially amongst young men. About a fifth of adult males in the communities were said to smoke cigarette. Women in the community rarely smoke cigarette. Most discussants in the focus group discussions conducted in Ofoni have heard of HIV/AIDS but the knowledge of its routes of transmission was noted to be poor. Most adult males and single girls in the communities had multiple sexual partners.

Health Infrastructure and Health Seeking Behavior

The Ofoni community has a health center that served their primary health care needs, although the services were often not provided on a regular basis. The health center is poorly staffed and provides mainly immunization services and out-patient treatment of some minor ailments. This encouraged the patronage of traditional medicine practitioners like masseurs and Traditional Birth Attendants, who are especially cherished by most members of the community. The members of the Ofoni community routinely access secondary health care services from the General Hospital in Bomadi. For tertiary health care, members of the community easily access the Central Hospital Warri and the Delta State University Teaching Hospital in Ogara.

Mortality Pattern

Discussants at the focus group discussion sessions held in the community were of the opinion that the mortality rates were not higher than those of the neighboring communities. It was said that women die during pregnancy and childbirth, at most, once every five years in the community. This is better than the national average. The average number of under-five deaths in the Ofoni community, in a year, was put at 62. This is approximately 31 under-five deaths per 1,000. This is better than the national average of 92 per 1000, but consistent with the south-south average. The common causes of under-five mortality include: malaria and its complications, anemia, febrile convulsion, gastro-enteritis (diarrhoea and vomiting), acute lower respiratory tract infection and vaccine preventable diseases (especially measles). The study shows an improvement in the child and maternal mortality rates as compared with the situation in the previous Iseni Appraisal Well study of 2012

Healthcare facilities

Primary Health Centers: All three communities have a health center that served their primary health care needs, although the services were often not provided on a regular basis.

Secondary health care facilities**:** The members of the communities access secondary health care services from the hospitals in Patani and Bomadi, which are about 90minutes travel time from the communities.

Tertiary health care: For tertiary health care, members of the communities can easily access the Central hospital Warri and the Delta State University Teaching Hospital in Oghara.

ES 16.0: Associated and Potential Impacts

he Project is likely to have biophysical, social and health impacts on the project area. After impacts were identified the ISO14001 tool was used to assess and evaluate impacts. Only significant positive and negative impacts were considered. Impacts were enumerated based on the various project activities in the various project phases

Premobilization and Mobilization

Activities within this phase include Reconnaissance visit, Land take, Movement and transportation of equipment, personnel and materials. Significant Impacts identified included risk of road transport accidents from increased traffic, risk of water transport accidents from increased traffic ,potential to disrupt vehicular traffic during movement of large equipment , air pollution from increased vehicular movement, noise pollution from increased vehicular movement, interference with local water transport and fishing activities due to increased traffic and third party agitation (locals, NGOs, etc).Other impacts were increased income, increased, pressure on existing social amenities/infrastructure from influx of job seekers, stimulation of local economy and markets from increased demand for food, and other products in the local market, increased social vices and STIs including HIV, kidnappings, Increase in inflation level, Inter and intra community conflict, changes in culture, lifestyle and habits.

Site Preparation for drilling, access road and camp site Ramp/Jetty

Associated and Potential Impacts identified in this phase included, nuisance from cleared vegetation debris dust, nuisance and threat to health from noise produced by equipment, loss of biodiversity, loss of habitat, soil degradation, third party agitation (community, NGOs, etc), pressure on community infrastructure (healthcare, housing, recreational etc.), stress on existing security structures as a result of influx of job seeker, decreased access to farms and forest interior enhanced potential for deforestation through increased accessibility. Other impacts were increase in dust, fumes, and reduction in air quality from equipment and activity Potential increase in erosion, exposure of project workers to snake bites, insect bites, injuries etc, increase in breeding grounds for disease vectors and other agents of diseases, influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc), opportunity for contracting and employment, ressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits, increase in social vices, change in local population, increase in inflation level and increase in morbidity (including STIs) and mortality.

Construction of Concrete Jetty & Concrete Ramp

Similar impacts as in the phase of Site Preparation for drilling, access road and camp site Ramp/Jetty were observed

Dredging of Forcados river and Sandwining

In addition to some of the impacts observed above impacts such as nuisance from dredging activity due to hampering of free movement and fishing activity, degradation of water quality (turbidity, total suspended solids), loss of aquatic biodiversity and habitat and possible river bank erosion from wrong dredging procedure were identified.

Flowline laying and Hook-up

The following project activities were identified in this phase. These were, trenching, stringing, cleaning, bevelling and Pipeline bending, welding, radiography field Joint Coating, lowering, inspection, testing and NDT of welds, cathodic Protection, backfilling, hydrotesting, manifold works, site Reinstatement, and extension of one of the existing well pads to accommodate manifold and flow line tie-in. In addition to some impacts identified above, specific impacts attributed to this phase included, igniting of welding flames red hot metals or flying sparks causing fires/explosion/injuries/loss of lives, alteration of natural drainage patterns and opportunity to indigenes for contracting and employment.

Drilling

Project activities attributed to this phase were rig positioning, boring, logging, casing, cementation, testing m and plugging. Identified significant impacts attributed to this phase included, contamination and degradation of soil, groundwater and surface water from drilling wastes and accidental spill, release of gaseous pollutants including greenhouse gases to the recipient environment from equipment, noise and vibration from drilling operation with potential to cause localised nuisance and scare away wild life from natural habitat range, injuries and death from accidental blowouts, continuous glare from rig operation at night with potential to scare wild life and affect vegetation physiology. Others were inter and intra community conflicts, increased cash flow and stimulation of local economies within the Community, increase pressure on community social amenities/infrastructure due to influx, third party agitation (Community, NGOs, etc), increase in social vice and impact of domestic waste from camp base on the environment and aesthetics.

Decommissioning, Restoration & Abandonment

Among other impacts significant impacts peculiar to this phase were contamination of soil, surface and groundwater, road and water traffic accidents, potential of erosion around abandoned site and restoration/Remediation.

ES 17.0: Mitigation Measures

Mitigation measures presented are in relation to specific sub activities of the different phases of the Project. Many of the potential impacts identified for the Project are associated with short term duration for which there are procedures and mitigation measures in place as part of standard operating practices. Specific mitigation measures were, however, prepared for impacts considered to be of high significance. These measures have been developed working within the framework of Best Available Technology (BAT) with the goal of reducing impacts or the risk of impacts to As Low As Reasonably Practicable (ALARP). In practice, however, they are implemented as part of the overall operational plans and procedures used by SPDC and its contractors to control their work and ensure compliance with protective measures.

ES 18.0: Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) provides a general overview of each of the major EMP components, as well as the guidelines and procedures for managing the significant impacts of the Project. An Environmental Monitoring Plan has also been developed from the EMP. It will ensure adequate monitoring key receptors and waste streams in the Iseni field. The EMP shall be used to ensure that potential adverse effects are reduced to ALARP levels. The EMP shall also be used to check and continuously monitor compliance and effectiveness of the mitigation and enhancement measures. These are outlined in the EIA report that SPDC has committed to implement for the Project. In addition, this EMP shall be used to ensure compliance with statutory requirements and corporate safety, health and environmental plans of SPDC. The primary objective of the EMP is to provide a set of consistent managerial tools, which will enable SPDC to monitor and control environmental performance.

ES 19.0: Conclusion

This Environmental Impact Assessment Report was carried out in accordance with relevant local, national and international regulations. The methodology applied for the study involved field work, laboratory analyses, review of previous reports and current field data within the area. To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various biophysical components. The Iseni Appraisal Well and Civil Works (Ramp/Jetty, Access Road and Location Preparation) Project will provide opportunity for access to the Iseni field to realize the gas obligation of SPDC and meet the 3rd party gas off taker schedule. Furthermore, other positive impacts of the proposed project include but not limited to the following: increase in business opportunities, provide Opportunity for direct and indirect Employment (Unskilled labour) and Opportunity for contracting.

The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. An Environmental Management Plan and a Monitoring Plan have been developed to ensure that the identified potential impacts are reduced to "as low as reasonably practicable" (ALARP). The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components. The approval of this EIA report for the execution of the proposed project is hereby recommended.

Acknowledgements

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CHAPTER ONE
INTRODUCTION

1.1: Background information

The Shell Petroleum Development Company of Nigeria Limited (SPDC), on behalf of its Joint Venture Partners (Nigerian National Petroleum Corporation, Total, and Nigeria Agip Oil Company) intends to develop the Iseni field to increase hydrocarbon production in Nigeria. It proposes to re-enter, complete and hook-up three existing wells to supply gas into Nigerian domestic gas market, through a 3rd party offtaker. It also proposes to embark on location preparation and construction of a camp site, access road, Compact Ramp and Jetty in the Iseni field to support hydrocarbon production. It will assist the company in contributing to Nigeria's desire to expand her Hydrocarbon Reserves Base, domestic gas market expansion and local content capability development. The Iseni appraisal well is required firm up hydrocarbon type and discovered volume in Iseni field. An opportunity exists to re-enter and complete three existing wells (ISENI-1, -2 and 4) to deliver about 100MMscf/d to a 3rd party customer as soon as possible in order to to meet domestic gas commitment.

An Environmental Impact Assessment (EIA) Report was initially submitted to the Federal Ministry of Environment (FMEnv) incorporating only the Iseni Appraisal Well scope. A further notification was forwarded to FMEnv on clarification and changes to the project scope and also the need for a fast track progression of the EIA to meet the changed schedule by the gas off takers. The FMEnv directed SPDC to develop an Environmental Management Plan to manage the impacts associated with the Iseni Civil Works (Ramp/Jetty, Access Road and Location Preparation) which are long lead activities. This was subjected to the FMENV approval process with FMEnv issuing the Final EMP approval Ref: FMENV/CONF/EIA/123:640/Vol.1/84 dated 2nd November, 2016 **(Appendix 1).**

A detailed gap assessment was carried out to ensure that all impacts (including cumulative) of the Iseni Wells Early hook up activities was fully captured and the identified gap was articulated in an addendum (to the Iseni Appraisal Well) scope of work (SoW)/ Terms of Reference (ToR) which was transmitted to the appropriate regulators for review and approval. Post approval, an additional field data gathering exercise was carried out from 2nd -7th June 2016 with the participation of all requisite regulatory authorities. The Iseni Wells Early Hook up to Domestic Gas Project will have several interactions with the environment, hence the need to conduct an Environmental Impact Assessment studies in line with the provisions of the EIA Act 86 of 1992. This EIA study has identified the key potential impacts of the project activities on Biophysical, Social and Health components within the project area and proffered mitigation measures for Environmental Management. The findings are hereby incorporated in this report.

1.2: Project Proponent

Shell Petroleum Development Company of Nigeria Limited is a major Oil and Gas Exploration and Production (E&P) Company in Nigeria. SPDC is the largest private-sector oil and gas company in Nigeria. It is the operator of a joint venture between the government-owned Nigerian National Petroleum Corporation – NNPC (55%), Shell (30%), Elf Petroleum Nigeria Limited – a subsidiary of Total (10%), and Agip (5%). SPDC's operations in the Niger Delta are spread over 30,000 square kilometres. Shell has a history of over 50 years in Nigeria and the largest footprint of all the international oil and gas companies operating in the country. Shell companies and investments have played a pioneering role in onshore, shallow and deep water oil exploration and production.

1.3: Objectives of the EIA

The objectives of the EIA are to:

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

1.4: Project location

The Iseni field is located in Ekeremor, Sagbama and Patani Local Government Areas (LGA) of Bayelsa and Delta States in the Niger Delta area of Nigeria. The Iseni field is adjoined by the SPDC Ogara field in the Northern part of (OML-35) and lies roughly between grid coordinates 125326mN; 394191.59mE and 118392mN; 389940., approximately 28km SW of Sagbama. The Ofoni community is the major settlement in the Iseni field, lying on the Southern bank of the Forcados River, one of the two major distributaries of the River Niger. The Ofoni community is bounded by River Forcados, Lalagbene, Angalabiri and Ayamasa in the North, South, East and West respectively. Vegetation in the area is fresh water swamp high forest. Land take shall be 44.2774HA for Iseni well-1& 2 and its access from Ofoni waterside. There is also additional **2.8481Ha** to be acquired for the access from Odorubu to New Odorubu Jetty.

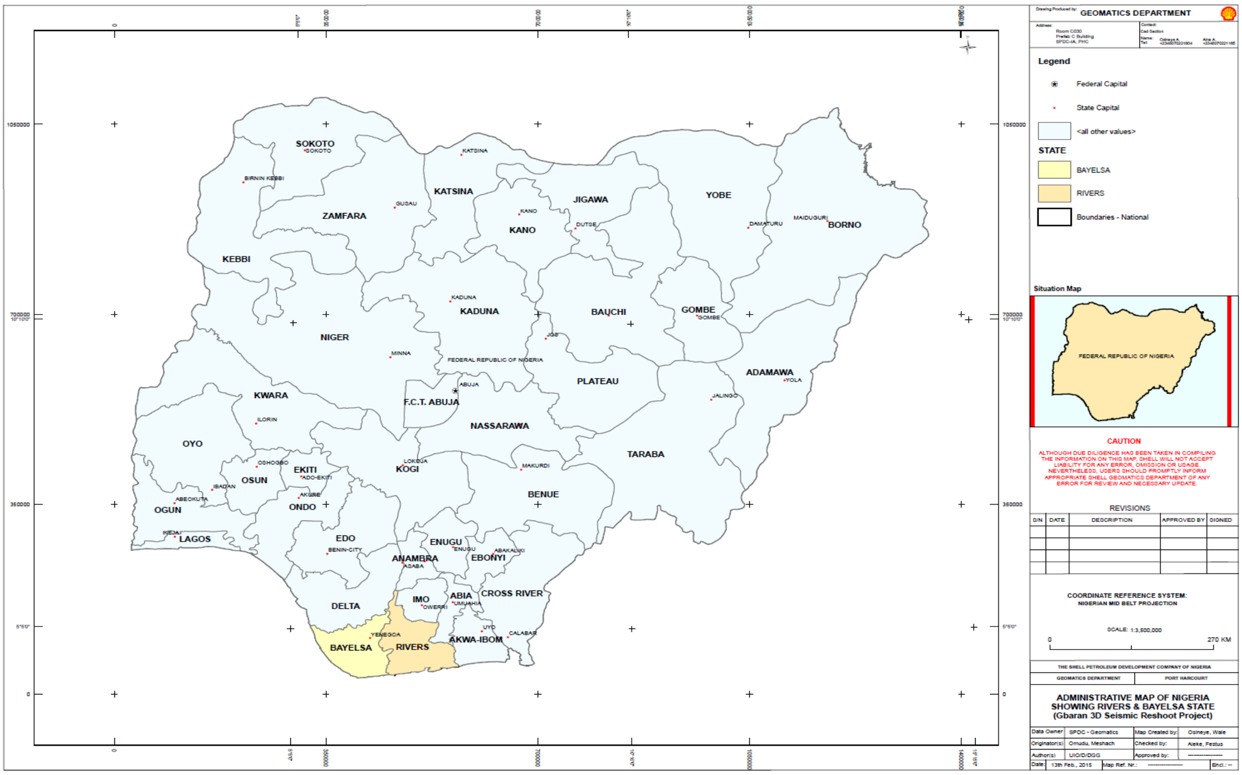


Fig 1.1: Map of Nigeria showing Bayelsa State where the Iseni field is located

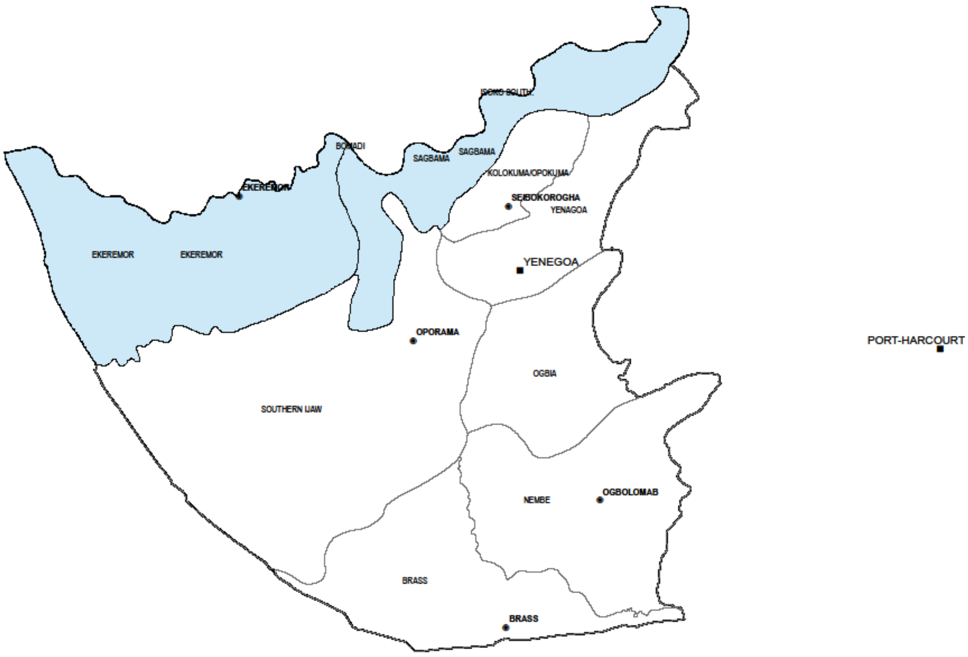


Fig. 1.2: Map of Bayelsa and Delta States showing Sagbama, Ekeremor and Patani Local Government Areas

1.5: 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:

1.5.1: 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, 2001

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), 1979
The Bonn Convention concerns the promotion of measures for the conservation and management of migratory species.

Convention on Biological Diversity, 1992
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), 1972
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 ofHazardous Wastes and their Disposal, 1989
The convention focuses attention on the hazards of the generation and disposal of hazardous wastes. The convention defines the wastes to be regulated and control their trans-boundary movement to protect human and environmental health against their adverse effects.

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.

1.5.2: Legislations guiding Environmental management in Nigeria

The Mineral Oil (Safety) Act CAP 350 LFN 1990
Sections 37 and 40 of the Mineral Oil (Safety) Act CAP 350 LFN 1990 require provision of Personal Protective Equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

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.

EIA Sectoral Guidelines for Oil and Gas Industry Projects, 1995

In compliance with its mandate, FEPA issued the EIA Sectoral Guidelines for Oil and Gas Industry Projects, 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 CAP E12 LFN 2004

The Act sets out general principles, procedures and methods to enable the prior consideration of Environmental Impact Assessment on certain public or private projects. The objectives of the Act is to promote the implementation of appropriate policies consistent with all the laws and decision making processes through which the goal and objectives maybe realized. The Act also encourages the development of procedures for information exchange, notification and consultation between the organs and persons when proposed projects or activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

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

Land Use Act CAP 202 LFN 1990
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.

Endangered Species Act CAP E9 LFN 2004
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.

Petroleum Act CAP 350 LFN 1990
An Act to provide for the exploration of petroleum from the territorial waters and the continental shelf of Nigeria and to vest the ownership of, and all on-shore and off-shore revenue

from petroleum resources derivable therefrom in the Federal Government and for all other matters incidental thereto.

Territorial Waters Act CAP 428 LFN 1990

The territorial waters of Nigeria shall for all purpose include every part of the open sea within twelve nautical miles of the coast of Nigeria (measured from low water mark) or of the seaward limits of inland waters. Any act or omission which-

(a) is committed within the territorial waters in Nigeria, whether by a citizen of Nigeria or a foreigner; and

(b) would, if committed in any part of Nigeria, constitute an offence under the law in force in that part, shall be an offence under that law and the person who committed it may, subject to section 3 of this Act, be arrested, tried and punished for it as if he had committed it in that part of Nigeria

Water Resources Act CAP W2 LFN 2004

The Water Resources Act vests the right to the use and control of all surface and groundwater and of all water together with the bed and banks in any watercourse affecting more than one state in the Government of the Federation. However, the Act essentially preserves existing rights, including customary rights, provided they are for domestic use, watering of livestock and personal irrigation schemes. A proviso to section 1(1) states that the subsection shall not be deemed to infringe or to constitute a compulsory right over or interest in property. Apparently, the idea is to separate rights over water resources from other rights in property.

Nigerian Oil and Gas Industry Content Development Act 2010

The Act provides for the development of Nigerian Content in the Nigerian Oil and Gas Industry, Nigerian Content Plan, Supervision, Coordination, Monitoring and Implementation of Nigerian content and for related matters. All regulatory authorities, operators, contractors, subcontractors, alliance partners and other entities involved in any project, operation, activity or transaction in the Nigerian oil and gas industry shall consider Nigerian content as an important element of their overall project development and management philosophy for project execution.

Employee's Compensation Act No. 13, 2010

The objectives of the Act are to— (a) provide for an open and fair system of guaranteed and adequate compensation for all employees or their dependants for any death, injury, disease or disability arising out of or in the course of employment ; (b) provide rehabilitation to employees with work-related disabilities as provided in this Act ; (c) establish and maintain a solvent compensation fund managed in the interest of employees and employers ; (d) provide for fair and adequate assessments for employers; (e) provide an appeal procedure that is simple, fair and accessible, with minimal delays; and (f)combine efforts and resources of relevant stakeholders for the prevention of workplace disabilities, including the enforcement of occupational safety and health standards.

National Inland Waterways Authority Act No. 13, 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.

1.5.3: Legislations guiding Environmental management in Bayelsa State

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

- Bayelsa State Environmental and Development Planning Authority Law 1998.
- Bayelsa State Pollution Compensation Tax Law 1998.
- Bayelsa State Forestry Law 1998.
- Bayelsa State Environmental (Ammendment) Bill 2013.

1.5.4: SPDC Policies and Principles

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

(a) Business Principles

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

(b) Governing Policies

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

(c) HSE Policy

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

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

The implications of implementing this policy are that,

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

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

(e) SCiN Biodiversity Policy

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

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

(f) Waste Management Policy

It is the policy of SPDC to:

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

(g) Emergency Response Policy

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

- Saving life
- Care for the injured
- Protection of the environment
- Limitation of damage to assets
- Defence of SPDC’s good corporate image

- SPDC shall provide appropriate organization, facilities, procedures and training so that immediate coordinated action can be taken to manage the situation in line with the above
- Maintenance of emergency equipment shall receive high priority. Close liaison will be maintained with appropriate Government and industry organization and communities
- Regular exercises will be carried out to confirm effectiveness, and any necessary improvements made promptly so as to maintain our readiness at all times.

(h) Community Relations Policy

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

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

1.6: Declaration

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

1.7: Structure of this EIA Report

- **Chapter One** - Introduction presents the background information, EIA objectives, Legal and administrative framework.
- **Chapter Two -** Project Justification, discusses the project background, project objectives, rationale for the project, envisaged sustainability, and development options considered;
- **Chapter Three** - Project Description, describes the type of project, scope, location, material input/output and by-products, waste generation, technical layout and process, operation and maintenance, project schedule;
- **Chapter Four -** Description of Existing Environment - provides information on the baseline environmental conditions of the project area describing the physical, chemical, biological social, and health environment

- **Chapter Five** - Associated and Potential Environmental Impacts - highlights the Associated and Potential Environmental Impacts of the proposed project;
- **Chapter Six** – Mitigation Measures/Alternatives – describes the mitigation options of impacts;
- **Chapter Seven -** Environmental Management Plan - provides the proposed plans for environmental management;
- **Chapter Eight -** Conclusion and Recommendations –

CHAPTER TWO
PROJECT JUSTIFICATION

2.1: Introduction

The development of the Iseni field is part of SPDC's drive to meet its gas obligation and commitment to 3rd party gas off taker schedule. This subsection highlights the Project objectives, Benefits, Sustainability, Options and Alternatives.

2.2: Project Objectives

The project will provide opportunity for access to the Iseni field to realize the gas obligation of SPDC and meet the 3rd party gas off taker schedule.

2.3: Need for the Project

The Federal Government of Nigeria through its joint venture participation is determined to earn more revenue from its hydrocarbon resources. The Project is one of such efforts being planned by SPDC to enable development decisions to be taken on gas growth plans. The Project will enable the establishment of the extent and readiness for development of the gas, as well as reducing the uncertainties.

2.4: Benefits of the Project

The Iseni Project (appraisal and completion), when successfully completed, will provide justification for full field development of the expected gas reserves in the field. This will entail the drilling of gas development wells and boost the potentials of SPDC as a major player in the development of Nigeria oil and gas resources. If the readiness and extent of the gas volume of the reservoir is proven by the results of drilling the appraisal well, it will enhance SPDC's capacity to meet the growing demand for gas. The outcome of this well will increase SPDC hydrocarbon reserves and gross production levels as well as improve the economic base of the country and be a catalyst to further promote foreign participation in the country's industrialization efforts. Furthermore, the drilling activities will lead to the creation of many business and employment opportunities through direct and indirect involvement of communities, consultants, contractors, supplies and other professionals at different stages of the project

2.5: Value of the Project

The estimated cost of the project is about 30 million USD. The project at this stage will be helpful in getting required information/data for further development.

2.6: Envisaged sustainability

Subsurface data acquired by SPDC suggest that the risk of oil development restricting access to the gas volumes is low. It is expected that the production of gas resource from the field can be sustained for longer than 10 years depending on the plateau rate. The location preparation and construction of camp site, access road, Compact Ramp and Jetty will provide access to the Iseni Well locations to enable the realization of the aspirations of the partners in embarking on the project. In line with SPDC standard operating procedures, the activity shall be carried out with full adherence to the standard health, safety, security, environment (HSSE) and sustainable development framework which highlights cost optimisation, effective environmental management and socio-economic responsibilities to the host communities. The activities will not only be carried out with full compliance with regulations, standards construction and engineering guidelines and procedures, but will also strive for performance improvement. Shell Petroleum Development Company Limited has built significant expertise in oil exploration and production activities over the years. The proposed project is envisaged to be sustainable Environmentally, Technically, Economically and Socially. The envisaged sustainability of the proposed project is as follows:

2.6.1: Environmental Sustainability

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

2.6.2: Technical Sustainability

The re-entery and hook-up three existing wells to supply gas to 3rd party gas offtaker, the drilling of an additional appraisal well and the construction of camp site, access road, Compact Ramp and Jetty is technically sustainable because of SPDC's proven oil and gas technology and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable shall be utilized in the execution of the proposed project.

2.6.3: Economic Sustainability

There is an opportunity exists to work over the three existing wells (ISENI-1, -2 and 4) to deliver about 100MMscf/d to a 3rd party customer as soon as possible in order to complement the effort to meet DOM gas commitment. The 3rd party gas off taker receiving facility is expected to be ready by Q2 - 2019 for commissioning. The Iseni field has proven reserves of gas that can economically and commercially support the project thereby contributing to the revenue accruing to Nigeria and SPDC.

2.6.4: Social Sustainability

The commencement of the Iseni field operations has the potential of causing an influx of expatriates and other skilled and unskilled labour force into the community. This has the likelihood of altering the socio-cultural lives of the people. This may lead to youth restiveness and some other social vices. The EIA is expected to identify and categorize the likely negative impact of the field operations on the community. The expected mitigation programme will include human capital development, with the establishment of training institutions, skills acquisition centres and functional guidance and counselling programmes for the youths and other adults. Every effort will be made to preserve the cultural lives of the people and ensure that the community is self-sustaining. The proposed project will in addition:

- 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.

2.7: Project screening

Screening is a procedure used to determine whether a proposed project is likely to have significant impacts on the environment. It normally takes place at an early stage in the design of the project or after a planning application has been made to the Regulatory Agency. In line with the EIA procedural Guideline of the Federal Ministry of Environment (FMEnv), an initial screening of the project was carried out. The outcome of the screening revealed that the proposed Iseni Project, being a major oil and gas project activity is likely have some impacts on the environment, hence the need for an Environmental Impact Assessment study.

2.8: Project Options

This section presents the various development concepts for the Iseni field opportunity. The concept that holds the most value for the opportunity was selected. The project options are presented in Table 2.1.

Table 2.1: Project Options considered

Project Options	Advantages	Disadvantages	Remarks
No Project Option	• No impact on Environment • No new risks	• Stakeholders (third party offtakers) will not be able to increase their gas target. • The Economic opportunities (commerce, employment, etc.) for the communities will be lost. • Huge investments that have already been committed into preliminary activities would be lost.	Not recommended
Delayed Project Option	• More time to plan and assess risks	• This will lead to a delay in achieving FID; • Loss of expected revenue for the period of delay; • Gas supply exposure of 3rd party and downstream customer.	Not recommended
Develop the Iseni field	• Increase the earnings of SPDC/Nigerian government. • Meet SPDC gas obligation to third party gas offtakers. • Boost local economy of communities within the Iseni field. • Provide Technology transfer to locals.	• Increase SPDC environment footprint. • High Unit Technical Cost (UTC).	**Recommended**

2.8.1: Project Alternatives for Drilling

The project alternatives for the drilling of the appraisal well were considered on the basis of technical feasibility, environmental and economic considerations.

“No Drilling” Option

The “no drilling “option implies that an appraisal well will not be drilled to confirm the commerciality of any potential oil rim, gas-water contact as well as extension of the field. This option is not considered favourable because:

- Iseni Appraisal is a necessary pre-condition for field development; the field must be appraised before development is planned.
- It will lead to total loss of investment already made in the area in data acquisition and analysis; and
- It is not in consonance with the policies of the Federal government and SPDC to continually replenish the hydrocarbon reserves base through exploration.
- The Economic opportunities (commerce, employment, etc) for the communities will be lost.

Drilling Alternative

Vertical Appraisal Well Option

The option of drilling a vertical appraisal well through the objective sequence expected to be penetrated was considered but dropped. This is because vertical well option will require the acquisition of a new portion of land for drilling whereas the deviated well option is to be drilled from an already acquired location, thereby conserving land. The second factor was the fact that a vertical well would not have allowed optimal penetration of the objective sequence thereby stalling the objectives of the appraisal well.

Deviated Appraisal Well Option

This is the preferred option because it will allow the drilling of the appraisal well from one of the four existing locations, thus reducing land take and minimizing associated environmental impacts (biodiversity). This acquired location is also ideal for efficient and optimal drilling of a deviated well that will penetrate the sequence in order to achieve the appraisal objectives.

2.8.2: Route Options for Construction of Camp site, access road, Compact Ramp and Jetty

The route options for the location preparation and construction of camp site, access road, Compact Ramp and Jetty considered for accessing the Iseni Field location are presented in Table 2.1a.

Table 2.1a: Route Selection Options

Options	Description	Advantages	Disadvantages	Remarks
Route Option 1: 11.7km rd from Odorobu to iseni location	• Construct 3.5km Surface dressed road from Odorobu to waterside. • Construct Ramp/Jetty at Odorobu water side. • Construct Ramp/Jetty at Ofoni water front • Construct 8.2km Surface dressed road from Ofoni to Iseni-001 location. • Estimated Cost $25Mln	• Ease of land acquisition • Existing road alignment • Easier EIA approval • Easier constructability • Better Geotechnics • Minimum pavement additional fill • Ease of field operations • High Social Impact • Overall lifecycle performance	• 2 Jetties required • Higher Cost	**Recommended**
Route Option 2: Odorobu Jcn -New Odu Jetty- Bomadi River- Iseni LAUY - Iseni 02 New Jetty	• Construct 3.5km surface dressed road from Oduboro to waterside • Construct Ramp/Jetty at Odorobu water side. • 3.2Km Mtce. Dredging from Odorobu water side to Iseni – LAUY Loc. • 2.0Km Capital Dredging from Iseni LAUY Loc. To Iseni 02 Ramp/Jetty. • Construct Ramp/Jetty at Iseni 02 • Construct 1.5km surface dressed road from Iseni 2 to Iseni 01 Location.	Lower construction cost	• EIA required (up to 2 years) • Land acquisition required • Impact of Capital Dredging on Environment • Does not meet Iseni hookup schedule • High Security Exposure • Difficult marine field operations • Low Social Impact	Not recommended

Options	Description	Advantages	Disadvantages	Remarks
Route Option 3: SPDC IA Ogunu-Burutu-Okwagbe-Foc River - Iseni LAUY - Iseni New 02 Jetty	• Sail from SPDC I.A Ogunu Jetty-Burutu -Okwagbe- Gbaregolo – Forcados River – ISENI Lauy Slot. • 2.0Km Capital Dredging from Iseni Lauy Loc. To Iseni 02 Ramp/Jetty. • Construct Ramp/Jetty at Iseni 02 Ramp/Jetty • Construct 1.5km surface dressed road from Iseni 2 to Iseni 01 Location.	Low construction cost Ease of execution	• EIA required (up to 2 years) • Land acquisition required • Impact of Capital Dredging on Environment • Does not meet Iseni hookup schedule • High Security Exposure • Difficult marine field operations • Low Social Impact	Not recommended

Table 2.1b: Summary of Route selection options

VALUE DRIVERS	OPTION 1 (3.5Km Rd – River Crossing - 8.5Km Road- Iseni Location)		OPTION 2 (3.5Km Rd – Sail 30Km Bomadi River- Iseni 02 location)		OPTION 3 (Sail direct from Ogunu to Iseni -3days)	
SCHEDULE 35%	(18months construction period)	90	(32months construction period – min 24mnths rqd for EIA)	30	(32months construction period – min 24mnths required for EIA)	30
CAPEX 15%	($25mln)	50	($19.5mln)	60	($14.7mln)	90
OPEX 10%	(minimum maintenance rqd)	90	(Routine maintenance. Dredging approximately. $3mln required bi-annually)	40	(routine maintenance. Dredging approximately. $3mln required bi-annually)	10
EASE OF EXECUTION 10%	(complex construction)	50	(Easy)	80	(moderate)	70
EASE OF FIELD OPS 10%	(easily accessible by car)	80	(Marine access; challenges with logistics, security, 3rd party activities etc.)	40	(Marine access; challenges with logistics, security, 3rd party activities etc)	30
SYNERGY WITH OKNU 5%	(synergizes with OKNU FDP)	80	(Does not synergize with OKNU FDP)	40	(does not synergize with OKNU FDP)	20
ENV. IMPACT 5%	(Min impact on environment)	90	(Dredging has significant impact on environment)	20	(Dredging has significant impact on environment)	20
SECURITY 5%	(Road access, min security exposure/manning requirement)	80	(High sailing exposure, marine logistics, sentry barges, military houseboats, gunboats rqd)	40	(Highest sailing exposure, marine logistics, sentry barges, military houseboats, manning requirements, gunboats required)	10
SOCIAL IMPACT 5%	(Connects communities, advance corporate image/reputation)	80	(Does not connect communities, dredging activities effect on fishing, turbidity etc, does not promote corporate image/reputation)	20	(Does not connect communities, dredging activities effect on fishing, turbidity etc, does not promote corporate image/reputation)	20
100%	77.5%		41.5%		38.5%	

Option 1 was selected

CHAPTER THREE
PROJECT AND PROCESS DESCRIPTION

3.1: Introduction

The project consists of three parts:

1. A drilling programme for an appraisal well within the western part of OML-35. The objective of the well is to appraise the Iseni field following the oil exploration and appraisal wells drilled between 1973 and 1987. In addition, the well will:
    - Confirm the absence or presence of a commercial oil rim in the E6000 and F1000 reservoirs
    - Estimate Gas Initially In Place (GIIP)
    - Obtain additional gas Pressure-Volume -Temperature (PVT) data
    - Confirm the readiness for the development of the field.
2. Re-enter and hook-up three existing wells to supply gas to 3rd party gas offtaker.
3. Location preparation and construction of camp site, access road, Compact Ramp and Jetty.

3.2: Project Objectives

The specific objectives of the project are as follows:

- to appraise the down-deep structure of E1000, E6000 and F1000 reservoirs to resolve the fluid typing and contact uncertainties.
- to acquire additional data for structural and stratigraphic control.
- to provide opportunity for access to the Iseni field to realize the gas obligation of SPDC and meet the 3rd party gas off taker schedule.

3.3: Project Location

Iseni field is located in Ekeremor, Sagbama and Patani Local Government Areas (LGA) of Bayelsa and Delta States in the Niger Delta area of Nigeria. The Iseni field is adjoined by the Ogara field in the Northern part of (OML-35) and lies roughly between grid coordinates 125326mN;394191.59mE and 118392mN;389940mE, approximately 28km SW of Sagbama. The Ofoni community is the major settlement in the Iseni field, lying on the Southern bank of the Forcados River, one of the two major distributaries of the River Niger. The Ofoni community is bounded by River Forcados, Lalagbene, Angalabiri and Ayamasa in the North, South, East and West respectively. Vegetation in the area is fresh water swamp high forest.

Table 3.1a: Proxity of of Iseni Field to third Parties Operators

S/N	Comminity	Proxity
1	Offtaker	WAEP in Utorogu
2	Communities/Settlement	Ofoni
3	River	Forcados, River Niger
5	Fields	Ogara, Okpokunou, Tuomo

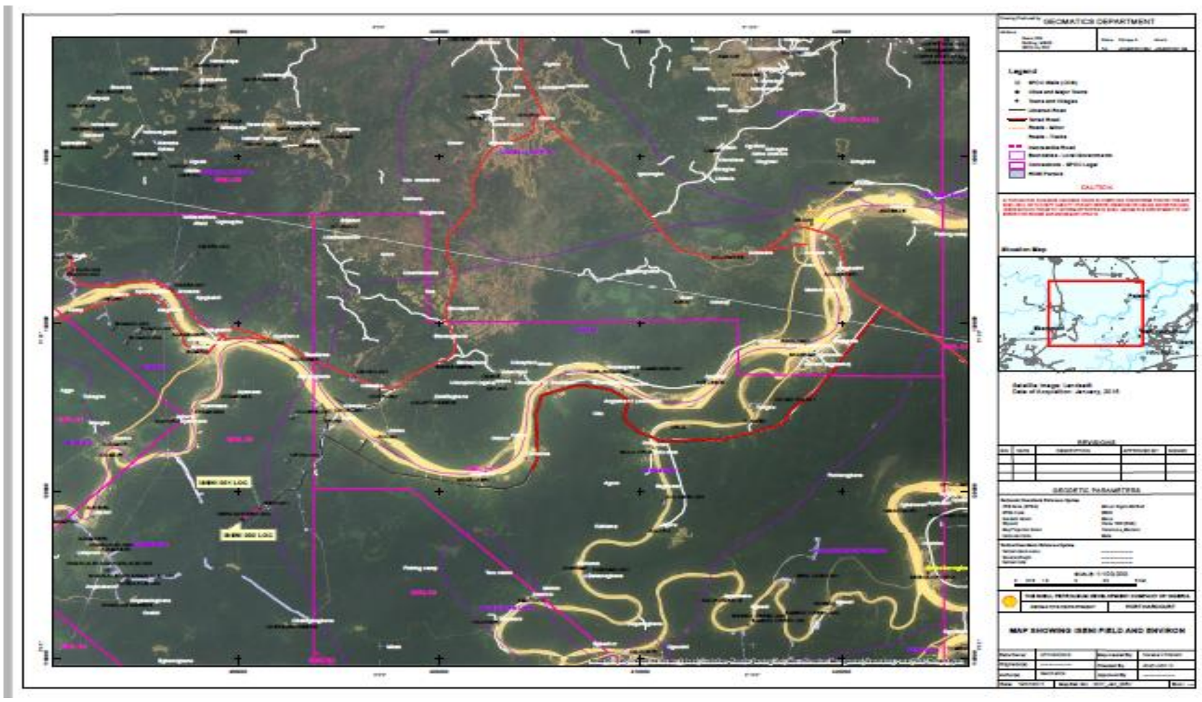


Fig. 3.1: Satellite imagery showing the Iseni field and other adjoining fields

3.4: Proposed Project Scope (Iseni Appraisal Well, Hook up of Existing wells, Access Road, Camp site, Ramp/Jetty)

The proposed project scope is as follows:

1. The drilling of an appraisal well within the Iseni Field area. Sidewall coring, wire line logging, pressure and fluid sampling will be done during the drilling of the appraisal well. The well is planned to appraise the 3 reservoirs; E1000, E6000 and F1000 reservoir in Iseni field. The appraisal well is planned to penetrate the structurally down-dip of these hydrocarbon-bearing reservoir to achieve the following:

- To establish fluid type in the undifferentiated 30ft of E1000 reservoir
- To establish F1000 fluid contact and typing beneath the proven Gas-Down-To (GDT) of the reservoir.
- The planned well will also provide additional structural and stratigraphic control.

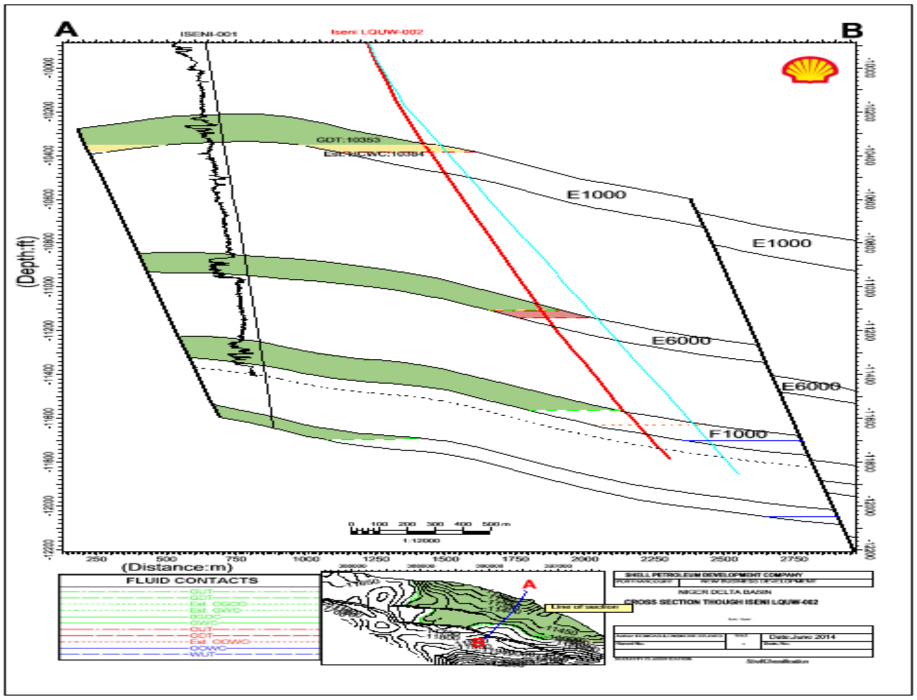


Fig. 3.2: Target reservoirs for the proposed Iseni appraisal well

7. Re-enter and hook-up three existing wells to supply gas to 3rd party gas offtaker.

The Project is focused on early hook-up of existing wells in the cluster to deliver early gas to western domestic market (OSD 2019) with a 3rd party commercial solution. The Iseni Wells Development project is mainly to re-enter existing Iseni wells number 1, 2 and 4 (Iseni well 3 was side tracked as Iseni-4); Iseni 001 and 002 will be initially completed as gas producers while Iseni 004 will be sidetracked and completed as a gas producer. The project scope involves laying of NAG flow lines from the individual wellheads to an infield manifold situated on one of the two wells pad which will be tied in a 3rd party pipeline that is expected to deliver the gas to either Utorogu Gas plant or a new gas processing facility near existing Utorogu plant. The scope includes:

- Re-enter, Complete and hook up 3 existing Iseni NAG wells from Iseni 1 and 2 Locations
- Install an infield manifold with metering, well control and data acquisition equipment at the iseni location
- 3rd party to lay bulkline to Utorogu gas plant or new CPF by Utorogu Gas plant

8. Location preparation and construction of Camp site, Access road, Compact Ramp and Jetty
    - Odorobu Junction – New Odorubu Jetty- across the river-new Ofoni Jetty- Iseni rd-Iseni location
    - Campsite
    - 3.5km access Road (Odorubu to waterside) - dressing
    - 8.5Km main access road (Ofoni to iseni 1) - dressing

- Iseni 01/02 Location box -(Retrievable Durabase Mats for Surfacing)
- 1.5km Iseni Location access road
- Compact ramp/Jetty at Odorubu waterside (Marine berth)
- Compact ramp/Jetty at Ofoni Waterside (Marine berth)

9. Pipelaying and Manifold
    - 4"/6" X 1.5Km flowline
    - 4"/6" X 0.5Km flowline
    - 4"/6" X 1.5Km flowline
    - Shut Down Valves, Sampling points ,HIPPS
    - 10"/12" (#1500/#2500) Infield Manifold (3 Nos inlet connection + 1 spare, and one 10"/ 12" outlet) including instrumentations
    - infield Manifold Platform

10. Power Transmission
    - 11kvA composite cable to Iseni Infield manifold from Utorogu
    - 50KVA Transformer; 11/0.42kv
    - 400A LV Switchboard
    - LV XLPE cables to wellheads

11. Fiscal Metering
    - 100MMscfd gas Fiscal meter
    - Multiphase /wet gas meter/Test separator for custody transfer metering
    - SPDC field auxiliary room

3.5: Project Activities (Drilling of Iseni Appraisal Well, Hook up of Existing wells, Access Road, Camp site and construction of Ramp/Jetty)

The minimum estimated workforce is forty (40) and can peak to one hundred and fifty (150) in both access and location preparation sites. Access road and Ramp/Jetty construction will start first and later run concurrently with location preparation. A summary of the Project activities is presented in this subsection.

Premobilization and Mobilisation

- Stakeholder Engagement
- Pre-drilling activities such as reconnaissance visit;
- Movement and transportation of equipment, personnel and materials.

Site Preparation for drilling

- Vegetation clearing within the existing Right-of-Way and additional land acquired.

Site Preparation for Access Road and Camp site Ramp/Jetty

- Setting Out
- Vegetation clearing

Construction of Campsite

- Excavation
- Earthworks (Sand filling)
- Concrete Works
- Perimeter Block wall
- Installation of Gates

Construction of Access Road

The construction of the Odorobu Junction – New Odorubu Jetty- across the river-new Ofoni Jetty road is divided into the following:

- 3.5km access road (Odorubu to waterside) - dressing
- 8.5km main access road (Ofoni to Iseni 1) - dressing
- Iseni 01/02 Location box - (Retrievable Durabase Mats for Surfacing)
- 1.5km Iseni Location access road.

The construction activities will involve the following:

- Sub-grade excavation
- Earthworks (Sand filling)
- Base Preparation (Soil-Cement Stabilization and crushed rock filling)
- Extension of one of the existing well pads to accommodate manifold and flow line tie-in
- Bituminous Surfacing
- Installation of culverts

Construction of Concrete Jetty and Concrete Ramp

The Construction of Concrete Jetty and Concrete Ramp will be in two (2) folds:

- Compact ramp/Jetty at Odorobu waterside (Marine berth)
- Compact ramp/Jetty at Ofoni Waterside (Marine berth)

This will involve the following activities:

- Piling Works
- Mobilise piling rig to site
- Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel schedule 40 casing)
- Steel works

- Reinforced Concrete works
- Steel works (hand rails etc.)
- Installation of Bollards & Fenders
- Dredging Works (Depending on siltation levels)

Construction, laying of three (3) flowlines and hook-up to the infield manifold

The description of the flowlines and manifolds are:

- 4"/6" X 1.5Km flowline
- 4"/6" X 0.5Km flowline
- 4"/6" X 1.5Km flowline
- Shut Down Valves, Sampling points, HIPPS
- 10"/12" (#1500/#2500) Infield Manifold (3 Nos inlet connection + 1 spare, and one 10"/ 12" outlet) including instrumentations
- infield Manifold Platform

The activities involved will include but not limited to the following:

- Trenching
- Stringing
- Cleaning, bevelling and Pipeline bending
- Welding
- Radiography
- Field Joint Coating
- Lowering
- Inspection, testing and NDT of welds
- Cathodic Protection
- Backfilling
- Hydrotesting
- Manifold works
- Site Reinstatement

Hook-up of Existing Wells to Manifold

The specific project activities to be carried out include:

Well Operation, Flow line and infield manifold Construction

- Well re-entry and completion operation
- Excavation / trenching
- 11.7km of access road preparation
- Wells and manifold location preparation.
- Pipe welding, coating and testing

- Pipe laying
- Pressure testing
- Backfilling
- Commissioning of Pipelines
- Well maintenance and operation activities
- Rig interventions

Rig movement, positioning and set up Drilling

Only one appraisal will be drilled. The activities involved in the drilling process include:

- Drilling
- Casing logging, cementation and completion of well
- Well testing and Hook-up
- Well handover Operations

Operation and Maintenance
Demobilization

Decommissioning and abandonment;

- Demolition and site clean-up;
- Disposal of wastes; and
- Site remediation and monitoring

Description of some of the above project activities are provided in this subsection:

Pre-Drilling Activities

The activities in this phase will be essentially desktop, feasibility, environmental, technical and financial considerations. These investigations are aimed at ensuring the viability and sustainability of the project while having minimal negative impacts on the environment. The results of these investigations will culminate in the preparation of a detailed drilling, casing and mud program. The operating environment was taken into consideration in deciding the type of drilling mud most suited for the project.

Consultations and meetings with regulatory bodies, project communities and contractors are prominent features of this phase. These consultations ensure that all stakeholders are notified, carried along and pathways and schedules clearly defined. The benefits of these meetings/consultations are to ensure that the appraisal drilling is carried out within the minimally possible time frame to ensure community goodwill and social license to execute the project.

Land Take:

There will be a land take of **44.2774Ha** for Iseni well-1& 2 and its access from Ofoni waterside. There is also additional **2.8481Ha** to be acquired for the access from Odorubu to New Odorubu Jetty.

Drilling Location Platform Preparation

The size of the drilling site shall be approximately 1ha. This will involve:

- Bush clearing to the appropriate size of location platform, including shoulders;
- Stripping of existing location platform earthworks;
- Reconstruction to suit the rig;
- Construction of generator platform;
- Excavation/concrete lining of standard waste pit;

Movement and Transportation of Equipment, Personnel and Materials

Materials that shall be transported during the drilling phase include:

- The rig;
- Pipes and casing;
- Drilling chemicals;
- Generators;
- Diesel; and
- Personnel

It is estimated that about 150 personnel shall be involved in the drilling operations at any time. An estimated average of 4 trips per week shall be made to the drilling site for the transportation of equipment and supplies.

Drilling Phase

Drilling

The drilling operations shall be managed at the rig. A blow-Out Preventer (BOP) shall be installed and the prevention liquid circulated in a closed system. In the event that large quantities of hydrocarbon are produced during the proposed well, the hydrocarbons will be evacuated in tankers/barges to the nearest flowstation.

Drilling, Work over and Completion of Wells

The drilling activities will involve the following major activities, details of which shall be in accordance with Standard Methods as clearly stated in the SPDC Drilling Engineering Procedures Manual (SPDC, 2003) and the DPR Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2002).

Surface Hole/Intermediate/Production Drilling

Appraisal well will have the following 67/ 68; 24’’ stove pipe - /(354ft10 ¾’’ 60.7ppf- /(120ft) 9 5/8’’ 47ppf -/ (11,725ft). The operation will include driving a 24” stovepipe to refusal depth. A 12-1/4” surface hole will be drilled to isolate the upper unconsolidated sands to a depth just before the topmost hydrocarbon sand and a 9-5/8” casing set. An 8 ½ - 10½” hole will be drilled to TD penetrating the reservoir and a 7” liner set. Communication with the reservoir will be established by perforating the casing with deep penetrating charges. The well will then be completed with 4 ½” chrome tubing based on the well potential. The projected well depths for W67/68 is /11,774ftah. Single completion per reservoir has been adopted for the development of the target gas reservoirs due to the favourable reservoir properties that support one well adequacy to drain each reservoir. The target reservoirs are consolidated and do not require sand control, hence through tubing recompletion can be achieved.

Mud System

Water based (bentonite) mud will be used for the top-hole sections to preserve the fresh water aquifer intervals. Some 8000 barrels of bentonite spud mud will be required. The bentonite spud mud contains bentonite; polymer, additives (e.g. CMC HV) and KCI (share inhibitors). Pseudo-oil based mud (POBM) system shall be used for the drilling of the intermediate and deeper-sections. The POBM is a synthetic oil (straight chain paraffin), which is biodegradable, and more environmentally friendly than oil based mud.

Logging

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

Completion

This is the process of hooking up a well for production. The process involves logging, well-bore clean-up, perforation, production testing, sand consolidation and installation of the Christmas tree. The completion is 4 ½’’ 13cr upper completions with external Gravel pack in the sand face. This is to enable 40Mmscf/day gas production. The completion of the drilling will be the hooking up to the field manifold. Casing strings are an important element of the protection of groundwater resources as they ensure the isolation of fresh water zones and groundwater inside the well. Casing is further used to transmit flowback fluids from well treatment and is the first line of defense and a second layer of protection for groundwater. Frequent sampling and laboratory analysis of water from boreholes drilled within the location will be conducted to provide groundwater monitoring array that will enable the setting of an environmental baseline and the ability to study and record groundwater conditions throughout the lifecycle of the operation.

This frequent monitoring, sampling and laboratory analysis is regulated by Nigerian Laws and International Standards viz;

- EGASPIN (2002) Part III Section E3.8
- Federal Ministry of Environment Regulation (Guidelines and Standards for Environmental Pollution Control in Nigeria),
- American Public Health Association (APHA, 1998),
- American Society for Testing and Materials (ASTM), and
- American Petroleum Institute (API)

Pipelines

There will be 3 flowlines, total length of 3.5km. Design will be in accordance with the requirements of SPDC's Pipeline and Flowlines Design Manual and Shell DEP 31.40.00.10-Gen. Material used for pipeline construction (Duplex Stainless Steel) Grade of pipes (2205, 22% Cr). Pipeline Engineering and other relevant DEP's. Pipelines routing shall be as per the completed route survey. Pipelines shall be designed in according to the Design case.

Design parameters

Pipe design is determined based on the maximum fluid flow rate without an additional design margin. Pipe size selection is to be in accordance with DEP 31.38.01.11-Gen. “Piping General Requirements”. All designs shall be based on site survey findings of the terrain, soil resistivity, stray currents and other possible interactions with neighboring pipelines' cathodic protection systems. All inter-field gas gathering pipelines shall be buried. Pipelines shall be trenched and back filled such that there is 1.5 meter of fill above the pipe. Three-layer polyethylene coating will be used as external anti-corrosion coating for the pipelines. Concrete coating shall be applied to swamp sections. Intelligent pigging facilities shall be provided for all pipelines.. Slug catcher surge volumes shall be sized to accommodate sphere generated slugs during controlled pigging under reduced flow operations.

Selection of pipe grade will be made on the basis of the following criteria:

- Pressure containment and stresses
- Construction lay stresses
- Pipe standardization
- Corrosion allowance and mitigation
- Design life of pipeline

Laying of Flow lines

The activities associated with Installation of 3flow lines (i.e. Total length of flow lines is 3.5km.

- RoW bush clearing;
- Trenching;
- Stringing;
- Welding;

- Radiography;
- Field joint coating;
- Lowering;
- Backfilling; and
- Hydrotesting.

RoW survey and bush clearing

Prior to commencement of any construction works, SPDC shall perform a detailed pipeline corridor survey to establish all crossings including locations of existing facilities. SPDC surveyors shall re-open the pipeline Right of Way (RoW) and confirm all set out boundaries along the RoW. SPDC shall also be responsible for ensuring that the existing survey pillars are maintained and not destroyed by construction activities. SPDC shall clear, grade and strip as need be, the RoW and prepare the areas where the new lines shall be laid. Grading operations shall be carried out only on dry land. The RoW shall be cleared for its complete width. SPDC shall provide adequate room for handling of materials and equipment on site. All worksites shall be prepared in accordance with Shell Standard Construction Specifications sections 2, 3 and 4.

Trenching

Trench dimensions shall be at least 30cm more than the outside diameter of the coated pipe. Trench depth and width shall be increased as necessary where the pipeline approaches crossings or other specialized route sections. Where required, the excavated trench shall be secured against collapse by suitable means e.g. timber planks, sheet piles, etc. All existing structures shall be located by manual excavation. After completion of pipeline installation activities, timber planks, sheet piles, etc. shall be completely removed.

Road Crossing

There will be no road crossings

Stringing & Bending

8” PE coated carbon steel pipes (L450/X65 grade) for flow lines and (L360/X52 grade) for 2” corrosion inhibition lines. The choice considerations for the flow lines from design parameters includes; the design well flow rates, NAG production forecast, NAG temperature, pressure and composition. SPDC shall string the line pipes along the ROW beside the open ditch with suitable equipment and handling tools. Stringing of pipes shall be interrupted where necessary to allow passage of vehicles, livestock, etc. Coated pipes shall rest on padded supports or timbers to avoid damage to coating. This shall apply also during transportation of pipes. Strung pipes shall be provided with caps at both joint ends to keep the joint free from dirt and extraneous materials. Joint and weld numbers shall be permanently marked on the external surface of the pipe at suitable locations to allow proper recording of welds.

Factory-made hot bends having a minimum bend radius of 15D shall be used in the project. Horizontal and vertical deviations shall be obtained as much as possible by stress free elastic bends. Stringing and Bending shall be carried out in accordance with Section 25 of the Shell Standard Construction Specification.

Bevelling, Welding and Non-destructive Weld Inspection

The welding procedure specification (WPS) approved for manual welding is in line with ASME B31.8 (Gas transmission and distribution piping systems), DEP 61.40.20.30-Gen (Welding of pipelines and related facilities -amendment/supplement to API 1104), DEP 31.40.00.10-Gen (Pipeline Engineering) and Standard Construction Specification Section 21(Welding).

An approved pipe cutter or thermal cutting and bevelling machine shall be used to perform joint bevelling. Manual cutting shall not be permitted. Bevels shall conform to the requirements of the welding specification. Pups required for tie-ins shall be cut from undamaged pipes. The minimum length of pup to be inserted in the line shall be 1.0m. The line pipes will be laid and welded by separate crews. They will be laid on padded supports or timber skids for welding along the ditch.

All field bends, required lengths of cut pipes and welds shall be in accordance with section 21 and 25 of Shell Standard Construction Specifications. Non-destructive testing of welds using radiographic procedures, which expose the full circumference of the joint, will be carried out following the completion of the weld. One hundred percent radiography of all weld joints shall be employed. All radiography films will be processed and interpreted on site to facilitate quick repairs of defective welds. Fillet weld joints shall be subjected to dye penetration tests. SPDC QA/QC representative on site prior to acceptance must certify the entire weld joints okay.

Pipeline Coating

The coating system for the proposed condensate line will be as follows:

- Anti-Corrosion Coating: Polyethylene-coated line pipes with shrink sleeve used for field joints; and
- Weight Coating: The section of the delivery line that falls in seasonal swamp area and river crossings will be coated with concrete to protect the anti-corrosion coating and to overcome negative buoyancy during installation.

The thickness of concrete coating will be determined after detailed buoyancy calculations are carried out as part of the detailed design. Heat shrinkable sleeves or repair patches shall be used for repairs of defective field joint coatings taking into account the extent of the portion to be repaired. Holiday test shall be conducted on all field joint coatings. SPDC QA/QC representative on site must certify this okay before lowering can commence. Defective coatings shall be clearly marked. All repairs shall be inspected visually and with a holiday detector to confirm that they are acceptable. All riser sections shall be protected using Riser clad.

Lowering and Backfilling

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

Backfilling

Initial backfilling shall be carried out by installation of soft material (medium sand bed) to obtain a dampened surround for the installed pipe. Initial backfill material shall be free of stones, rocks, timber, roots, debris and any other material, which may damage the pipe coating. The sand bed shall have a minimum depth of 150mm. Stockpiled spoil and shall crown it (heap up) along the top of the trench line. Backfilling operations shall be carried out with due attention to avoid pipeline uplifting.

Cathodic Protection

The cathodic protection test stations will be done in two phases. The below ground installation (cable connections) will be carried out soon after lowering-in prior to backfilling. The above ground installation will be carried out on completion of the back-filling exercise. The sacrificial anode design lifespan is 5years. This would be replaced by a deep ground bed cathodic protection system upon commissioning.

Cleaning, Gauging, Pressure testing and De-watering

Pipeline Cleaning:

In line with SPDC standard Construction Specification procedure on completion of pipeline construction, pre-commissioning activities will include cleaning by introducing swabbing and brushing pigs into lines via the pig traps. Hydrotesting of pipelines to 1.25 of the design operating pressure for 24h using tested borehole water (will most likely be used and the time the water kept in the pipes will be kept to a minimum so to eliminate the use of inhibitors).

Pipelines were properly cleaned by running air-driven swabbing and brushing pigs in order to ensure the lines were free of debris. Filling of the lines with tested potable water followed and introduction of two swabbing pigs in order to ensure removal of air. On arrival of water filling pigs, flushing continued until an acceptable clean level of the lines were achieved. Water pressure-driven gauging pigs were thereafter introduced and deformity checks carried out upon arrival at the exit point. Thereafter, hydrostatic pressure was applied moderately up to 30% of the test pressure ensuring that the air content in the line does not exceed 0.5% of volumetric capacity and held for 2hours to confirm no pressure loss. On satisfactory completion, pressure was moderately raised to 70% of the test pressure with a maximum pressure of 20bar/hour. After attaining 70% of the specified test pressure, rising of the pressure continued moderately at 15% of the test pressure (or 10bar/hour) until the specified test pressure was achieved. This was held for 2hours and thereafter, the pressure was reduced to 50% of the test pressure at a rate of 20bar/hour for the first hour and later 60bar/hour. This process was repeated in order to achieve the required test pressure. Then the ambient and water in the line temperatures were recorded. After ensuring stabilization of the lines, the chart recorder was now connected and monitored for 24hours with the initial temperature and pressure readings taken. Also, gauge pressure and temperature readings were recorded on hourly basis. On successful completion of the hydrostatic pressure test, the lines were depressurized immediately at a rate of 20bar/hour at first and thereafter 60bar/hour. The specified test pressures used are 1.25 of the design operating pressure for flow lines and 1.5 for piping. Water in the lines was properly discharged into an impermeable containment pit using air-driven high density foam pigs. Drying process followed immediately by introducing low density foam pigs through the pig traps and blowing of the lines continuously with air in order to remove moisture and achieved the required dew point of -20ºc.

Gauging and Pressure Testing:
Hydrotest of pipelines to 1.25 of the design operating pressure for 24h using tested borehole water will be used and the time the water kept in the pipes will be kept to a minimum so to eliminate the use of inhibitors.

Dewatering:
There will also be depressurizing and drying of the lines with compressed air-driven high and low density foam pigs in order to remove moisture from the lines to the required dew point of -20ºc were all carried out. Thereafter, leak test, purging/preservation of lines with nitrogen and awaiting final commissioning which will involve introducing the products. SPDC site representative shall supervise the pressure test. Calibrated pressure and temperature charts shall be used to record pressure and temperature respectively during the pressure test. The new line shall be de-watered after pressure testing using compressed air and foam pig.

Source of hydrotest water would be potable water most likely from Benisede flowstation being the nearest SPDC facility to Iseni or SPDC Ogunu industrial area warri. Hydrotest water would be tested, and where necessary treated then applied. Used hydrotest water would be barged and transported to Forcados terminal for treatment and discharge. Anticorrosion agent will be among the suite of chemicals for water treatment approved by DPR.

Camp Site

A new campsite shall be constructed as there are no existing ones in the area for use. Suitable sites for base and field camps among other considerations shall be selected/chosen with due regard to the planned construction activities within the project area. The area of coverage of campsite for site preparation is 5000m^2. The completed camp shall accommodate a maximum of fifty (50) persons. The source of power for the completed camp will be diesel powered generator.

Pictures of campsites would be taken before being occupied and after use. The plan is to restore the site to its original state as much as possible at the end of the activity.

The camp will accommodate the project supervisors and will be equipped with following;

- Standard living and office accommodations
- Recreational facilities
- Logistics facilities including maintenance workshop,
- Clinic,
- Water treatment facility
- Telecommunication systems.
- Fuel Store/dump
- Soakaway toilets, showers and sumps
- Kitchen

Construction of Access Road, Campsite and Ramp/Jetty

Access road and Ramp/Jetty construction will start first and later run concurrently with location preparation. The estimated quantity of sand to be used for sand filling will be 320,000m^3. Height and depth of sand fill will be 1.5m. Equipment for use for compaction and safety procedures during compaction (mitigation against vibration) would be steel drum rollers. Source (location)of crushed rock for filling is Ishiagu/Ukpilla. Quantity/volume of crushed rock to be used for filling is 15,979cubic meters. Transportation of this crushed rock to the site from Ukpilla will be with use of Tipping trucks. The quantity/volume of bitumen to be used for surfacing of roads will be 191,763litres. Bitumen will be obtained from Port Harcourt. Bitumen will be transported to the site from Port Harcourt with Bitumen Trucks.

Access Road, Campsite, Ramp/Jetty, Location Construction Activities

Road construction involves:

- Setting Out
- Bush Clearing/Sub-grade excavation
- Earth works (Sandfilling)
- Base Preparation (Soil-Cement Stabilization and crushed rock filling)
- Extension of one of the existing well pads to accommodate manifold and flow line tie-in
- Bitumenous Surfacing
- Installation of culverts

Campsite construction involves:

- Setting Out
- Bush Clearing/
- Excavation
- Earthworks (Sandfilling)
- Concrete Works
- Perimeter Block wall
- Installation of Gates

Construction of Concrete Jetty &Concrete Ramp involves:

- Piling Works
  - Mobilise piling rig to site
  - Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel schedule 40 casing) piles to required depth or refusal
  - Steel works
- Reinforced Concrete works
- Steel works (hand rails etc)
- Installation of Bollards & Fenders

Diagrammatic representation of the jetty, ramp, access roads and wells are shown in Fig. 3.3.

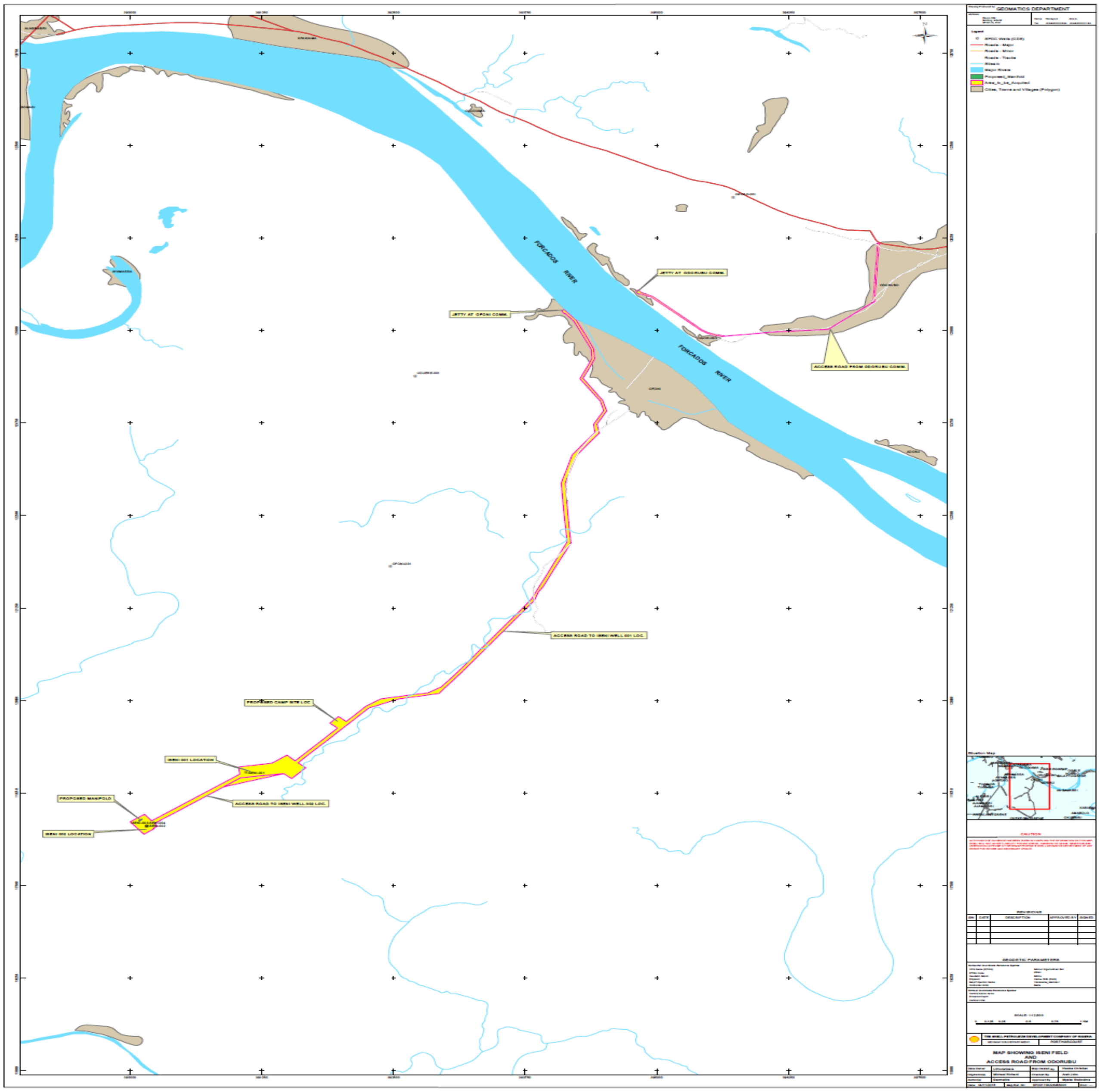


Fig. 3.3: Map with diagrammatic representation of Jetty, Ramp, Access Road, Manifold and wells

Site Preparation civil works

Site preparation may involve demolition (both above and below ground), soil clearing, site plan designs, zoning restrictions, managing environmental concern and co-ordinating how everything on the project should run. Preparing a site properly ensures faster, more productive work environment and a total project that is up to established standards. This involves site clearing which is the first task of site preparation. The site should be in a cleared and graded condition. It involves the removal of trees, demolishing of any unwanted structures removal of any obstructing underground infrastructure that might impact future construction works.

Bush Clearing/Sub-grade excavation

The cutting/uprooting of vegetation on the road Right of Way (RoW) or construction site is referred to as clearing, while Grubbing refers to the clearing and removal of stumps and organic debris. Trees should be felled and cleared to a minimum of 1-3 m from the top of the embankment. The logs should be decked outside the construction area.

Site Investigation

Geotechnical site investigation shall be carried out to characterize the soil, rock and ground water condition of the proposed site prior to mobilization. It is the activity of collecting information and evaluating the conditions of the site for the purpose of designing, and constructing the foundation for a structure such as building, plant, road, parking lot or bridge. This, activity has not been done now due to heightened security situation in the area.

Setting Out

This is the act of moving the design information from the plan to the ground. This is accomplished by staking. It is done especially on slopes to keep the soil disturbance to an absolute minimum. Stakes are used by the equipment operator in locating where to begin cutting and maintain proper subgrade.

Civil Works

The following civil works will also take place as part of the site construction activities, namely excavations (sub-grade, waste pit, cellar pit drainage structures etc.), Earthworks/Sandfilling, Piling (dependent on sub- soil investigation report), Soil-Cement stabilization, Concrete works, extension of one of the existing well pads to accommodate manifold and flow line tie-in, Installation of culverts, Perimeter Fencing, Bituminous surfacing. SPDC standard construction health, safety, security and environmental management procedures shall be deployed in the execution of these activities.

Excavation Works

Excavation will be by manual means, using suitable and appropriate equipment (digger, shovel etc) and the following sub-structural activities shall be carry out:

- Probing of the work area to confirm that there is no buried services underground before commencing excavation work.
- Disconnect, Remove and Relocate any such underground services encountered along the proposed fence line.
- Establish ground controls for leveling and excavate trenches as per AFC drawing.

- In case of ground water and / or soft soil encountered, shoring of vertical faces of excavation will be done using well-braced fair-faced plywood to secure sides from falling. Water pump will be provided for dewatering when necessary.
- Immediately upon completion of excavation, the specified thickness of blinding layer of approved grade of concrete will be provided to prevent the deterioration of the ground formation and provide a sound clean working surface for construction of the permanent foundation works.

Earthworks (Sandfilling)
Earth fills as sub-base materials are used to elevate road pavement above flood level. Only approved mineral soils free of organic debris such as stumps, tree tops, and humus shall be used. Fills should be built up in layers and each layer should be spread evenly before compaction.

Compaction
Proper compaction results in significant reduction of voids in the sub-base and overall stability of the layer. The key to a stable road pavement is adequate compaction of fill materials including the base course (crushed rock filling) and surfacing.

Base Preparation (Soil – Cement Stabilization & Crushed rock filling)
Due to the low strength properties of soil material in the terrain, soil cement stabilization will be carried to improve the bearing capacity of the sub-base layer before placing the crushed rock road base course.

Bituminous Surfacing/Sealing
The standard method of sealing and surface treatment for roads shall be various forms of surface dressing in which a hot or cold setting bitumen compound is sprayed on to the prepared road surface and covered by a thin layer of coarse sand or crushed rock chippings, rolled in so as to adhere to the bitumen compound.

Installation of Culverts
To improve cross drainage and maintain flow balance on both sides of the road, ring culverts (pipe or concrete) will be installed at intervals across the access roads to be constructed. This will avert any tendency for flooding as a result of damming effect from the access road construction.

Piling Works
The berthing facilities (Concrete Ramp/Jetty) will be supported on pile foundation. Pile type will be steel cased piles. This construction involves driving of hollow steel casing piles to design depths and filling the hollows with reinforced concrete. Pile heads will be cut-off and tied to the reinforced concrete deck as par design drawings.

Reinforced Concrete works

Large reinforced concrete works will be executed in the course of the project. The following facilities will be reinforced concrete. Cellar Slabs, Waste pits, Ramp/Jetty deck, Evacuation pits, Perimeter drains, etc. Manual batching method for the concrete constituent materials will be widely deployed. Self-loading concrete mixers will also be allowed. Preparatory works for concrete casting involves leveling, blinding concrete, laying of reinforcement cages as par design drawings and formwork construction.

Steel Works

Some aspects of the work will involve welding and fabrication of steel components for the jetty deck, hand-rails and drain covers.

Installation of Bollards & Fenders

Mobilize piling rig to site, position and set up piling rig for the installation of bollards.

Supply and place grade 35 concrete in sheet piles measured with reinforcement and complete with all fittings handling, pitching raking and cutting off pile heads as specified. Install rubberized fenders (including M30 bolts) to water front of the installed sheet pile wall as directed by Company. The fenders; pre-fabricated studs/brackets and some of the equipment to be employed during the installation works shall be loaded on the work barge. The equipment to be used shall include; Crane, Chain blocks, Come Along, Hammer and Chisels, etc.

Crane Positioning and Stabilization

The crane shall be used to lift the fenders (in line with approved Lifting Plan) and hold in place for final installation. Prefabricated 25mm diameter studs will be buried in the holes drilled in the fender and installed sheet walls. The fenders will be installed and bolted down from the top of the work barge after the studs have been passed through sheet walls.

Dredging Works

Depending on the siltation levels at the approaches to the Ramp/Jelly, maintenance dredging of the area shall be carried out to provide the required draft for vessel to birth safely.

Approved personnel flotation devices (PFD) are to be deployed and used daily on the project by all personnel. Life Lines (with small floating rings), Life buoy & Rescue Stick shall be available on site. In line with safety consciousness and alertness, workers shall be advised to shout for help should there be an event of man overboard for the deployment of probing/rescue stick for the victim to grab if he is within reach.

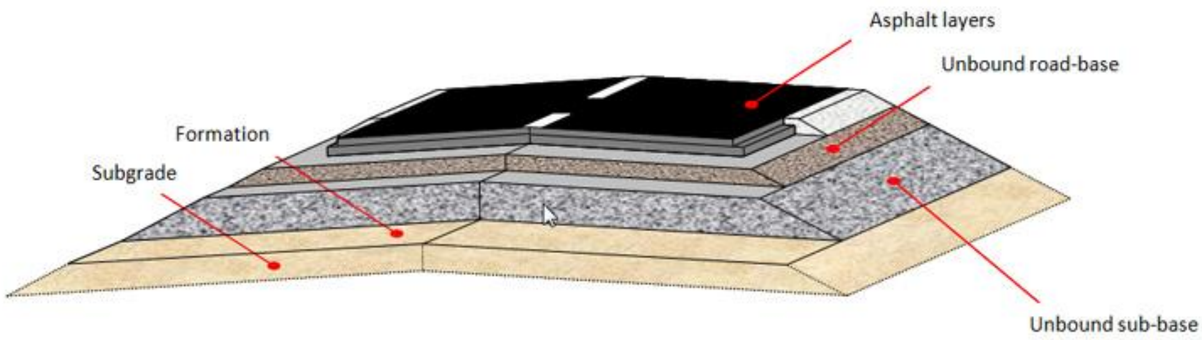


Fig. 3.4: A typical road structure showing the various components

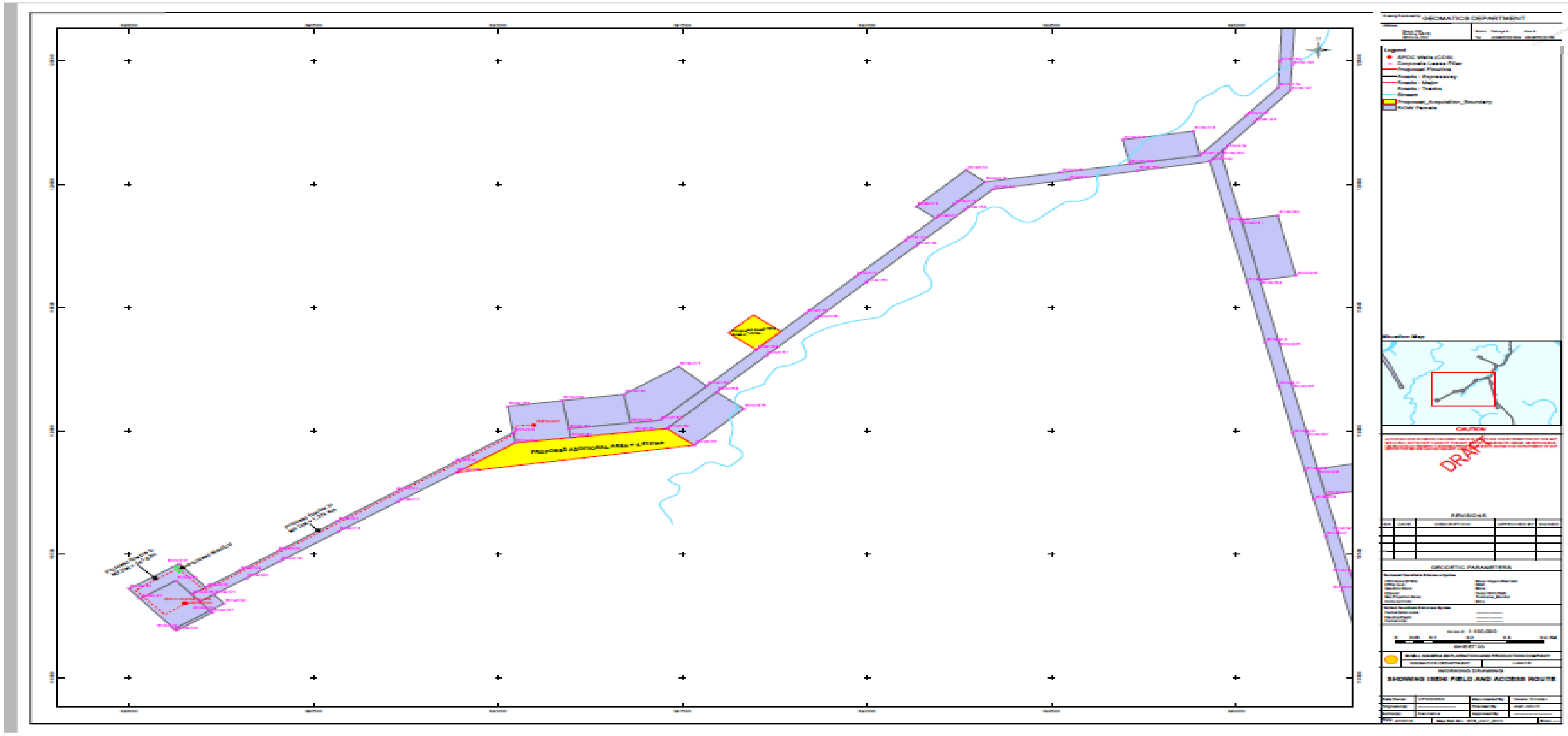


Fig. 3.5: Sketch of Project area showing additional land acquisition (Yellow shaded area)

Commissioning and Handover

A pre-commissioning audit of the newly constructed pipelines to verify their conformity with the construction drawings and operability shall be carried out. The contractor shall participate in the pre-commissioning audit, and shall effect any remedial works identified. SPDC personnel shall manage the commissioning operations at the well heads, pipelines, manifolds and Jetty/Ramp. The contractor shall provide crew support as necessary during the start-up and the introduction of gas into the line.

Operation

The operations of the Pipeline (Iseni to Utorogu) is planned to be managed by a third party gas offtaker at Utorogu gas plant or from a new CPF adjacent to Utorogu gas plant. RoW will be cleared and maintained free of obstruction. Pipeline route markers will be placed along the RoW with third party contact numbers inscribed on it. An impressed current cathodic protection (CP) system will be used to protect the line from corrosion while coating surveys and RoW survey will be part of the pipeline integrity management system.

Reinstatement

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

Risk of Accidents Resulting in Pollution or Hazards

Blow outs and tank leaks are potential causes of accidental spills during drilling activities. A blow out is an uncontrollable discharge of hydrocarbon from the formation. Though the chance of a blowout is very low, the potential impact on environment is very high. The primary safeguard against a blowout is the pressure exerted by the drilling mud. The mud shall be tested/checked regularly (every 15 minutes on site) to ensure the properties and weights are in order. The secondary control is the equipment referred to as Blow Out Preventer (BOP) with surface safety valves. This equipment shall be used to close in a well at the slightest detection of formation fluid ingress/flow into the well bore (mud system). This equipment shall be tested regularly to ensure proper functionality. Increased land and air logistics, which will result from movement of materials and workers to site, are another potential cause of accidents during drilling construction. Proper logistics management will be put in place as a safeguard.

3.6: Decommissioning and Abandonment Plan

The well installations have a life expectancy of about 25 years. When the integrity of the system is no longer assured, 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:

- Removal and site clean-up; and
- Disposal of wastes.

The removal exercise shall be carried out with skill and diligence to avoid spill of hazardous liquids and damage to the environment. The well installations shall be removed and the well property abandoned using an appropriate drilling unit (hoist). The well installations shall then be disposed of according to SPDC waste disposal guidelines.

The decommissioning plan for the facilities proposed as part of the Iseni Appraisal Wells Project is presented in Table 3.1. This is subject to change in future as technology develops.

Table 3.1b: Decommissioning Plan

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

Facilities	**Decommissioning**
	recycle or reuse gravel (if clean); decompact subsoils and re-establish vegetation.

All wastes generated in the course of project execution will be handled in line with existing statutory and SPDC Waste Management guidelines.

3.7: Waste and/or By-Products Generated

This section describes the waste and by-products that could be generated during drilling activities.

Drilling Waste

The drilling waste management principles in this project will focus on waste minimisation and recycling. The wastes that will be generated during the drilling operations are:

- Drill cuttings / excess
- Spent drilling mud and completion fluids
- Rig wash (Detergent) water.
- Cementing waste.
- Discarded consumables.
- Domestic waste (solid and sewage).
- Drilling effluents (waste water)

Table 3.2 presents an estimate of waste volumes from drilling activities per Well.

Table 3.2: Estimated Waste Volume Forecast

Activity	**Waste**	**Amount**
Drilling	WBMCuttings	266.7 m^3/well
	SBM Cuttings	114.3 m^3/well
	Plastic drums	<1T
	Metal drums	<1T
	Sewage	11 m^3/month
	Grey water	50 litres/person/day
	Spent Water Based Mud	101.6 m^3/well
	Spent Synthetic Based Mud	154.41 m^3/well
Others	Office waste	1.0 kg/day
	Medical waste	1.5 kg/day
	Kitchen waste (food waste)	10 kg/day

Waste water shall be treated and used for building new mud and also for the rig and equipment washing. Drill cuttings disposal will be carried out based on if they are generated by a water or an oil based drilling fluid system. The wastewater and drilled cuttings from the drilling operations will be channeled into waste pits. A pay loader shall be used to scoop out the drilling waste from the waste pit into cutting skips. The cuttings will be washed and used for construction purposes while the waste fluid will be injected into Rumuekpe-4 Cuttings Re-injection well. While for oil based system cuttings will be washed and taken to a Thermal Desorption Unit (TDU) in compliance with FMEnv / DPR directives while the waste water will injected into Rumuekpe-4. The Federal Ministry of Environment (FMEnv) and Department of Petroleum Resources (DPR) have already approved these wells for drill cutting re-injection.

Non Drilling Waste

Discarded consumables include unused drilling chemicals, chemical/material bags, scrap metals used in constructions etc. All these will be trucked back to Kidney Island base in Port Harcourt for recycling. A strict inventory control of all chemicals in use shall be maintained. All chemicals, lubricating oils and fuels will be stored in containers and safely placed in a sheltered area on the rig. Appropriate Safe Handling of Chemicals (SHOC) cards will be provided for every chemical on board the rig for the safety of personnel and the environment.

Human Waste

All human wastes shall be treated on site using international standard in-built biological sewage treatment plants. This provides an excellent way of handling all human wastes on board the rig. Under normal circumstances, the total number of personnel on board the rig is not expected to exceed one hundred (100).

Waste Generation Forecast

The Project aims at a maximum of 500 Personnel at the peak of the project. Allowing for occasional visitors, waste generation has been estimated with 500 personnel working all – time – across all Project sites. Using a weighted average waste generation of 1kg/capital/day, the rate of waste generation is estimated as shown in Table 3.3.

Table 3.3: Estimated Rate of Waste to be Generated

WASTE	RATE OF WASTE GENERATED
Sewage	24lit./day/capita
Food wastes (vegetables/putrescible)	300 kg/day
Glass wastes (burnt bulbs, broken bottles, glass plates and cups)	42 kg/day
Hazardous wastes (e.g. paints, thinners, aerosol cans,)	10 kg/day
Plastics wastes (cans, polyethylene/ urethane packaging, plates, bags)	150 kg/day
Wood and Paper	260 kg/day
Metal Waste	190 kg/day
Batteries from cars, calculator, radios torches, cameras	0.2 kg/day
Textile (e.g. used Hand Gloves non-oil soaked rags)	40 kg/day
Saw Dust	2.2 kg/day

Table 3.4: Waste Identification, handling and disposal

WASTE TYPE / WASTE NAME	**Handling**			**Minimization / Disposal Method /Facility**
NON-HAZARDOUS WASTES				
Domestic	**Color Code of Bin**	**Storage**	**Transportation**	
Food/Kitchen Wastes	Green	Keep either in their bins or neatly packaged in a well labelled polythene	Either in their bins or neatly packaged in a well labelled polythene inside a covered truck	Land farming.
Garden Waste	Green	Move to designated storage site in the facility	Transport in covered vehicle with fully completed WCN (Waste Consignment Note)	Move to government approved dumpsite
Garbage	Green	Can be sorted to recover recyclable items	In covered truck with fully completed WCN	Move to government approved dumpsite
Plastic	Brown	Collect & store temporary in recyclable Waste depot.	By land transport to RWD (Recyclable Waste Depot)	Sell to third party for recycling.
Wood	N/A	Store at designated scrap yard	Transport in trucks	Dump at approved dump sites or landfill/Sale to vendors
Office				
Toner cartridge	Navy Blue	Good Housekeeping procedure	Collected with the waste bag closed and transported with appropriate label for recycling	Reuse. Move to WRD – (Waste Recycling Depot), IA, P/H
Paper	Grey	Store under waste shed before moving to RWD	Transport to Recyclable Waste Depot	Recycle; sell to third party for recycling
Industrial				
Glass	Blue	Store in RWD	Transport in closed waste bag with appropriate label to RWD	Recovery & Recycling; Send to glass manufacturing company
Scrap metal	NA	Store in designated areas in the facility	Transport In vehicle/trucks fit for the type of metal to be moved	Re-use, Recycle; Move to a WRD (Waste recycling Depot), IA
Cans and Tins	Black	NA	It shall be collected by waste contractor with the waste bag closed and transported with appropriate label to SPDC dumpsites	Dispose at SPDC approved dumpsite
Computer Scraps & Consumables	N/A	Arrange neatly in a cool dry place	In covered truck with fully completed WCN	Move to the WRD, IA, PH

WASTE TYPE / WASTE NAME NON-HAZARDOUS WASTES	Handling			Minimization / Disposal Method /Facility
Domestic	**Color Code of Bin**	**Storage**	**Transportation**	
Oil/Fuel Filters	Blue	Drain oil, Cut open to remove diaphragm and crush metal case	In trucks to the scrap metal yard	Send to designated scrap yard where the waste contractor collects them from
Oil Rags	Red Bin	Store in covered plastic bin	In covered truck to disposal site	Incinerate at TDU (Thermal Desorption Unit
WASTE TYPE / WASTE NAME NON-HAZARDOUS WASTES	**Handling**			**Minimization / Disposal Method /Facility**
Industrial Contd.	**Color Code of Bin**	**Storage**	**Transportation**	
Cables	NA	Neatly keep in the Waste depot	In covered truck to disposal site	Re-use; Can be sold to a vendor for re-cycle and reuse
Pigging Waste	Red	Store in Drums and transport to TDU at Bonny	Move to TDU	Burn off in Thermal Desorption Unit (TDU)
Absorbents	NA	Store in storage bins	In Covered Trucks	Burn off in TDU
Spent Oil		Store in dedicated pit	Transport in appropriate drums or tankers.	Collect in dedicated pits and sent to waste oil collector
Construction Debris	NA	Move neatly to a corner	Mostly done in open vehicles, depending on the size and location for reuse	Reuse in minor road mending
HAZARDOUS WASTES				
Clinical Waste	Red	Neatly place in black polythene before putting in the red bin.	Transport in sealed bags to SPDC IA incinerator	Incinerated at high temperature in IA.
Fluorescent bulb	Red	Arrange neatly to avoid breaking	In covered truck with fully completed WCN	Recycle; Sell to vendor to recycle mercury.
Sewage	Red	Septic Tanks	The same hauler truck that pumps out the sewage can be used to transport and dispose the sewage	Stock pile in a cool dry place pending the final decision on appropriate disposal option
Chemical drums	Red	Segregate drums and store in compatible groups	In covered trucks	Crush metal drums and sell as scrap. Sell plastic containers to recycling companies.

WASTE TYPE / WASTE NAME	Handling			Minimization / Disposal Method /Facility
NON-HAZARDOUS WASTES				
Domestic	**Color Code of Bin**	**Storage**	**Transportation**	
Spent Batteries	Red	Arrange neatly without breakage in a cool dry place	In covered truck with dully completed WCN	Recycle/Recovery; Move to Recyclable Waste depot (RWD)
Spent Chemical	Red	Store in dedicated pit	Transport in appropriate drums or tankers.	Collect in dedicated pits and sent to waste oil collector

Dredge Spoil Management

Dredging is the removal of materials (dredge spoils) from underwater by hydraulic suction and mechanical means. Dredge spoil is not a poisonous waste. However, prior to the commencement of the dredging works, perimeter bundwalls are constructed on designated spoil dump sites on either side of the river and the dredge spoil is discharged into the spoil dump sites by means of cutter suction dredger. All dredge spoil dredged from the river are deposited at the spoil dump sites enclosed by perimeter bundwalls which provide the required containment for the dredge spoil. The dredge spoil is clayey silty – sand and Mechanical equipment to be used for dredging is cutter suction dredger.

3.8: Project schedule

The project schedule is shown in Fig. 3.6 and Fig. 3.7. The duration for the drilling of the well is specified in the schedule.

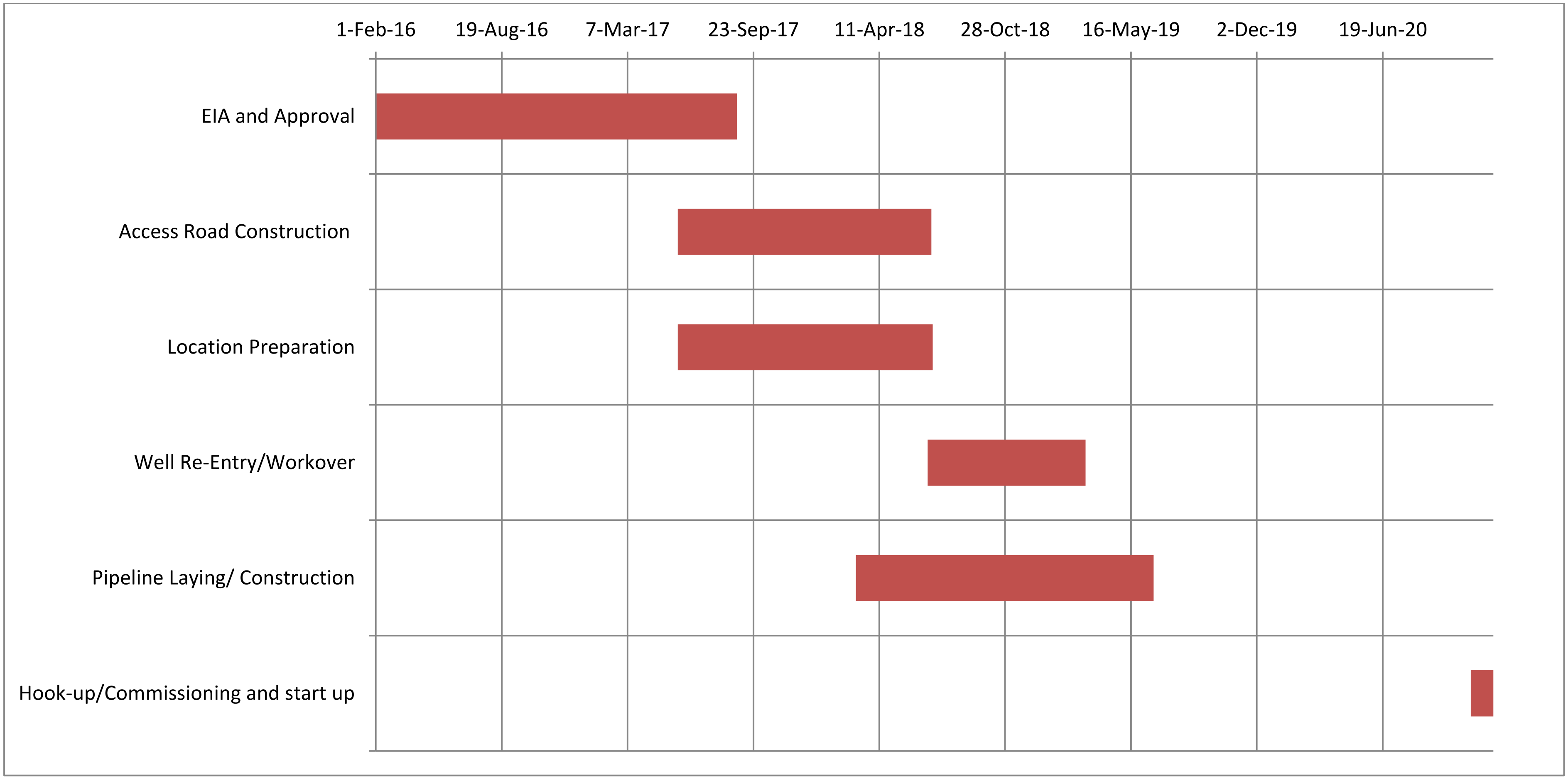


Fig. 3.6: Project schedule for the Access route and location preparation activities

CHAPTER FOUR
DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1: Introduction

The purpose of the environmental 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 project. The environmental data presented in this chapter is a representative of the status of the biophysical, social and health profile of the people in the Iseni field. A multi-disciplinary approach was adopted for data acquisition and ecological characterization which include Climate and Meteorology, Air quality and Noise, Soil quality and Land use, Vegetation and Wildlife, Hydrobiology and Fisheries, Geology, Social and Health Profile. Data were also generated through literature review of existing environmental studies report in the area, consultations with stakeholders, Field study, Laboratory and Statistical data analysis. The current report represents an integration of the Environmental Impact Assessment (EIA) of Iseni Appraisal Well Project (2015) in which data was obtained from the approved one season field study carried out between 29th October and 5th November 2013 (Dry season) and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty and Access Road) Project, 2016 in which data was obtained from an approved one season field study from 18th to 23rd of July, 2016 (Wet season).

4.2: Literature Review

Some information used for the description of the environment in this report was obtained from the following documents:

- Environmental Impact Assessment of Iseni Appraisal Well Project, 2013 in which data was obtained in February 2008.
- Scientific publications.

4.3: Description of Sampling Location

The sampling map showing the study area with the sampling stations is shown in Fig. 4.1. The sampling points were geo-referenced by means of Global Positioning System (GPS). Two sets of data were obtained. Field data gathering exercise for the one season study of Iseni Appraisal Well Project, 2015 was conducted from 29th October to 5th November 2013 and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty and Access Road) Project, 2016 from 18th to 23rd of July, 2016 respectively. The study covered a spatial boundary of 2km radius of the proposed well locations in the Iseni field. The stratified sampling design protocol was adapted for the study. In stratified sampling, the target population or study area was separated into non-overlapping strata, or subpopulations that are known or thought to be more homogeneous (relative to the environmental sensitivities or contaminants). This allowed for less variation among sampling units in different strata. The strata were chosen on the following bases:

- Vegetation type;
- Surface water bodies and other environmental components and sensitivities;
- Existing well location;

- Human presence and population density;
- Proposed development area (such as well locations and flowlines);
- Professional judgment.

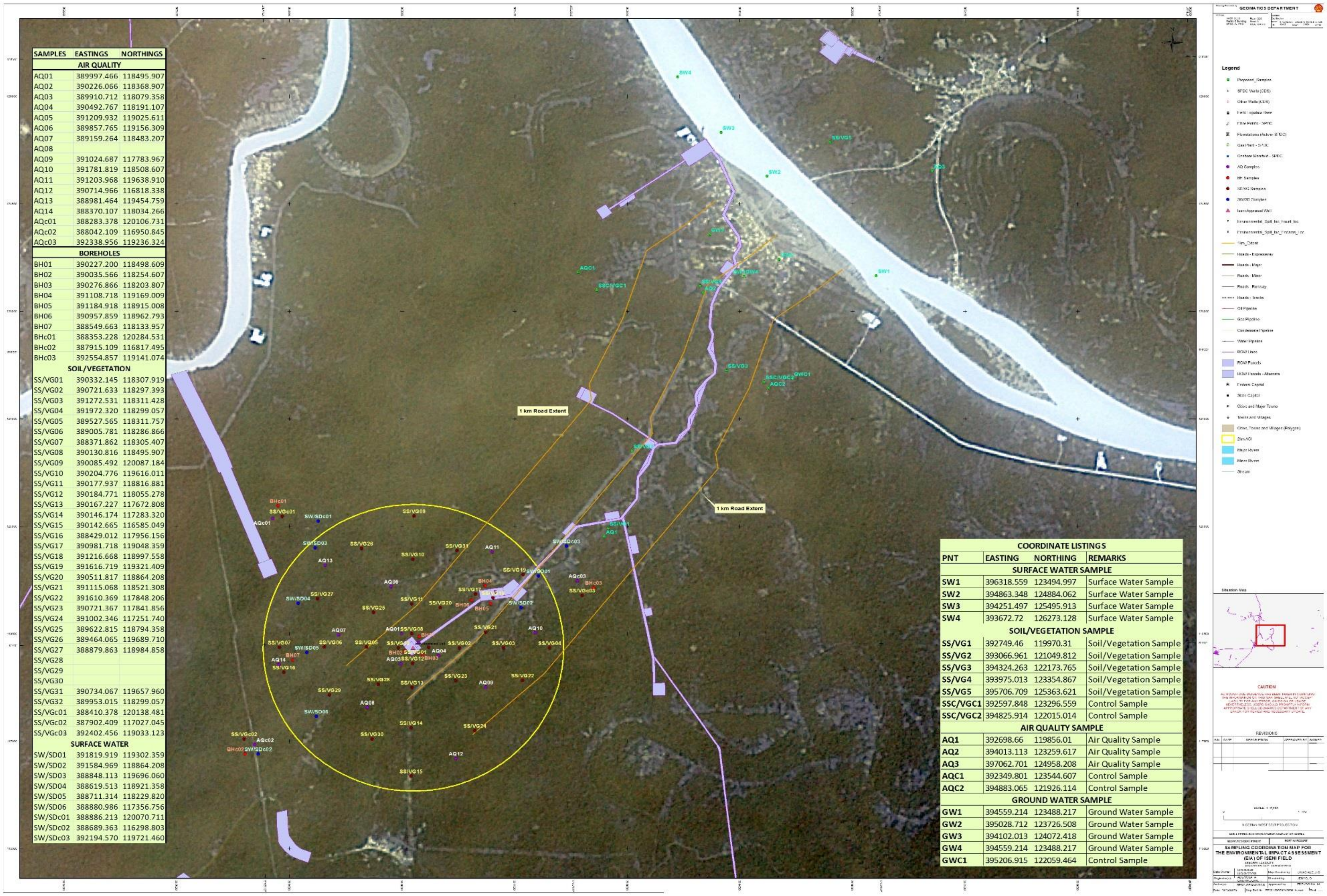


Fig. 4.1: Sampling Map for the Iseni field

The summary of sampling points for various environmental spheres in the Iseni field is presented in Table 4.1. The details of the coordinates of each environmental component are presented in Appendix 3. All samples were analysed in Tudaka Laboratory Limited, Warri, Delta State.

Table 4.1: Summary sampling points for various environmental spheres obtained in the 2013 and 2016 Field Data Gathering exercises

Environmental component	2013	2016	Rationale/Description of sampling points
Air Quality and Noise quality	12+3 controls	4 +2 controls	Sampling points concentrated around the existing wells, proposed Wells, flowlines, Ramp/Jetty, Access Road and communities
Soil quality	18+3 controls	7 +2 controls	Sampling points concentrated around the existing wells, proposed Wells, flowlines, Ramp/Jetty, Access Road and communities
Vegetation/Wildlife	18+3 controls	7 +2 controls	Transects were established along existing wells, proposed Wells, flowlines, Ramp/Jetty, Access Road and communities
Surface water quality	6+3 controls	2 +2 controls	Surface water samples were collected upstream and downstream of the Forcados river and creeks around the Odorubu and Ofoni communities
Sediment quality	6+3 controls	2 +2 controls	Sediment samples were collected upstream and downstream of the Forcados river and creeks around the Odorubu and Ofoni communities
Ground water quality	6+3 controls	3 + 2 controls	Around the proposed Iseni Appraisal Well and Existing Wells
Social Profile	Odorubu and Lalagbene communities	Ofoni (Pougelle) community	Communities within the 2km radius of the Iseni field
Health Profile	Odorubu and Lalagbene communities	Ofoni (Pougelle) community	Communities within the 2km radius of the Iseni field

4.4: Sampling Methodology

Table 4.3 gives a summary of the methods, parameters and instruments used for sampling and analyzing the various environmental components identified. The details of the methodology of data acquisition for each of the environmental components are presented in Appendix 2. For socio-economic and health studies structured questionnaires were administered to a random sample of households.

Plate 4.1a: Air quality measurement during the field data gathering in Odorubu community

Source: Field survey, 2013

Plate 4.1b: Focus Group Discussion session in the communities

Source: Field survey, 2013

Table 4.2a: Proposed Iseni Appraisal Well Sampling Stations

S/N	Groundwater	Air quality	Soil	Vegetation	Surface water	Sediment
1	BH1	AQ02	SS08	VG08	SW03	SD03
2	BH3	AQ01	SS12	VG32	SW04	SD04
3	BH2	AQ03	SS01	VG12	SW05	SD05
4		AQ04	SS02	VG01	SW06	SD06
5			SS13	VG02		
6			SS05	VG23		
7			SS11	VG13		
8			SS20	VG28		
9				VG05		
10				VG25		
11				VG11		
12				VG20		

Table 4.2b: Existing Iseni Wells Sampling Stations

S/N	Groundwater	Air quality	Soil	Vegetation	Surface water	Sediment
1	BH05	AQ05	SS18	VG18	SW01	SD01
2	BH06	AQ10	SS17	VG17	SW02	SD02
3	BH04	AQ11	SS19	VG19		
4		AQ06		VG31		

Table 4.2c: Unimpacted area Sampling Stations

S/N	Groundwater	Air quality	Soil	Vegetation
1	BH07	AQ13	SS09	VG09
2		AQ12	SS26	VG26
3		AQ08	SS27	VG27
4		AQ14	SS15	VG15
5		AQ09	SS14	VG14
6		AQ07	SS30	VG30
7			SS07	VG07
8			SS16	VG16

Table 4.2d: Proposed Access Road

S/N	Groundwater	Air quality	Soil	Vegetation
1	GW3	AQ1	SS1	VG1
2	GW1	AQ2	SS2	VG2
3	GW4		SS3	VG3
4	GW2		SS4	VG4
5			SS5	VG5
			SS24	VG24
			SS22	VG22
			SS04	VG04

Table 4.2e: Proposed Jetty/Ramp

S/N	Surface water	Sediment	Air quality
1	SW3	SD3	AQ3
2	SW4	SD4	AQ4
3	SW2	SD2	
4	SW1	SD1	

Table 4.2f: Sampling Stations: Controls (Appraisal well)

S/N	Air quality	Soil	Groundwater	Surface water	Sediment
1	AQC1	SSC1	GWC1	SWC1	SDC1
2	AQC2	SSC2	GWC2	SWC2	SDC2
3	AQC3	SSC3	GWC3	SWC3	SDC3

Table 4.2g: Controls (Access Road, Jetty)

S/N	Air quality	Soil	Vegetation	Groundwater	Surface water	Sediment
1	AQC1	SSC1	VGC1	GWC1	SWC1	SD1
2	AQC2	SSC2	VGC2	GWC2	SWC2	SD2

Table 4.3: Summary of sample type and method of collection

Environmental Component	Parameter	Equipment	Unit
Air quality	Suspended Particulate Matter	Microdust pro Monitor	µmg/m^3
	Nitrogen Oxides	ToxiRae	ppm
	Sulphur Oxides	ToxiRae	ppm
	Carbon monoxide	Gastella Monitor	ppm
	VOC/HC	Photoionization Detector	ppm
Noise	LAeq,90	Sound Level Meter	dB(A)
Soil quality	Soil Sampling	Sampling with a stainless steel auger	
	pH	pH meter	
	Electrical conductivity	Hilgar portable conductivity meter.	µS/cm
	Mechanical Analysis	Hydrometer method	
	Organic carbon	Wet combustion method	%
	Available Phosphorus	Ascorbic and acid-molybdenum blue colour method	mg/kg
	Total Nitrogen	Micro-kjeloahl digestion method.	mg/kg
	Exchangeable Bases	By Extraction within ammonium acetate	
	Exchangeable Acidity (EA)	KCL method	
	Effective Cation Exchange Capacity (ECEC)	By summation of exchangeable cation and exchangeable acidity	
	Ammonium (NH4)	Alkaline Pherate method	
	Nitrate and Nitrite	Brucine method and Alpha-naphthol method respectively.	mg/kg
	Sulphate	Turbidometric method	mg/kg
	Heavy metals	Agemcan and chan method	mg/kg
	Hydrocarbon content	Extraction with carbon tetrachloride	mg/kg
	Soil characterization/ classification	Mechanical analysis	
Vegetation	Sampling	Reconnaissance survey, Ground truthing –, Sampling with quadrant, information from existing literature and oral interviews.	
Surface water and groundwater quality		Water sampling with hydrobios water sampler	
	Temperature	In situ Measurement with Mercury -in-glass thermometer for surface water and temperature probe for sub surface water from the bottom.	oC
	pH	In situ Measurement with a HACH-one pH meter	
	Total, Dissolved and Suspended Solid	Gravimetric method for total solids (TS), In situ measurement with HACH dissolved solid meter for dissolved solids (DS) and TS-DS gives suspended solids	mg/l
	Total Alkalinity	HACH Digital Titration method	mg/l
	Dissolved Oxygen	Azide modification of Winkler method	mg/l
	Biological oxygen Demand (BOD5)	Winkler method	mg/l

Environmental Component	Parameter	Equipment	Unit
	Total Hydrocarbon Content (THC), Aliphatic hydrocarbons. Organics, TPH, THC, Oil and grease, Monocyclic Aromatic Hydrocarbons, BTEX, PAHs	Extraction with CCL4, GC-MS	mg/l
	Conductivity	In situ measurement with a HACH Portable Conductivity Meter.	
	Salinity	In situ measurement with oceanographic salinity measuring Bridge or Laboratory measurement using Harvey's titrimetric method	‰
	Sulphate	Modified Turbidometric method	mg/l
	Available Reactive Phosphorus	Stannous chloride method	mg/l
	Nitrate and Nitrite	Hach modification of the Cadmium reduction method	mg/l
	Sodium and Potassium	Flame Photometry	mg/l
	Calcium	EDTA Titration method	mg/l
	Heavy metals	Flame Atomic Absorption Spectrophotometry	mg/l
	Total heterotrophic bacteria and fungi , Hydrocarbon Utilizing bacteria and fungi, Total and Faecal coliform	Composite samples for laboratory analysis	cfu/ml
Sediment quality	Colour, Texture, Temperature, pH, Redox potential, THC, Oil & Grease, TPH, Monocyclic and Polycyclic Aromatic Hydrocarbons, Phenols, BTEX, PAHs, Sediment geochemistry (Fe, Ni, V, Cd, Cr, Pb, Zn, Hg), Sediment microbiology	Composite grab samples for laboratory analysis (Extraction, AAS)	mg/kg
Hydrobiology (plankton and benthic fauna)	Species composition, distribution, diversity and abundance and seasonality of Phytoplankton, Zooplankton, Benthos, Aquatic macrophytes, Macrophyte-associated macrofauna	Composite samples collected by plankton nets and Ekman grab for laboratory analysis	
Fisheries	Species composition, catch-composition, Fisheries activities (including aquaculture) catch-per-unit of effort and price, fishing gears/methods, population in fisheries, spawning grounds, migration routes and patterns, productivity and pathology.	Direct observations/interview, In situ measurements, Fish tissue analyses for TPH, PAH and phenols, composite samples for laboratory analysis	
Hydrodynamics	River water depth and width, flow direction and flow rate.	Direct observation/ interviews	
Vegetation	Vegetation types, floral composition, Identification of health conditions, plant tissue analysis	In situ study, Herbarium studies, Plants and crops pathological studies, AAS for heavy metal analysis	
Wildlife	Mammals, reptiles, birds, amphibians and invertebrates	In situ transect and visual observation, interviews, secondary data	

Environmental Component	Parameter	Equipment	Unit
Social Profile	Demography, Population size and distribution, Livelihood, Social Infrastructure Cultural Properties, Natural Resources and Land Use, Perception of the project, The role of women and children, Physically Challenged, Social Structure and Organisation, Vehicular Traffic Analysis, Sex Trade	Key informant interviews, Focus Group Discussion (FGD), direct observation, Administration of structured questionnaires and Collection of secondary data.	
Health Profile	Demographic profile of the Communities, Morbidity/Mortality Patterns, Healthcare facilities, availability of Medical Emergency Response Facilities (MEDEVAC), Nutritional Status of Under-fives and the general population, Maternal and Child Health, Knowledge, Attitude Practice and Behaviour (KAPB), Environmental health factors.	Key informant interviews, FGD, Administration of structured questionnaire and interviews, Physical examination of volunteers, Walk-through survey and Collection of secondary data.	

4.5: Quality Assurance/Quality Control

The quality assurance/control programme covered all aspects of the study, including sample collection, handling, laboratory analyses, data coding, statistical analysis, presentation and communication of results. The Federal Ministry of Environment (FMEnv) and the Department of Petroleum Resources (DPR) Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) Part VIII D (2) on sampling and handling were strictly adhered to in the course of field sampling. Where these were not possible due to logistics or safety reasons, other proven scientific and standard methods were used. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory were also implemented. The following precautions were also observed:

- Samples were collected in bottles that have been thoroughly washed with detergent (nutrient free) and rinsed with distilled water;
- All sampling equipment were properly protected and maintained in accordance with manufacturers' manuals;
- Sampling bottles were adequately labeled with masking tapes and indelible markers to avoid mistaken identity;
- Only analytical grade (Analar) chemicals were used and where applicable redistilled;
- Automated equipment were calibrated prior to field sampling.

Basic information was recorded together with results of analysis, in a sample register. With proper, sustained calibration of the instrument and the use of standardized observational procedures, equipment errors were brought to acceptable minimum.

Field Procedures

- All field procedures were in accordance with general QA/QC requirements.
- Contamination of samples was avoided by using clean and sterile sampling containers;
- Separate samples was used in analysing for parameters requiring different treatment or preservation before analysis;
- Composite sampling technique was adopted for soil;
- Control samples was collected at appropriate points remote from focus areas;
- Samples were appropriately preserved and labelled;
- Proper chain of custody was applied.

4.6: Statistical Analysis

All data generated in this study were subjected to statistical analysis to test for spatial variation between sampling stations and control stations during sampling periods 2013 and 2016 separately; data could not be compared with data obtained in 2008 in the Iseni Appraisal Well EIA (2013) because the latter was obtained in the dry season February while data obtained in 2013 and 2016 were both obtained in the wet season. The Dunnett's test was used to identify stations responsible for the variations.

Other tools employed in this study included descriptive statistics (range, mean, standard deviation, coefficient of variation, frequency and percentages) and *chi square goodness of fit test* ratio 1:1 and SPSS 15.0 packages as applicable. One level of significance ($p<0.05$) was considered in the results interpretation. Bar and pie charts, and line graphs were also used in comparing the results. The analytical results were also compared with local and international standards where applicable and also with data from previous studies on the area.

4.7: Results

The results, findings and discussions of the environmental components are presented in this subsection.

4.7.1: Climate and Meteorology

The study area situated in the Niger Delta falls within the typical humid tropical climatic zone which is influenced by two dominant seasons, the wet and dry seasons. The two climatic regimes depend on two dominant air masses: the tropical continental air mass of Saharan origin and the tropical maritime air mass blowing from the Atlantic at different times of the year. The rainy season commences in the study area from March and extends to early November, while the dry season is experienced between November and March. The incidence of fog is common, especially in February to March during the transition from dry to rainy season but it is quickly dispersed by the first radiation of the sun. During the dry season, the Northeast Trade Winds sweep through the region. This hot-by-day and cold-by-night wind brings in dust of large vertical extent. Visibility is restricted by a haze of dust carried from the Sahara region in December to February.

Two data sets were used in the analysis of the atmospheric parameters for climate and meteorology. One set pertained to long-term meteorological data for a nearby synoptic station in Warri, Delta State. The benefit of the long-term was that it depicted the regional atmosphere of the study area thereby providing a macro-climatic cover. The data from Warri synoptic station covered a period of nineteen years (1991 to 2010). The second set of data used in this analysis was recorded on the project site during the field data gathering exerice. The relevance of this quality of data is that it provides insight into the state of micro-climatic variables of the study area as well as diurnal variations if specified.

Rainfall

Annual rainfall pattern shows that the month of September recorded the highest rainfall of 386.5 mm while the lowest was recorded in January i.e., 22.4mm. The dip in rainfall in August is explained by the phenomenon of little dry season or “August break” (Fig 4.2). The peak and low periods are June-September which had rainfall amounts that are more than 300mm; while January-March had rainfalls below 100mm, respectively. The annual rainfall around the proposed project area was over 2500 mm due to the moisture-bearing southwest trade winds blowing from the Atlantic Ocean.

Table 4.4a: Average monthly rainfall (mm) in Bayelsa State (1991 – 2010)

Month	Maximum Rainfall (mm)	Minimum Rainfall (mm)	Mean Rainfall (mm)
January	85.2	0.0	22.4
February	153.5	2.3	53.2
March	306.1	5.2	112.9
April	345.2	46.5	173.9
May	430.5	113.2	248.4
June	462.6	114.8	327.2
July	742.4	162.0	365.7
August	682.3	49.4	310.2
September	722.9	91.3	386.5
October	647.5	59.7	289.3
November	312.8	0.0	67.5
December	140.3	0.0	20.2

Source: NIMET, ERA-40; ERA interim data

Relative humidity

Long term measurements (1991 to 2010) of the Relative Humidity (RH) around the Project area show that the moisture contents were lower in the drier months (December to March) and higher in the Wet months (June to October). The RH values exceeded 85% during the wet season under the influence of moisture laden South-westerly wind. As temperature increases, relative humidity drops, therefore months with maximum humidity values coincide with those with low temperature and months with low relative humidity coincide with those of maximum temperature (Offodille, 1991). The mean values were 72.32±5.74% and 71.87±4.01% in the study area and control stations for the Iseni Appraisal Wells Project, 2013. Similarly, the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 recorded mean values of 77.98±6.43% and 70.25±6.43% in the study area and control stations. The mean onsite data for Relative humidity were not significantly different (p=0.920) when compared to the control stations in the Iseni Appraisal Wells Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The similarity in the RH values maybe attributed to the fact that the field data were both obtained during the Wet season. Long term measurements of Relative humidity around the project area corroborated with this findings.

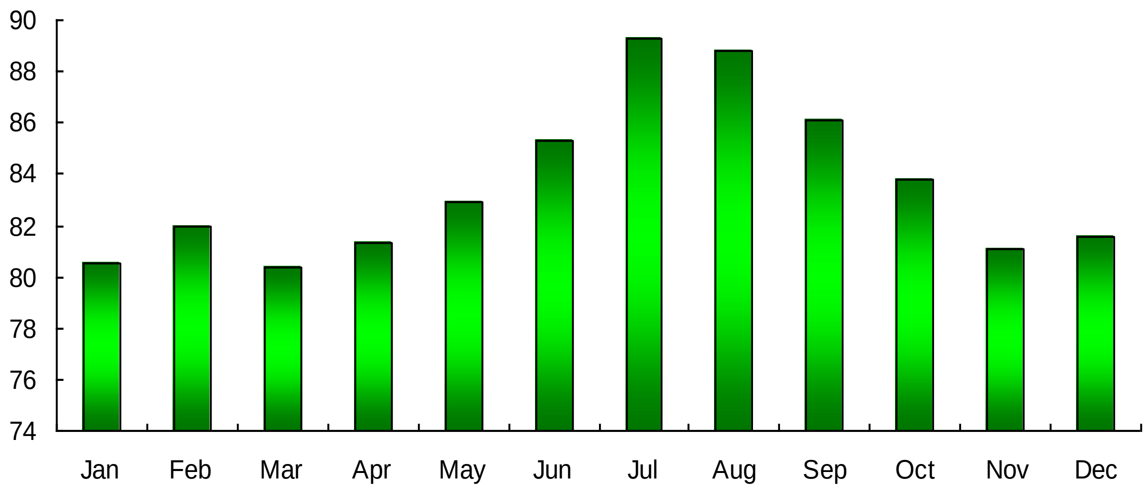


Fig. 4.2: Average trend for Relative Humidity (1991 to 2010) in Bayelsa State
Source: NIMET (Warri Synoptic station)

Temperature
Long-term average air temperatures obtained from the Nigerian Meteorological Agency for 1991 to 2010 as shown in the Table 4.4 indicates that the highest mean monthly temperatures was in March (34.5°C) and the lowest recorded in August (29.5°C). The ambient temperatures in the study area are usually high and with little variation all year round, which is typical of the equatorial belt. Overall, air temperatures are moderate in the peak of the rainy season (July - September) due to constant cloud cover and are higher and extreme during the drier months (November - March). Mean air temperature for microclimatic data in the study area and control stations were 30.23±1.66°C and 30.03±0.21°C for Iseni Appraisal Wells Project, 2013. No significant difference (p=0.966) was observed when compared to the study area and control stations of the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 as values were 28.38±1.27°C and 31.75±1.20°C. Long term monitoring of ambient temperatures compared favourably with the microclimatic data in the Iseni field and suggests a stable weather condition.

Table 4.4: Mean monthly maximum and minimum temperature (°C) (1981-2010) in Bayelsa State

Month	Mean Maximum (ºC)	Mean Minimum (ºC)	Highest Maximum (ºC)	Lowest Minimum (ºC)
January	32.2	22.8	33.0	19.9
February	33.6	23.8	34.5	22.9
March	33.3	24.6	34.6	24.1
April	33.1	24.4	34.1	23.2
May	31.9	23.8	32.7	23.2
June	30.5	23.2	31.1	22.5
July	28.6	22.7	30.6	21.7
August	27.3	22.9	29.5	21.3
September	29.3	22.6	30.1	20.5

Month	Mean Maximum (ºC)	Mean Minimum (ºC)	Highest Maximum (ºC)	Lowest Minimum (ºC)
October	30.9	23.1	31.5	22.3
November	32.4	23.9	33.2	23.0
December	32.1	22.8	32.8	21.4

Source: Federal Department of Meteorological Services, Oshodi, Lagos.

Wind speed and direction

Surface wind speed in the Niger Delta region is characterized by small diurnal variation and influenced by both land and sea breezes, resulting from alternate warming of the land and sea. It reaches maximum level during noon due to insolation, leading to instability in the surface layer. The two major wind regimes around the Project area are North-Easterly (NE) and South-Westerly (SW) winds. During the months of June to September (wet season), the region mainly experiences South-Westerly (SW) winds, while in the months of October to April (dry season), the winds are mainly North-Easterly (NE). Onsite wind measurements showed no spatial variation (p=0.079) between the study area and control stations in the Iseni Appraisal Wells Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The wind speed was rated light air on the beaufort's scale in both studies and corroborated with the historical data (March to October).

Table 4.4c: Summary of microclimatic data in the Project area

Parameters	SPDC, 2013a (DS)		SPDC, 2016b (WS)		p value	Sig.
	Study area (x±SD)	Control (x±SD)	Study area (x±SD)	Control (x±SD)		
Temperature (°C)	30.23±1.66	30.03±0.21	28.38±1.27	31.75±1.20	0.966	Non sig.
Relative humidity (%)	72.32±5.74	71.87±4.01	77.98±6.43	70.25±6.43	0.920	Non sig.
Wind speed (m/s)	0.28±0.37	0.33±0.06	0.4±0.35	0.95±0.35	0.079	Non sig.
Wind direction	SW	SW	SW	SW		

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

P>0.05 = Not significant; P<0.05 = Significant; DS: Dry season, WS: Wet season

4.7.2: Air Quality and Noise

The concentrations of Sulphur dioxide (SO2) and Nitrogen dioxide (NO_2) in the Iseni Appraisal Well Project, 2013 were generally low around the proposed Iseni Appraisal Well, Existing Wells, Unimpacted/community area and control stations. Similarly, the concentration of these gaseous pollutants (SO_2 and NO_2) for the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 around the proposed access road, proposed Jetty/Ramp area and the control stations compared favourably with the 2013 data as the concentrations were below the equipment detection limits (<0.001ppm). A test of significance on the tempo-spatial variation between the gaseous pollutants of the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 was carried out using the non-parametric Chi-square goodness of fit test, ratio 1:1 showed that there were no significant differences ($p>0.05$) in the gaseous pollutants when compared to the control stations. These values complied with the DPR limits of 0.04-0.06ppm and 0.08ppm for daily average/mean values.

Furthermore, the mean concentration of VOCs in the Iseni Appraisal Well Project, 2013 were 0.22±0.01 ppm, 0.20±0.03 ppm, 0.21±0.06 ppm and 0.19±0.12ppm around the Proposed Iseni Appraisal Well, Existing Wells, Unimpacted area/Community and control stations. The concentrations of VOCs around the proposed access road, Jetty/Ramp and control stations of the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were at variance ($p=0.000$) with the 2013 values. The mean VOCs concentrations were 4.85±3.89 ppm, 8.05±1.06 ppm and 4.05±0.21ppm. The variance in the VOCs levels when compared to the 2013 data maybe attributed to its proximity to Ofoni community (via emission sources from automobile exhausts and generators).

The SPM levels in the proposed Iseni Appraisal Well, Existing Wells, Unimpacted area/community and control stations in the Iseni Appraisal Well Project, 2013 were 2.88±0.26 $\mu g/m^3$, 3.37±0.48 $\mu g/m^3$, 3.4±0.81 $\mu g/m^3$ and 2.29±1.46 $\mu g/m^3$. The chi square goodness of fit test showed that there were significant differences ($p=0.001$) in the SPM levels when compared to the proposed access road, Jetty/Ramp and control stations of the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 as values were 12.65±6.58 $\mu g/m^3$, 17.45±0.78 $\mu g/m^3$ and 7.2±0.57 $\mu g/m^3$. The high SPM values in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 maybe attributed to its proximity to Ofoni community (via emission sources from automobile exhausts, generators, and construction activities). The SPM values in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 complied with the DPR limits of 60 to 90 $\mu g/m^3$ for daily average/mean values.

The Noise levels measured at the Proposed Iseni Appraisal Well, Existing Wells, Unimpacted area/Community and control stations were 48.03±0.90 dB(A), 51.35±1.95 dB(A), 49.86±4.65 dB(A) and 36.34±24.96 dB(A). No significant variation ($p>0.05$) was observed across the sampling stations including the control stations for the Iseni Appraisal Well Project, 2013. Similarly, there was no spatial variation ($p=0.497$) in the noise levels when compared to the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 as the mean values were 42±0.42 dB(A), 42.75±4.88 dB(A) and 41.3±1.13 dB(A) for Proposed access road, Proposed Jetty/Ramp and Control stations. The noise levels complied with the DPR and FMEnc limits of 85 dB(A) and 90 dB(A) for 8 hour exposure. A statistical summary of the air quality variables is presented in Table 4.4d while the detailed field measurements are presented in Appendix 5.

Table 4.4d: Mean ± SD Air Quality Variables, and *chi square goodness of fit test* comparing differences in the values.

Parameters	**SPDC, 2013a (Dry season)**				**SPDC, 2016b (Wet season)**			**DPR limits**	**FMEnv limits**	**p value**	**Sig.**
	Proposed Iseni Appraisal Well (x±SD)	**Existing Wells (x±SD)**	**Unimpacted area/Community (x±SD)**	**Control (x±SD)**	**Proposed access road (x±SD)**	**Proposed Jetty/Ramp (x±SD)**	**Control (x±SD)**				
SO_2, ppm	0.02±0	0.02±0.01	0.03±0.01	0.02±0.01	<0.001	<0.001	<0.001	0.04-0.06	0.01		
NO_2, ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.08	0.04-0.06		
H_2S, ppm	<0.001	<0.001	<0.001	<0.001							
NH_3, ppm	0.001±0.001	0.0003±0.001	<0.001	<0.001							
CO, ppm	0.01±0.01	0.013±0.013	0.01±0.013	0.013±0.01	<0.001	<0.001	<0.001	10	10		
VOC, ppm	0.22±0.01	0.20±0.03	0.21±0.06	0.19±0.12	4.85±3.89	8.05±1.06	4.05±0.21			0.000	Sig.
BTEX, ppm	<0.001	<0.001	<0.001±0	<0.001							
SPM, µg/m^3	2.88±0.26	3.37±0.48	3.4±0.81	2.29±1.46	12.65±6.58	17.45±0.78	7.2±0.57	60-90	250	0.001	Sig.
Noise, dB(A)	48.03±0.90	51.35±1.95	49.86±4.65	36.34±24.96	42±0.42	42.75±4.88	41.3±1.13	85	90	0.497	Non sig.

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

P>0.05 = Not significant; P<0.05 = Significant;

4.7.3: Soil quality

A statistical summary of the physicochemical parameters of the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted/community and the proposed Access road, Jetty and Ramp in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 are presented in Table 4.5a and Table 4.5b.

pH, Electrical conductivity

The pH values were generally acidic in the top and bottom soils of the Iseni Appraisal Well Project, 2013 as mean values were 4.88±0.4, 4.51±0.37 (proposed Iseni Appraisal Well); 4.85±0.62, 4.51±0.36 (Existing Iseni Wells), 4.78±0.49, 4.45±0.38 (Unimpacted area/community) and the control stations (4.55±2.51, 4.24±2.32). There were no significant differences ($p=1.000$) in the pH values across the sampling stations including the control stations in the top and bottom soils. Similarly, the mean pH values in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 compared favourably ($p>0.05$) with the data obtained in the Iseni Appraisal Well Project, 2013. The mean values in the top and bottom soils were 3.68±0.38, 3.73±0.44 and 4.25±2.25, 3.93±1.97 in the proposed access road and control stations. No significant variation was obtained when compared to the control stations ($p=1.000$). According to Aprile (2012) tropical soils are generally acidic and acidity can be very high in tropical lowland peak forest ecosystem such as is common in swamp forests of the study area. The pH levels are however normal for soils in the Niger Delta (Udoh, 1986, NDES, 2008).

The Electrical conductivity (EC) levels around the Existing Iseni Wells were significantly different ($p=0.000$) when compared to the proposed Iseni Appraisal Well, Unimpacted area/community and the control stations in the Iseni Appraisal Well Project 2013. The mean EC values in the top and bottom soils were 146±30.25 µS/cm, 142.8±43.59 µS/cm (proposed Iseni Appraisal Well), 230.55±4.88 µS/cm, 209±16.97 µS/cm (Existing Iseni Wells), 184.67±33.84 µS/cm, 141±32.45 µS/cm (Unimpacted area/community) and the control stations (166.26±94.72 µS/cm, 158.48±89.30 µS/cm). The variance in the EC levels maybe attributed to local variation in the soil minerals and nature of parent rock materials around the proposed Iseni Appraisal Well (Wei *et al*, 2013). Furthermore, the EC levels in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were significantly lower ($p<0.05$) when compared to the data obtained in 2013. The EC values in the top and bottom soils of the proposed access roads and control stations compared favourably ($p=0.261$) as mean values were 50.74±9.22 µS/cm, 44.72±14.52 µS/cm and 63.22±36.53 µS/cm, 44.32±26.59 µS/cm. The levels of conductivities observed in the soils are low and correspond to non-saline soils. Ideal salinity for agricultural soils is <0.2dS/m (200 µS/cm) (Baker and Gourley, 2011).

Nutrients

The concentration of Ammonium (p=1.000), Nitrates (p=1.000) and Available phosphates (p=0.974) in the top and bottom soils around the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community were not significantly different when compared to the control stations. The mean concentration of ammonium in the top and bottom soils were 0.99±0.43 mg/kg, 0.79±0.29 mg/kg; 0.84±0.11 mg/kg, 0.56±0.32 mg/kg; 1.10±0.82 mg/kg, 1.31±0.64 mg/kg; 0.82±0.57 mg/kg, 0.57±0.46 mg/kg in the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations. The concentration of available phosphates also followed the same trend as the mean values in the top and bottom soils around the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations were 4.07±1.19 mg/kg, 3.38±0.88 mg/kg; 4.62±0.91 mg/kg, 3.34±1.51 mg/kg; 5.2±0.28 mg/kg, 3.26±0.67 mg/kg; 3.55±2.02 mg/kg, 2.52±1.46 mg/kg. No significant variation was observed in the mean ammonium (p=0.655), nitrates (p=1.000) and available phosphates concentrations (p=0.655) when compared to the control stations in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The concentration of the nutrients in the top and bottom soils were 2.98±0.73 mg/kg, 1.41±0.40 mg/kg (NH_4^+), 0.21±0.07 mg/kg, 0.14±0.04 mg/kg (NO_3) and 3.1±0.59 mg/kg, 2.05±0.83 mg/kg (Av. P). The concentrations of these nutrients were within ranges for optimal crop yield as described by Baker and Gourley, 2011.

Exchangeable cations (Na, K, Ca, Mg)

Exchangeable cations refer to the positively charged ions which are loosely attached to the edge of clay particles or organic matter in the soil. The cations include Sodium, Potassium, Calcium and Magnesium.

Sodium

The concentration of sodium in the top and bottom soils around the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations in the Iseni Appraisal Well Project, 2013 were 0.49±0.11 cmol/kg, 0.41±0.09 cmol/kg; 0.6±0.03 cmol/kg, 0.47±0.04 cmol/kg; 0.50±0.02 cmol/kg, 0.51±0.09 cmol/kg; 0.50±0.27 cmol/kg, 0.46±0.25 cmol/kg. No significant variation (p=1.000) was observed when compared to the control stations. Similarly, in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project 2016, the mean Na concentration in the top and bottom soils were 0.06 cmol/kg, 0.03 cmol/kg for the proposed access roads and control stations respectively.

Potassium

The potassium concentration in the top and bottom soils of the Proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and Control stations were 0.16±0.06 cmol/kg, 0.14±0.05 cmol/kg; 0.21±0.03 cmol/kg, 0.15±0.09 cmol/kg; 0.15±0.05 cmol/kg, 0.18±0.05 cmol/kg; 0.11±0.02 cmol/kg, 0.18±0.05 cmol/kg. There was no significant difference (p=1.000) in the potassium concentration when compared to the study area. Similarly, the concentration in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 compared favourably as the mean values were 0.12±0.03 cmol/kg, 0.08±0.04 cmol/kg and 0.11±0.06 cmol/kg, 0.08±0.04 cmol/kg around the proposed access road and control stations respectively. The levels of potassium measured are generally low (<5 meq/kg) for the soil textures in the area (Baker and Gourley, 2011).

Calcium

The mean calcium concentration in the top and bottom soils of the Iseni Appraisal Well project 2013 did not differ significantly (p=1.000) when compared to the control stations as the mean values were 0.21±0.05 cmol/kg, 0.18±0.05 cmol/kg (Proposed Iseni Appraisal Well); 0.25±0.04 cmol/kg, 0.20±0.02 cmol/kg (Existing Iseni Wells), 0.21±0.06 cmol/kg, 0.21±0.06 cmol/kg (Unimpacted area/community) and the control stations (0.19±0.11 cmol/kg, 0.18±0.10 cmol/kg). In the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016, the calcium concentration was in tandem with the 2013 data. The Ca concentrations in the top and bottom soils were 0.41±0.07 cmol/kg, 0.34±0.07 cmol/kg (Proposed access road) and 0.44±0.23 cmol/kg, 0.31±0.16 cmol/kg (control stations). The exchangeable calcium were generally low in the Iseni Appraisal Well project 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. Optimum levels of calcium for agriculture is >50 meq/kg (Baker and Gourley, 2011).

Texture

Sand dominated the textural class across the sampling stations (Proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations) in the Iseni Appraisal Well Project, 2013. No significant variation was observed in the clay (p=0.889), silt (p=0.695) and sand (p=0.152) composition when compared to the control stations. Similarly, in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016, Clay dominated the textural class. The dominance of clay maybe attributed to weathering processes of soils around the Iseni Wells Location. The clay (p=0.128) and silt (p=0.866) composition compared favourably with those around the control stations except sand (p=0.000). Local variation in the geologic conditions maybe attributed to the variance (USGS, 1999).

Bulk Density

This is the mass of the soil material in relation to the total volume it occupies. Bulk density of soil depends on the mineral make up of soil and its degree of compaction. The mean bulk density in the top and bottom soils of the Iseni Appraisal Well Project 2013 were 1.37±0.26 g/cm^3, 1.19±0.17 g/cm^3 (proposed Iseni Appraisal Well), 0.97±0.20 g/cm^3, 1.01±0.05 g/cm^3 (Existing Iseni Wells), 1.42±0.55 g/cm^3, 1.34±0.11 g/cm^3 (Unimpacted area/community). The bulk density in the control stations (0.99±0.54 g/cm^3, 0.92±0.51 g/cm^3) were not significantly different (p=0.001) when compared to the study area. The bulk densities in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 did not show any variance (p>0.05) when compared to the data obtained in 2013. The bulk density values in the top and bottom soils were 1.28±0.08 g/cm^3, 1.33±0.07 g/cm^3 and 1.24±0.62 g/cm^3, 1.29±0.65 g/cm^3. Most soil bulk densities fall between 1.0 g/cm^3 and 2.0 g/cm^3; root penetration is severely impacted at bulk densities greater than 1.6 g/cm^3 (Chaudhari *et al*., 2013).

Trace Elements (Heavy Metals)

In the Iseni Appraisal Well Project 2013, the concentration of V, As, Hg, Ba, Co, Al and Ag in the top and bottom soils of the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations were below the equipment detection limits (<0.001mg/kg). Similarly, Cr (p=0.934), Pb (p=0.881), Cu (1.000), Zn (p=0.919), Ni (p=0.753) and Cd (p=1.000) were generally within background levels and compared favourably with the control stations except Iron (p=0.000). Furthermore, the V, As, Pb, Hg and Ba concentrations in the top and bottom soils around the access road and control stations (Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016) were below the equipment detection limits (p<0.001). There was no significant variation in the concentration of Cr (p=0.074), Cu (p=0.705), Ni (p=0.782) and Cd (p=0.096) when compared to the control stations. The concentration of iron in the top and bottom soils were generally high (p=0.007) and typical of the Niger Delta soils (Anderson, 1967).

Organics

The concentration of TPH, PAH, BTEX, Oil and Grease in the top and bottom soils of the Iseni Appraisal Well Project 2013 (proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations) and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (proposed access roads and control stations) were below the equipment detection limits (<0.001mg/kg). The soil was relatively pristine with regards to organics.

Table 4.5a: Summary of Soil physicochemical characteristics and ANOVA. Means highlighted are significantly different from the Control (Dunnett's test) (SPDC 2013a) (Dry season)

Parameters	Proposed Iseni Appraisal Well		Existing Iseni Wells		Unimpacted area/community		Control		p-value	Sig.
	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)		
pH	4.88±0.4	4.51±0.37	4.85±0.62	4.51±0.36	4.78±0.49	4.45±0.38	4.55±2.51	4.24±2.32	1.000	Non sig.
EC (µS/cm)	146±30.25	142.8±43.59	230.55±4.88	209±16.97	184.67±33.84	141±32.45	166.26±94.72	158.48±89.30	0.000	Sig.
THC(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
TOC (%)	0.05±0.02	0.02±0.01	0.04±0.01	0.02±0.01	0.07±0.02	0.02±0.01	0.04±0.02	0.014±0.01	1.000	Non sig.
NH_4^+(mg/kg)	0.99±0.43	0.79±0.29	0.84±0.11	0.56±0.32	1.10±0.82	1.31±0.64	0.82±0.57	0.57±0.46	1.000	Non sig.
NO_2^-(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
NO_3^-(mg/kg)	0.26±0.13	0.15±0.05	0.19	0.12±0.10	0.22±0.12	0.1±0.04	0.19±0.10	0.12±0.07	1.000	Non sig.
AV.P(mg/kg)	4.07±1.19	3.38±0.88	4.62±0.91	3.34±1.51	5.2±0.28	3.26±0.67	3.55±2.02	2.52±1.46	0.974	Non sig.
Oil and grease (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Ca^{2+} (cmol/kg)	0.21±0.05	0.18±0.05	0.25±0.04	0.20±0.02	0.21±0.06	0.21±0.06	0.19±0.11	0.18±0.10	1.000	Non sig.
Na^+(cmol/kg)	0.49±0.11	0.41±0.09	0.6±0.03	0.47±0.04	0.50±0.02	0.51±0.09	0.50±0.27	0.46±0.25	1.000	Non sig.
Phenol (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
K^+(cmol/kg)	0.16±0.06	0.14±0.05	0.21±0.03	0.15±0.09	0.15±0.05	0.18±0.05	0.11±0.02	0.18±0.05	1.000	Non sig.
EA(cmol/kg)	1.06±0.40	1.02±0.17	1.12±0.20	1.10±0.14	1.36±0.74	0.78±0.50	1.01±0.21	1.51±0.33	1.000	Non sig.
ECEC (cmol/kg)	2.33±0.54	2.13±0.27	2.09±0.21	2.00±0.33	2.18±0.55	2.10±0.28	2.45±0.89	2.61±0.45	1.000	Non sig.
TPH(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
PAH(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Benzene(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Toulene(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Ethyl Benzene(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Xylene(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		

Parameters	Proposed Iseni Appraisal Well		Existing Iseni Wells		Unimpacted area/community		Control		p-value	Sig.
	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)		
Redox potential, mV	107.6±29.47	98±17.79	94.3±18.1	85.57±11.20	137.33±9.81	89±18.52	90.50±57.55	68.77±43.70	0.008	Sig.
Clay (%)	10.32±2.50	12.28±1.26	13.15±1.97	14.39±2.50	11.53±0.95	14.37±1.44	35.95±6.23	27.63±7.69	0.889	Non sig.
Silt(%)	4.78±2.22	4.94±0.92	5.55±0.95	5.71±1.98	3±1.31	4.57±1.17	3.08±1.91	3.84±2.54	0.695	Non sig.
Sand(%)	84.9±2.83	82.78±2.10	81.3±1.99	79.90±4.50	85.47±1.26	81.07±2.37	63.97±44.92	60.85±42.71	0.152	Non sig.
Permeability (cm/s)	0.11±0.04	0.09±0.05	0.1±0.01	0.08±0.02	0.12±0.03	0.08±0.01	0.11±0.06	0.09±0.05		
Porosity (%)	56.4±3.05	53.2±4.09	57.5±7.78	59.5±2.12	50.67±4.73	50±6.24	51.66±27.89	49.09±26.36		
Bulk density (g/cm^3)	1.37±0.26	1.19±0.17	0.97±0.20	1.01±0.05	1.42±0.55	1.34±0.11	0.99±0.54	0.92±0.51	1.000	Non sig.
Total .N (%)	0.18±0.08	0.25±0.06	0.26±0.04	0.21±0.08	0.21±0.09	0.24±0.05	0.19±0.11	0.19±0.10		
Fe^{2+}(mg/kg)	418.70±82.67	366.10±55.37	619.94±8.41	389.95±73.48	406.24±114.57	305.52±13.66	417.73±238.08	295.78±159.73	0.000	Sig
Cr^{3+}(mg/kg)	1.61±0.61	1.25±0.49	2.03±0.07	1.44±0.46	1.57±0.83	1.40±0.53	1.43±0.77	1.06±0.58	0.934	Non sig.
V^{+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
As^{+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Pb^{2+}(mg/kg)	1.72±0.29	1.35±0.51	2.11±0.64	1.04±0.37	1.08±0.40	0.46±0.11	1.02±0.78	0.59±0.43	0.881	Non sig.
Cu^{2+}(mg/kg)	0.07±0.06	0.09±0.12	0.19±0.01	0.16±0.14	0.08±0.08	0.13±0.17	0.07±0.07	0.10±0.11	1.000	Non sig.
Zn^{2+}(mg/kg)	7.36±1.44	6.20±0.73	9.23±3.73	8.42±2.00	8.99±2.62	5.23±0.61	7.04±4.05	5.42±3.25	0.919	Non sig.
Hg^{+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Ba^{2+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Ni^{+}(mg/kg)	3.94±1.05	3.00±0.57	1.63±0.25	1.00±0.16	2.20±1.08	1.61±0.58	1.97±1.18	1.31±0.76	0.753	Non sig.
Co^{4+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Cd^{2+}(mg/kg)	0.59±0.48	0.36±0.35	0.17±0.02	0.13±0.02	0.46±0.43	0.38±0.44	0.29±0.19	0.21±0.16	1.000	Non sig.
Al^{3+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Ag^{+}(mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		

SPDC 2013[a]: Iseni Appraisal Well Project, 2013

P>0.05 = Not significant; P<0.05 = Significant

Table 4.5b: Mean ± SD Soil quality Variables, and *chi square goodness of fit test* comparing differences in the values. Means highlighted are significantly different (SPDC 2016b) (Wet season)

Parameters	Proposed access road, Jetty and Ramp		Control		p value	Sig.
	Top	Bottom	Top	Bottom		
pH	3.68±0.38	3.73±0.44	4.25±2.25	3.93±1.97	1.000	Non sig.
EC (µS/cm)	50.74±9.22	44.72±14.52	63.22±36.53	44.32±26.59	0.261	Non sig.
THC(mg/kg)	<0.001	<0.001	<0.001	<0.001		
TOC (%)	0.67±0.11	0.46±0.16	0.42±0.23	0.23±0.16	0.366	Non sig.
NH_4^+(mg/kg)	2.98±0.73	1.41±0.40	1.89±0.96	1.29±0.66	0.655	Non sig.
NO_2^-(mg/kg)	<0.001	<0.001	<0.001	<0.001		
NO_3^-(mg/kg)	0.21±0.07	0.14±0.04	0.22±0.11	0.14±0.07	1.000	Non sig.
AV.P (mg/kg)	3.1±0.59	2.05±0.83	2.09±1.05	1.34±0.69	0.655	Non sig.
O&G (mg/kg)	<0.001	<0.001	<0.001	<0.001		
Ca (cmol/kg)	0.41±0.07	0.34±0.07	0.44±0.23	0.31±0.16	1.000	Non sig.
Na (cmol/kg)	0.06±0.02	0.03±0.02	0.06±0.03	0.03±0.02	1.000	Non sig.
Phenol (mg/kg)	<0.001	<0.001	<0.001	<0.001		
K(cmol/kg)	0.12±0.03	0.08±0.04	0.11±0.06	0.08±0.04	1.000	Non sig.
EA(cmol/kg)	1.89±0.31	1.42±0.21	1.93±0.99	1.46±0.76	1.000	Non sig.
ECEC (cmol/kg)	3.24±0.36	2.51±0.28	3.34±1.69	2.52±1.26	1.000	Non sig.
TPH(mg/kg)	<0.001	<0.001	<0.001	<0.001		
PAH(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Benzene(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Toulene(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Ethyl Benzene(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Xylene(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Clay (%)	60.84±27.12	65.57±27.79	79.13±39.92	83.8±42.10	0.128	Non sig.
Silt(%)	17.89±4.99	15.54±3.05	17.2±9.89	14.27±8.31	0.866	Non sig.
Sand(%)	21.27±28.37	18.89±28.10	3.67±1.89	1.93±1.13	0.000	Sig.
Permeability (cm/s)	0.08±0.03	0.06±0.02	0.06±0.03	0.05±0.03	0.593	Non sig.

Parameters	Proposed access road, Jetty and Ramp		Control		p value	Sig.
	Top	Bottom	Top	Bottom		
Porosity (%)	49.71±9.86	54.14±10.78	57.33±28.93	60.67±30.60		
Bulk density (g/cm^3)	1.28±0.08	1.33±0.07	1.24±0.62	1.29±0.65	1.000	Non sig.
Total .N (%)	0.05±0.02	0.02±0.01	0.02±0.01	0.01±0.005		
Fe(mg/kg)	1735.40±136.60	1404.36±207.17	1580.19±794.86	1264.96±633.85	0.007	Sig.
Cr(mg/kg)	14.24±2.155	9.92±2.47	6.26±3.58	3.58±2.18	0.074	Non sig.
V(mg/kg)	<0.001	<0.001	<0.001	<0.001		
As(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Pb(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Cu(mg/kg)	3.52±1.01	2.203±0.74	2.58±1.88	1.59±0.89	0.705	Non sig.
Zn(mg/kg)	91.00±17.87	75.11±16.11	64.13±34.36	54.82±30.83	0.030	Sig.
Hg(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Ba(mg/kg)	<0.001	<0.001	<0.001	<0.001		
Ni(mg/kg)	6.91±1.65	4.83±1.83	5.72±2.97	3.47±2.15	0.782	Non sig.
Cd(mg/kg)	7.06±2.48	4.29±2.12	2.12±1.30	0.91±0.49	0.096	Non sig.

P>0.05 = Not significant; P<0.05 = Significant;

SPDC 2016[b]: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

Soil microbiology

The summary of the soil microbiological parameters in the Iseni Appraisal Well Project, 2013 (proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations) and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (proposed access roads and control stations) are presented in Table 4.5c and 4.5d The THB and TF counts were in the order of 10^5cfu/g and 10^3 cfu/g in the top and bottom soils of the proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and compared favourably (p=0.801, p=1.000) with those in the control stations. Similarly, the THB and TF counts were higher (THB 107cfu/g) in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (proposed access roads and control stations) compared to the Iseni Appraisal Well Project, 2013 (THB 10^5cfu/g). The THB (p=0.564) and TF (p=1.000) counts suggest high microbial activity and may be attributed to the presence of utilizable organic substrates in the soils around the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016.

The proportion of the hydrocarbonoclastic counts in the top and bottom soils was <1% in the Iseni Appraisal Well Project, 2013 (proposed Iseni Appraisal Well, Existing Iseni Wells, Unimpacted area/community and control stations) and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (proposed access roads and control stations). This suggests the near-pristine nature of the soils in the Iseni field as the analytical results of TPH, PAH, BTEX, Oil and Grease also lends credence to this findings. Dominant bacterial genera identified in the soil include: *Micrococcus sp, Deinococcus sp, Pseudomonas sp, Bacillus, Acinetobacter sp, Enterobacter sp, Nocardia, Proteus, Micrococcus sp., Staphylococcus, Flavobacteria, Vibrio sp.* The fungi isolates identified were*: Candida, Penicillium, Geotrichum sp., Aspergilus sp, Mucor sp, Sporobolomyces, Cladosporium sp., Fusarium sp., Penicillium sp., Rhizopus sp., Penicillium sp. Aspergillus, Bacillus sp.*

Table 4.5c: Summary of Soil microbiology characteristics. Means highlighted are significantly different from the Control (Dunnett's test) (SPDC 2013a) (Dry season)

Parameters	Proposed Iseni Appraisal Well		Existing Iseni Wells		Unimpacted area/community		Control		p-value	Sig.
	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)	Top (x±SD)	Bottom (x±SD)		
THB $x10^5$ (cfu/g)	1.35±0.23	1.98±0.29	3±1.15	2.04±1.03	1.72±0.49	1.95±0.45	1.91±1.12	1.59±0.92	0.801	Non sig.
TF $x10^3$ (cfu/g)	0.58±0.04	1.188±0.44	1.06±1.02	0.52±0.62	0.78±0.65	1.16±0.22	0.80±0.51	0.70±0.44	1.000	Non sig.
HUB $x10^3$ (cfu/g)	1.14±0.15	1.74±0.26	1.99±0.36	1.62±0.72	1.35±0.54	1.74±0.39	1.39±0.76	1.33±0.76	0.896	Non sig.
HUF x10 (cfu/g)	0.2±0.06	0.47±0.31	0.25±0.20	0.1±0.04	0.21±0.11	0.46±0.24	0.29±0.17	0.32±0.21	0.940	Non sig.

P>0.05 = Not significant; P<0.05 = Significant;
SPDC 2013[a]: Iseni Appraisal Well Project, 2013

Table 4.5d: Summary of Soil microbiology characteristics. Means highlighted are significantly different (SPDC 2016a) (Wet season)

Parameters	Proposed access road, Jetty and Ramp		Control		p value	Sig.
	Top	Bottom	Top	Bottom		
THB (cfu/g)	$1.74x10^7$±$0.23x10^7$	$1.47x10^7$±$0.29x10^7$	$1.35x10^7$±0.79 $x10^7$	$1.12x10^7$±0.64 $x10^7$	0.564	Non sig.
TF (cfu/g)	$0.64x10^5$±0.22 $x10^5$	0.47 $x10^5$±0.20 $x10^5$	$0.61x10^5$±0.45 $x10^5$	$0.50x10^5$±0.43 $x10^5$	1.000	Non sig.
HUB (cfu/g)	$1.40x10^2$±0.24 $x10^2$	$1.29x10^2$±$0.24x10^2$	$1.09x10^2$±0.62 $x10^2$	$0.99x10^2$±0.58 $x10^2$	1.000	Non sig.
HUF (cfu/g)	0.53x10±0.18 x10	0.35 x10±0.18 x10	0.40x10±0.23 x10	0.27x10±0.16 x10	0.739	Non sig.

P>0.05 = Not significant; P<0.05 = Significant;

SPDC 2016[b]: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

4.7.4: Land Use

Land use in Iseni community comprises residential, schools, recreational facilities, health center, worship centers. Also, the area is surrounded by forests which provide arable lands for agricultural purposes. Agricultural lands host agricultural activities including crop cultivation and artisanal fish ponds which are localised mostly within farm settlements. Fallow lands also occur. Fig. 4.3 depicts the landuse distribution in the proposed project influence zone.

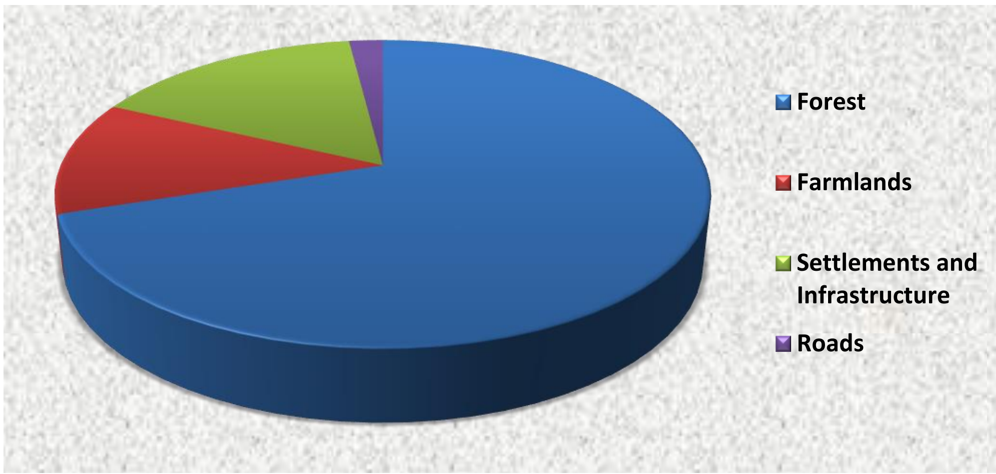


Fig. 4.3: Land use distribution in the proposed project influence zone

4.7.5: Geology, Stratigraphy and Geomorphology

The proposed project location is within the Niger Delta Basin of Nigeria. The Niger Delta occupies a pride of place as one of the world's largest Tertiary delta systems and a highly prolific hydrocarbon province. It is situated on the West African continental margin at the apex of the Gulf of Guinea, which formed the site of a triple junction during continental break-up in the Cretaceous. Throughout the Delta's history, it has been fed by the Niger, Benue and Cross Rivers, which between them drain over 106 km^2 of continental lowland savannah. The delta sequence comprises an upward-coarsening regressive association of Tertiary clastics up to 12 km thick. It is informally divided into three gross lithofacies: (i) marine claystones and shales of unknown thickness, at the base; (ii) alternations of sandstones, siltstones and claystones, in which the sand percentage increases upwards; (iii) alluvial sands, at the top. The area constitutes an extensive plain open to periodic inundation by flood resulting in flood plains and levees at the River banks(Reijers *et al.*, 1997).

Regional Geology and Stratigraphy of the Area

The Niger Delta coastal sedimentary basin has undergone three depositional cycles. The first began with a marine incursion in the middle Cretaceous and was terminated by a mild folding phase in Santonian time. The second included the growth of a proto-Niger delta during the late Cretaceous and ended in a major Paleocene marine transgression. The third cycle, from Eocene to Recent, marked the continuous growth of the main Niger delta. The delta structure and stratigraphy are intimately related, the development of each being dependent on the interplay between sediment supply and subsidence rates. The dominant subsurface structures are syn- and post- sedimentary listric normal faults which affect the main delta sequence. They die out upwards into the alluvial sands and sole out at depth near the top of the marine claystones. Major growth-fault trends cross the delta from northwest to southeast, dividing it into a number of structural and stratigraphic belts, called depobelts, which become younger towards the south. The deltaic sequence in each of these depobelts is distinct in age, so that they actually represent successive phases in the delta's history.

Hydrocarbons have been located in all of the depobelts of the Niger Delta, in good quality sandstone reservoirs belonging to the main deltaic sequence (the 'paralic sequence' of common usage). Most of the larger accumulations occur in roll-over anticlines in the hanging-walls of growth faults, where they may be trapped in either dip or fault closures. The Niger Delta province is the twelfth richest in petroleum resources, with 2.2% of the world's discovered oil and 1.4% of the world's discovered gas (Petroconsultants, Inc. 1996a). Most of the petroleum is sourced from the Akata Formation with smaller amounts generated from the mature shale beds in the lower Agbada Formation (Evamy et al., 1978). The hydrocarbons are found in multiple pay sands of The Agbada Formation which have relatively short columns, and adjacent fault blocks with independent accumulations (Doust and Omatsola, 1990).

Geomorphology

The geomorphology of the Niger Delta is that of a wave-dominated delta, with a smoothly seaward-convex coastline crisscrossed by distributary channels. From apex to coast, the sub aerial portion stretches more than 300 km, covering an area of 75 000 km^2. Below the Gulf of Guinea, two enormous lobes protrude a further 250 km into deeper waters. The area has a mostly low lying elevation (usually not exceeding 20m above sea level). It constitutes an extensive plain open to periodic inundation by flood. Prominent features of rivers and creeks in the area is occurrence of natural levees on banks behind which are vast areas of back swamps and lagoon lakes where surface floor is negligible. In all the area can be subdivided into five major geomorphological units, namely:

- coastal beaches
- saltwater mangrove swamps
- freshwater swamps, backswamps deltaic plain alluvium and meander belt
- dry deltaic plain
- dry flat land and plain

Local Geology of the Area

The Niger Delta consists of three diachronous geologic units, namely: (1) Akata Formation (oldest) consisting of marine claystones and shales of unknown thickness, at the base (ii) Agbada Formation (intermediate), made up of alternations of sandstones, silstones and claystones, in which the sand percentage increases upwards and (iii) Benin Formation (youngest) , of about

2100 m thickness consisting majorly of alluvial sands, at the top (Tables 4.6a and 4.6b). The Agbada Formation is the major hydrocarbon bearing unit in the Niger Delta Basin.

Table 4.6a: Stratigraphic units of the Niger Delta basin

Outcropping Units	Subsurface Units	Present-day Equivalents
Benin Formation	Benin Formation	Continental (fluviatile) deposits mainly sandstones
Ogwashi –Asaba Formation Ameki Formation	Agbada Formation	Mixed continental brackish water and marine deposits, sandstones and clays
Imo Shales	Akata Formation	Marine deposits, mainly clays

Table 4.6b: Geologic units of the Niger Delta

Geologic Unit	Lithology
Alluvium	Gravel, sand, clay and silt
Freshwater swamp	Sand, clay, silt and gravel
Mangrove/saltwater swamps	Fine-medium grained sand, clay and silt
Active/Abandoned beach ridges	Sand, clay and silt
Sombeiro-Warri Deltaic plain	Sand, clay and silt
Benin Formation (Coastal plain-sand)	Medium-coarse grained sand, clay lenses
Agbada Formation	Intercalation of sand, clay and silt
Akata Formation	Clay and Shale

Hydrogeology

Groundwater in the area occurs in shallow aquifers belonging to the coastal plainsand, comprising of sand, gravel and clay intercalations. Borehole yields are generally very good, with production rates of about 20,010 l/h and borehole success rate is usually high. The Benin Formation is the most prolific aquifer in the region. Overlying this Formation are the Quaternary deposits (Table 4.6c), an unconfined aquifer sequence made up of rapidly alternating sequence of sand, silt and clay with the silt and clay becoming very prominent seawards. Recharge to aquifers is by direct infiltration of rainfall and from surface water bodies. The base flow of the surface water bodies influences the ground water recharge rate especially during the dry season when the water table level drops.

Aquifer Characteristics

Boreholes were drilled within the study area using Auger rotary drilling method. Drill cores were sampled at intervals of 2m for lithologic analysis. These boreholes were cased using’’ PVC pipes, gravel packed and cemented. The depths to water levels of all the boreholes were obtained using an electronic dip meter. Some chemical parameters of the borehole water samples were measured insitu before they were dispatched for further labouratory analysis. GPS coordinates were recorded for all sample locations.

(a) Borehole 1 – 3 Area

The lithostratigraphy of this axis is made up of dark brownish humic loam material at the surface. The clay content of the lithology increases from about one meters (1m) from the surface level down to a depth of six meters (5m) This clay material overlies a fine sandy-clay material that is about two meters (2m) thick. Underlying this sandy-clay material is a higher proportion of fine grained sand that stretches down to a depth of ten meters (10m). The fine sandy materials become coarser with increasing depth, and join the aquifer (water-bearing lithology) at about fifteen meters (15m) depth. The formation materials also become lighter in colour with increasing depth.

(b) Borehole 4 – 6 Area

The lithostratigraphy of this area where is made up of dark brownish humic loam material at the surface. The clay content of the lithology increases from about one meter (1m) from the surface level down to a depth of four meters (4m) This clay material overlies a sandy clay material that is about four meters (4m) thick. Underlying this fine silty-sand material is sand materials that become coarser with increasing depth, and joins the aquifer (water-bearing lithology) at about twelve meters (12m) depth.

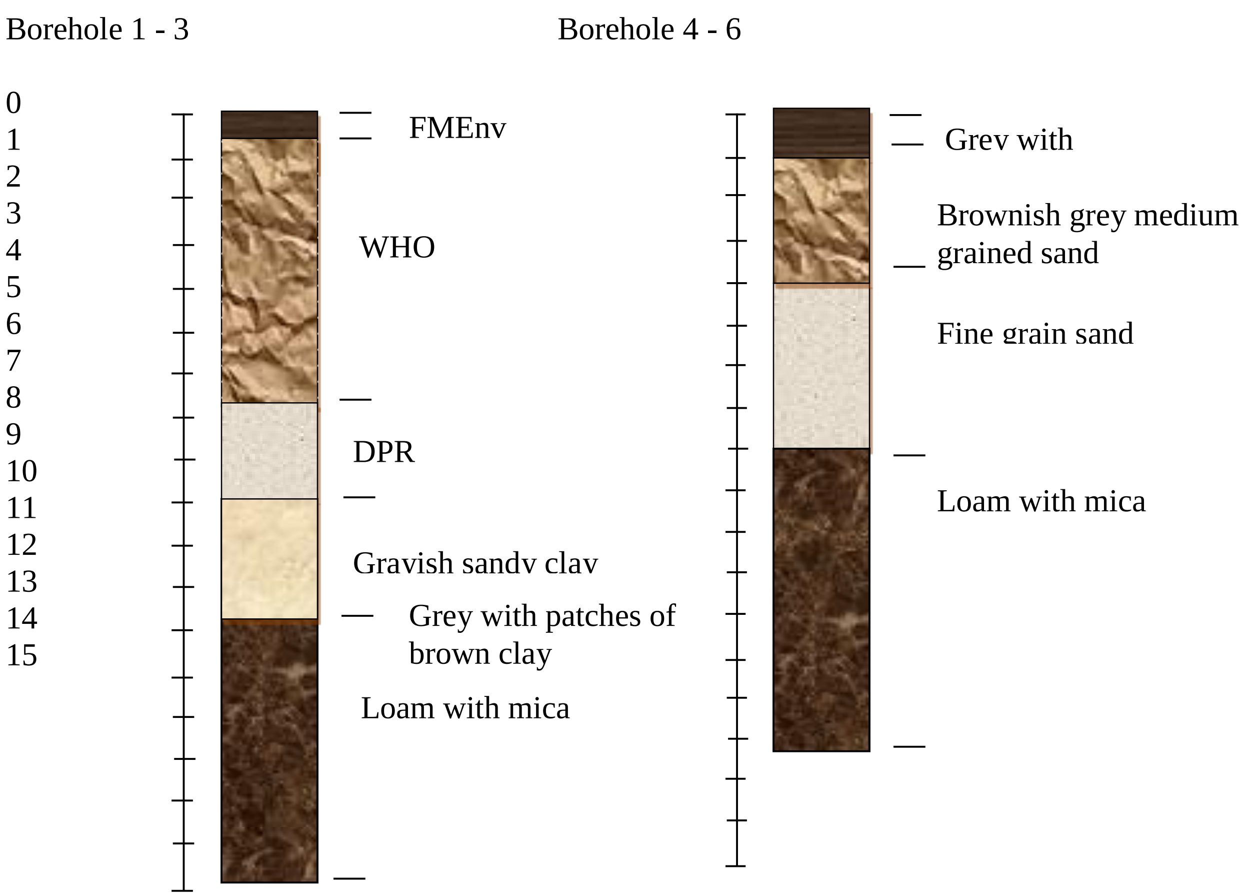


Fig 4.4a: Lithologic log of boreholes in the area of study

Table 4.6c: Stratigraphic sequence of the Niger Delta Basin with aquifer properties

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

(Source: Olobaniyi et al., 2006)

Ground Water Movement

On a regional scale, groundwater movement and flow direction is controlled by hydraulic gradient (flow direction is usually from areas of higher gradient, i.e, water level, to areas of lower gradient). However in areas near saline water/ fresh water boundaries, hydraulic gradient alone may not be sufficient to determine flow direction as there is a tendency for saltwater to flow towards fresh water against hydraulic gradient. This is referred to as salt water intrusion, a phenomenon that hampers groundwater quality. This reversal of flow direction may be made worse by excessive freshwater abstraction via boreholes or hand-dug wells. Groundwater flow direction in the area was determined using the data from 3 boreholes each from two axes of the study area. The data show that the groundwater flow direction in the area is from North to South. This is in conformity with the regional groundwater flow direction in Nigeria and the Niger Delta, which is from Northeast towards the coast in the south. Thus if there is any pollution of groundwater in the area, those south of the point of pollution are most likely to be affected.

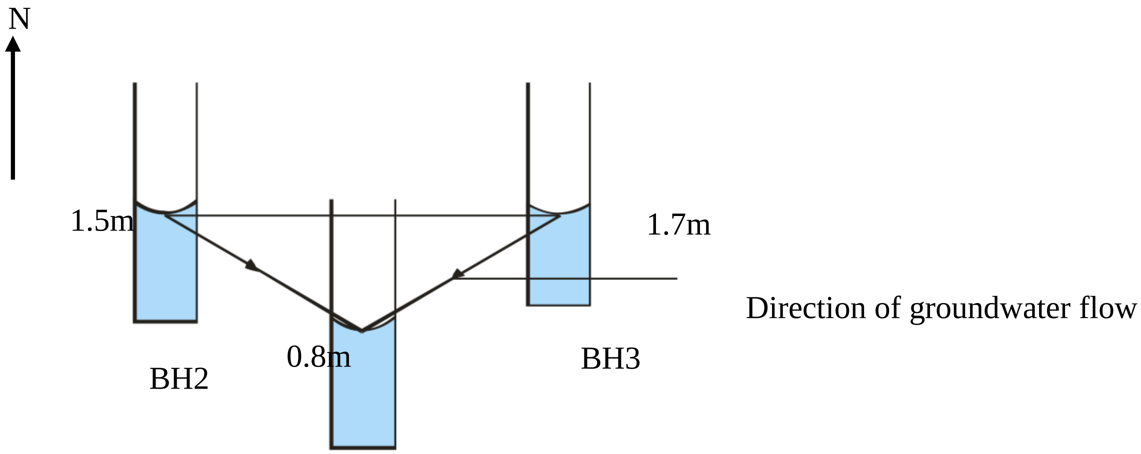


Fig 4.4b: Groundwater flow direction in the study area as determined from boreholes 1, 2 and 3

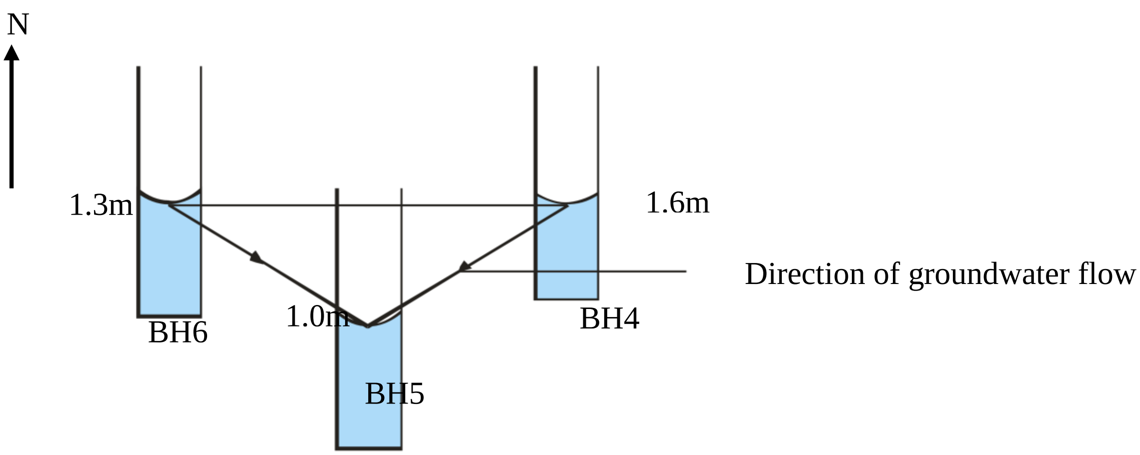


Fig 4.4c: Groundwater flow direction in the study area as determined from Boreholes 4, 5 and 6

4.7.6: Groundwater quality

The groundwater was sampled around the proposed Iseni Appraisal Well, Existing Iseni Wells, Community in the Iseni Appraisal Well Project, 2013 and around the proposed Access road in Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The summary of the physicochemical parameters is presented in Table 4.7a.

Groundwater physicochemistry

The mean pH of the groundwater in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community were slightly acidic and compared favourably with the pH in the control stations ($p>0.05$). Similarly, no significant differences ($p=0.289$) was observed in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 as the mean values were

6.13±0.70 and 5.65±3.31 around the proposed access road and control stations respectively. The mean pH values around the proposed Iseni Appraisal Well, Existing Iseni Wells, Community (Iseni Appraisal Well Project, 2013) and the proposed access road projects were at variance with the DPR/FMEnv/WHO limits of 6.5 to 9.2 for substances and characteristics affecting the acceptability of water for domestic use. This finding lends credence to Efe and Mgborukor 2012 who reported slight acidity in groundwater around some part of the Niger Delta. The interaction of meteoric water with pyrite which is widely presenting the lateritic overburden material in many parts of the study area, easily results in the formation of the mild acid H_2SO_4 and its presence in groundwater may be largely responsible for acidity and low pH observed in groundwater in the region.

Turbidity

The turbidity levels in the Iseni Appraisal Well Project, 2013 were significantly higher (p=0.000) than the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The mean turbidity values in the proposed Iseni Appraisal Well, Existing Iseni Wells and Community were 97.58±3.28 NTU, 25.88±21.92 NTU and 50.92 NTU. Furthermore, the turbidity levels around the proposed access road and control stations in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were 1.53±0.16 NTU and 1.73±1.00 NTU. The variance in turbidity levels maybe attributed to the composition/nature of the aquifer and regular aquifer recharge. The turbidity levels were above the WHO limits of 5NTU.

Salinity related parameters

The concentration of Total Dissolved Solids (TDS) (p=0.000), Electrical Conductivity (EC) (p=0.000) and Salinity (p=0.000) were higher in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (around the proposed Access road and control stations) compared to the Iseni Appraisal Well Project, 2013 (proposed Iseni Appraisal Well, Existing Iseni Wells and Community). The levels of the salinity related parameters suggest a freshwater bearing aquifer. Local variation in aquifer composition, hydraulic pressure and source of aquifer recharge may be responsible for the variance (Dennis, 2002).

Nutrients

The concentration of nutrients (Nitrate, Phosphate and Sulphate) in the Iseni Appraisal Well Project, 2013 were generally low as the values compared favourably with the control stations. The mean concentrations were: 0.012±0.004mg/l, <0.001 mg/l, 1.16±0.12 mg/l (Proposed Iseni Appraisal Well), 0.01±0.004 mg/l, <0.001 mg/l, 0.73±0.36 mg/l (Existing Iseni Wells) and 0.009 mg/l, <0.001 mg/l, 0.879 mg/l (community). There was no significant difference in the concentration of nitrates, phosphates and sulphates (p=0.881) when compared to the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The concentration of nutrients was 0.15±0.10mg/l, 0.51±0.31mg/l, 2.34±1.80mg/l (proposed access road) and

0.11±0.07 mg/l, 0.68±0.49 mg/l, 2.49±1.53 mg/l (control stations). The sulphate concentration complied with the 400mg/l limits for the acceptability of water for domestic use.

Calcium, Sodium, Potassium and Magnesium

The concentration of Calcium (p=0.000), Sodium (p=0.721), Potassium (p=1.000) and Magnesium (p=0.475) concentrations in the Iseni Appraisal Well Project, 2013 (proposed Iseni Appraisal Well, Existing Iseni Wells and Community) were not significantly different when compared to the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 (around the proposed Access road and control stations) except for calcium. The variance in the calcium concentration maybe attributed to the mineral composition of the aquifer. These minerals (Ca and Mg) also influence the levels of Hardness in the groundwater. The Ca and Mg concentration compared favourably with the hardness levels in the SPDC, 2013 and SPDC 2016 data.

Heavy metals

The concentration of As, Ag, Co, Mn, Cr, Cd, Ni, Pb, Hg, V, Al and Ba were generally below the equipment detection limits (<0.001mg/l) in the Iseni Appraisal Well Project, 2013 and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. Other heavy metals (Zn, Fe and Cu) were withn background levels and complied with the DPR/FMEnv/WHO maximum permissible limits for the acceptability of water for domestic use.

Organics

The concentration of THC, TPH, PAH and BTEX were generally very low and below the equipment detection limits (<0.01mg/l) in the Iseni Appraisal Well Project, 2013 and the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The concentrations of organics were within the DPR/FMEnv/WHO maximum permissible limits for the acceptability of water for domestic use.

Total Alkalinity

The total alkalinity levels in the groundwater around the proposed and existing Well area, Community, 2013 were significantly different (p=0.000) when compared to the groundwater around the proposed Access road area. The variance in the total alkalinity levels maybe attributed to localized differences in groundwater quality influenced by varying concentration of carbonates.

Redox Potential

The Redox Potential in the ground water around the proposed Iseni appraisal well, existing well and communites (88±4.58 mV, 82.67±6.66 mV and 79 mV) were significantly different (p=0.000) compared to those around the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) (40.00±13.23 mV and 45.00±26.46 mV). The variance maybe attributed to the depth to water level from the surface elevation of the boreholes. The groundwater around the SPDC 2013 data suggests a more oxidizing environment compared to the SPDC, 2016.

Table 4.7a: Summary of groundwater in the Proposed and Existing Well area, Community (2013) and the Proposed Access Road area (2016). Means highlighted are significantly different (p<0.05)

Parameters	SPDC, 2013a (Dry season)				SPDC, 2016b (Wet season)		P value	Sig.	*DPR/FMEnv/ WHO limits
	Proposed Iseni Appraisal Well(x±SD)	Existing Iseni Wells(x±SD)	Community (x±SD)	Control(x±SD)	Proposed Access road(x±SD)	Control (x±SD)			
pH	6.43±0.49	5.75±0.33	6.37	6.57±2.97	6.13±0.70	5.65±3.31	0.289	Non sig.	6.5 – 9.2
Temp. (ºC)	29±0.36	29.43±0.21	29.3	29.2±13.06	27.37±0.51	27.2±15.70	0.986	Non sig.	
TDS (mg/l)	46.17±1.14	35.13±12.16	50.11	42.71±21.18	112.8±33.08	116.88±74.10	0.000	Sig.	
EC (µS/cm)	82.95±2.433	61.05±24.02	90.15	76.11±37.67	225.6±66.17	233.75±148.20	0.000	Sig.	
DO (mg/l)	4.07±0.25	4.2±0.36	4.3	5.15±2.32	2.23±0.42	2.25±1.32	0.557	Non sig.	
Colour	10.33±2.52	7.33±2.08	11	4.25±2.70	3.33±1.53	3.5±2.08	0.221	Non sig.	
T.Alkalinity (mg/l)	17.14±1.08	13.50±5.85	20.28	16.43±8.85	0.19±0.04	0.16±0.09	0.000	Sig.	
R.P (mV)	88±4.58	82.67±6.66	79	63.75±30	40.00±13.23	45.00±26.46	0.000	Sig.	
BOD_5 (mg/l)	0.89±0.04	0.85±0.09	0.79	0.84±0.38	0.72±0.18	0.5±0.31	1.000	Non sig.	
Salinity (mg/l)	7.94±1.44	7.57±2.12	10.9	8.26±4.02	33.91±6.85	39.68±29.37	0.000	Sig.	600
COD(mg/l)	2.34±0.13	1.88±0.23	1.96	2.12±1.00	1.79±0.44	1.25±0.76	0.934	Non sig.	
Turbidity (NTU)	97.58±3.28	25.88±21.92	50.92	57.80±45.09	1.53±0.16	1.73±1.00	0.000	Sig.	5
CO_3 (mg/l)	<0.001	<0.001	<0.001	<0.001					
Cyanide (mg/l)	<0.001	<0.001	<0.001	<0.001					
H2S (mg/l)	<0.001	<0.001	<0.001	<0.001					
THC(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
TSS(mg/l)	10.832.31	11.44±0.60	10.26	8.17±3.71	4.33±0.58	5±2.89	0.232	Non sig.	
NH4(mg/l)	<0.001	<0.001	<0.001	<0.001					
NO2(mg/l)	<0.001	0.002±0.001	<0.001	<0.001					
NO3(mg/l)	0.012±0.004	0.01±0.004	0.009	0.01±0.004	0.15±0.10	0.11±0.07			
PO4(mg/l)	<0.001	<0.001	<0.001	<0.001	0.51±0.31	0.68±0.49			
SO4(mg/l)	1.16±0.12	0.73±0.36	0.879	1.01±0.57	2.34±1.80	2.49±1.53	0.881	Non sig.	400
Hardness (mg/l)	4.63±0.73	4.09±1.80	3.89	4.70±2.40	81.32±18.90	79±50.64	0.000	Sig.	
Ca(mg/l)	1.06±0.13	0.91±0.19	0.991	0.99±0.47	11.63±2.37	13.69±9.77	0.000	Sig.	200
Na(mg/l)	2.00±0.16	1.49±0.57	1.683	1.59±0.78	4.30±1.07	3.69±2.74	0.721	Non sig.	
K(mg/l)	0.73±0.11	0.58±0.26	0.684	0.67±0.35	1.12±0.15	1.29±0.93	1.000	Non sig.	
Mg(mg/l)	2.54±0.32	2.18±0.85	2.505	2.62±1.24	5.35±1.69	5.89±3.98	0.475	Non sig.	150

Parameters	SPDC, 2013a (Dry season)				SPDC, 2016b (Wet season)		P value	Sig.	*DPR/FMEnv/ WHO limits
	Proposed Iseni Appraisal Well(x±SD)	Existing Iseni Wells(x±SD)	Community (x±SD)	Control(x±SD)	Proposed Access road(x±SD)	Control (x±SD)			
O&G(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Phenol (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			0.002
THC (mg/l)	<0.001	<0.001	<0.001	<0.001					
As(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Ag(mg/l)	<0.001	<0.001	<0.001	<0.001					
Co(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Mn(mg/l)	<0.001	<0.001	<0.001	<0.001					0.5
Cu(mg/l)	0.001±0.001	0.003±0.002	0.001	<0.001	<0.001	<0.001			1.5
Fe(mg/l)	0.03±0.01	0.02±0.01	0.019	<0.001	0.029±0.004	0.014±0.01			1.0
Cr(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Cd(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Ni(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Pb(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Hg(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
V(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Zn(mg/l)	0.32±0.09	0.30±0.03	0.3±0.04	0.26±0.13	0.01±0.002	0.004±0.003	0.000	Non sig.	15
Al(mg/l)	<0.001	<0.001	<0.001	<0.001					
Ba(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

*Limits for substances and characteristics affecting the acceptability of water for domestic use

P>0.05 = Not significant; P<0.05 = Significant;

Groundwater microbiology

The summary of the groundwater sampled around the proposed Iseni Appraisal Well, Existing Iseni Wells, Community in the Iseni Appraisal Well Project, 2013 and around the proposed Access road in Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 is presented in Table 4.7b. The mean THB and TF counts in the Iseni Appraisal Well Project, 2013 were in the order of 10^4 cfu/ml and 10^2cfu/ml and compared favourably with the control stations. The microbial count suggests the presence of organic substrates in the groundwater. Similarly, the THB ($p=0.000$) and TF ($p=0.000$) counts were at variance with the counts obtained in 2013 as the mean microbial counts were in the order of 10^2cfu/ml. The hydrocarbon utilizing organisms (HUB and HUF) were generally low in the groundwater and also higher in the Iseni Appraisal Well Project, 2013 compared to the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The HUB and HUF composition in the groundwater were <1% suggesting the low hydrocarbon burden of the groundwater (Atlas, 1981). The analytical data obtained from the groundwater physicochemistry also supports this finding. The mean coliform counts ($p=0.000$) in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were 66.67±25.17MPN/100ml and 30±20MPN/100ml. Predominant bacterial and fungal genera identified include: *Pseudomonas sp, Micrococcus sp. Arthrobacter sp, Bacillus sp., Candida sp., Mucor sp.*

Table 4.7b: Microbiology of the Groundwater in the Proposed and Existing Well area (2013) and the Proposed Access Road area (2016)

	SPDC, 2013a (Dry season)		SPDC, 2016b (Wet season)		P value	Sig.	WHO limit
	Study area (x±SD)	Control (x±SD)	Study area (x±SD)	Control (x±SD)			
THB (cfu/ml)	$1.43x10^4$±0.48 $x10^4$	1.21 $x10^4$±0.01 $x10^4$	$2.97x10^2$±0.10 $x10^2$	3.15 $x10^2$±1.84 $x10^2$	0.000	Sig.	
TF (cfu/ml)	0.30 $x10^3$±0.26 $x10^3$	0.14 $x10^3$±0.02 $x10^3$	0.6 $x10^2$±0.13 $x10^2$	0.37 $x10^2$±0.23 $x10^2$	0.000	Sig.	
HUB (cfu/ml)	0.56 $x10^2$±0.52 $x10^2$	0.26 $x10^3$±0.06 $x10^3$	1.88±0.11	1.65±0.96	0.000	Sig.	
HUF(cfu/ml)	$0.04x10^2$±0.04 $x10^2$	0.03 $x10^2$±0.01 $x10^2$	0.56±0.10	0.2±0.12	0.000	Sig.	
TCC (MPN/100ml)	0	0	66.67±25.17	30±20	0.000	Sig.	0

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

P>0.05 = Not significant; P<0.05 = Significant;

Groundwater vulnerability

Groundwater pollution is generally considered to occur where contaminants attain concentration levels that are considered to be objectionable. Freeze and Cherry (1979) defined contaminants as all solutes introduced into the hydrologic environment as a result of man's activities, regardless of whether or not the concentration reaches levels that cause significant degradation of water quality. Virtually, all groundwater comes from precipitation that soaks into the soil and passes down to the aquifer (Nelson, 2002). Rain water has a slightly acidic pH; therefore, it tends to dissolve solid minerals in the soil and in the aquifer. The concept of groundwater vulnerability is based on the assumption that the physical environment of an area may provide a degree of protection to the groundwater from anthropogenic and natural contaminants and that the degree of vulnerability is a function of hydrogeological conditions and prevailing human waste disposal systems and other practices.

The environment was carefully observed to identify activities that were likely to cause contamination and or pollution of water within the study area. The important question is whether the contaminant is able to move from the source through a pathway to the receptor. The clayey overburden material would serve to retard advective flows of contaminant down to the water table. However, the water table is shallow, which reduces contaminant attenuation and exposes the aquifer to risk of contamination. Also, the groundwater occurs under unconfined conditions and would be prone to pollution from surface waste disposal sites through infiltration of rainwater. The hydraulic gradients throughout the area are directed towards the streams and rivers suggesting considerable groundwater base flow. Hence, surface water bodies are also at risk in the event of pollution of the groundwater system.

4.7.7: Vegetation Study

The study area is situated in an ecological zone designated as the Lower Guinean forest zone: the regional ecoclimatological corridor that runs from the eastern coast of the Gulf of Guinea (in the eastern Republic of Benin), through Nigeria and Cameroon (Fig. 4.5a). This biogeographic region is part of the Guinean forests biodiversity hotspot and is thus designated, because it is one of earth's few areas with very high biodiversity and species endemism. The area is critically endangered by human related activities (CI, 2008; Myers, 2000; WWF, 2014).

The study area is characterized by a natural vegetation cover type designated as Niger Delta Swamp forest ecoregion: one of the five World Wildlife Foundation (WWF) distinct ecoregions of the Lower Guinean forests in Nigeria (Olson et al., 2001). It is a region of Coastal Tropical Moist Broadleaf forests (tropical rainforest). Such nomenclature easily suggests the Lowland Rain Forest (or Lowland Evergreen Equatorial Tropical Rain forest) which actually belongs to ecoregion. It is one of the types of tropical wet/ rain forests (Olson et al., 2001). The Niger Delta Swamp Forest ecoregion forms a partial triangle/wedge between the Lowland Forests Ecoregion on the west, and the Cross-Niger Transition Forests on the east of the Niger. The town of Aboh on the Niger River is the northernmost tip and is contained within three states (Rivers, Bayelsa, and Delta) of Nigeria (Fund, W. 2014).

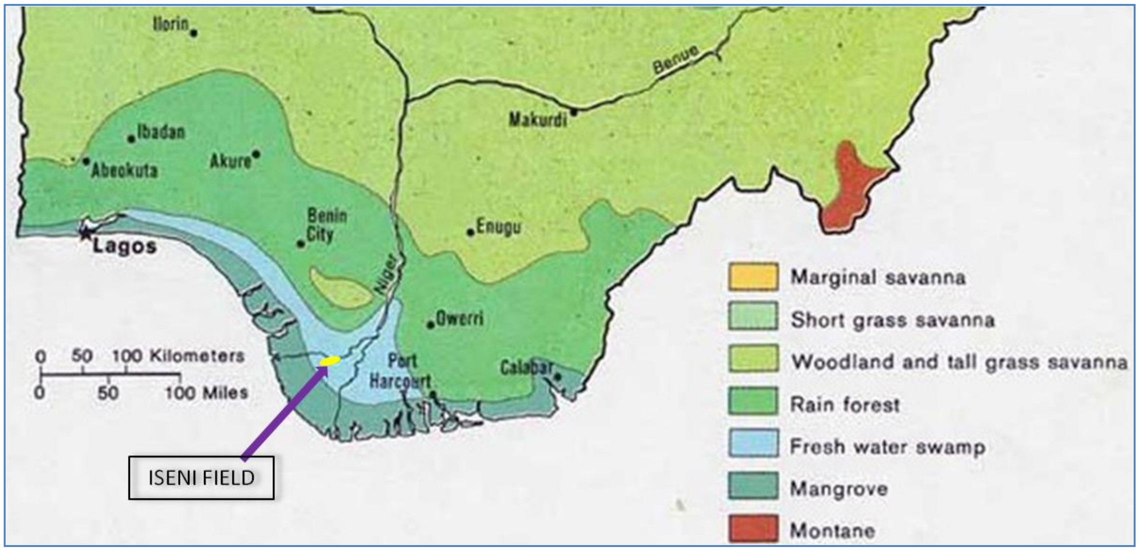


Fig. 4.5a: Iseni field location and the vegetation zones of the lower Guinea Ecoregion in southern Nigeria
Source: PCLM, 1979

The high groundwater table, low lying terrain, heavy and prolonged rainfalls as well as the Forcados River which floods the area with non-saline water, defines the structure and species composition of the vegetation in this habitat. This seasonally flooded swamp forest ecotype is referred to as the Niger Delta Flood Forest and consequently supports its own floral assemblage (Roger, 2007; Powell, 1995). The influence of the Niger River flooding is observed to be fullest in the North West quadrant of the study area which is in closest proximity to the river (Fig. 4.5b). Apart from the mesh of streamlets that supply the area, the other main water body is a stream just outside the study area, whose influence reaches the south west quadrant. The vegetation composition of the western hemisphere of the study area confirms this near perennial abundant water supply; while the eastern hemisphere along with the south western quadrant preserves a very mature swamp forest vegetation of the Niger Delta. Species diversity is typically lower as only water tolerant tree species thrive in this habitat.

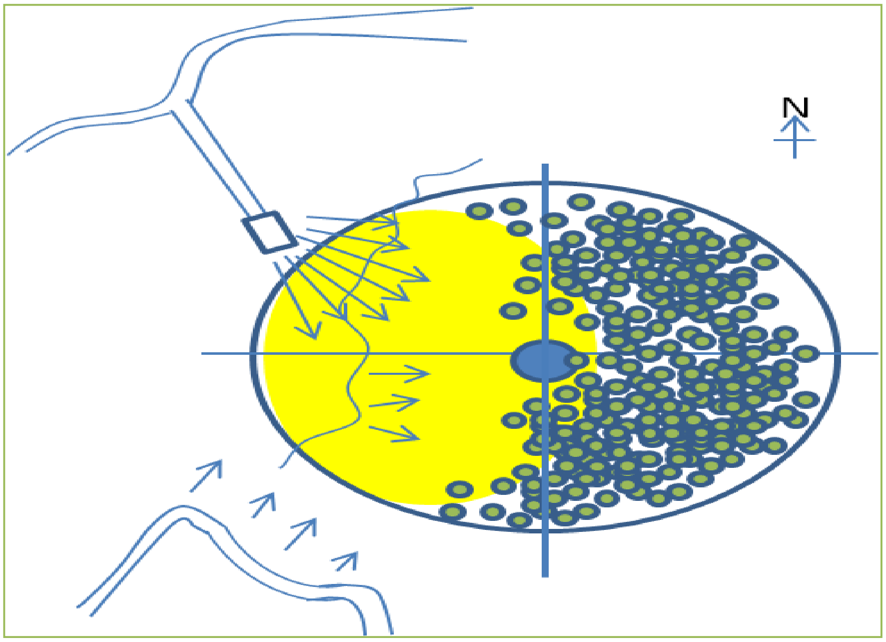


Fig 4.5b: Model showing the direct impact zone of the Niger flood and the vegetation cover variation in the Iseni study area

Key: Arrows – Flood direction from water channels; Yellow field – Flood/Raphia dominance zone; Green circles – dense Swamp vegetation.

Vegetation Ecotypes

The Fresh Water Swamp vegetation in the study area includes the Raffia Swamp forest sub community; while the artificial vegetation cover of the area consists of the agricultural farmlands and fallows. Percentage composition of the land cover types observed is: Fresh Water Swamp (75%) > Raffia Swamp (16%) > Artificial Vegetation Cover (8%) (Fig. 4.5c). Vegetation in the first two vegetation systems is mostly secondary forest at climax stage and predominantly mesophanerophytic. Average height of vegetation across the habitats in decreasing order is 28 meters > 13 meters > 3.5 meters. The ecological characteristics of the identified vegetation sub-communities and peculiar plant associations are discussed under the specific headings, in order of prominence:

Fresh Water Swamp Forest

The prevailing Freshwater Swamp Forest cover observed in the Iseni Appraisal well study area confirms the ecological description of Gbile *et al.* (1981) which states thus: "Hygrophilous Coastal Evergreen Rainforest is the commonest rainforest type in Niger Delta". Since the most important determinant of biological variation in the Niger Delta is its hydrology, habitat description is thus based on the chemistry and abundance of the water supply. Based on hydrological variation, the ecological variant of this rain forest habitat of the Iseni study area is the Upper Riverine Flood Plain (Hughes & Hughes 1992; Powell, 1995). This ecological condition results in frequent flooding in many areas through old levees, permanent streams, and inland water lakes. Slowly rising water levels leading to complete inundation especially during the Forcados / Niger River flood season: August to December annually (Powell, 1995). Flood extent is subject to yearly variation in annual rainfall volume. Very importantly, the timing and level of flooding is also determined by the opening and closing of the sluices of any of the many upstream dams.

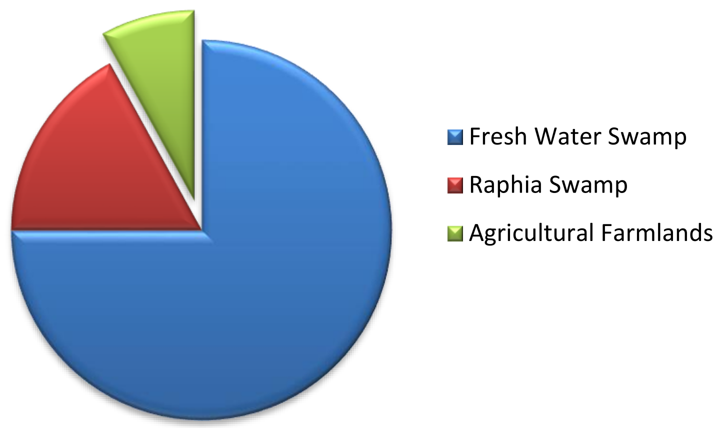


Fig. 4.5c: Percentage composition of vegetation cover

Floristic Composition and Vegetation Structure

From the sampling perspective, the stage of maturity of the vegetation cover as well as its closeness to the pristine nature varies according to the extent of anthropogenic disturbances in each location. Vegetation within the sampling area is climax and is mostly at the secondary forest stage especially at Vegetation sampling points 3, 10, and 11. According to Raunkiaer's (1934) life form classification spectrum, the vegetation is predominantly mesophanerophytic (trees < 30 meters). Such areas were observed to be mature swamp high forest having a profile of a dense jungle of trees with mostly touching crowns and poorly illuminated and flooded forest floor (Plate 4.2a and Plate 4.2b). The vertical profile of the fresh water swamp vegetation shows that it is fairly stratified into two layers of trees: the canopy layer of trees between 21-30 meters in height, and the emergent layer of trees between 30 – 40 meters in height. The forest floor is mostly bare while the shrub layer is poorly developed. Plank buttresses and stilt roots are common tree adaptations which help them to bear their large biomass and heights despite the muddy substratum. Overall species diversity is therefore characteristically low unlike the drier lowland rain forests. However, a diversity of plant forms was identified which includes trees, shrubs, herbs, epiphytic ferns and orchids; and also a few grasses. Dominant families include Fabaceae and Euphorbiaceae with four species each; and Apocynaceae, Palmae, Asteraceae, and Orchidaceae with three species each. A total of 62 species belonging to 41 plant families were identified and are taxonomically treated in **Table 4.7c.**

Plate 4.2a: Panoramic view of the fresh water swamp vegetation cover
Source: Field survey, 2016

a. Open canopy forest regrowth; b. Plantain farm on the edge of the secondary forest regrowth;

Plate 4.2b: Post Extraction Secondary forest, vegetation profile at the background; Left: VG C2, Right: VG 3.

Source: Field survey, 2013

Table 4.7c: Checklist of plant species of the study area

S/N	ECOSYSTEM	SPECIES NAME	COMMON NAME	FAMILY
	TREES			
1	EMERGENTS	*Lophira alata*	Ekki, Iron Wood	OCHNACEAE
2		*Ceiba pentandra*	Okha	BOMBACACEAE
3		*Irvingia gabonensis var. excels*	Bush Mango	IRVINGIACEAE
4		*Staudtia stipitata*		MYRISTICACEAE
5		*Brachystegia eurycoma*		CAESALPINIOIDEAE
6		*Spondianthus preussii*	Okolota	EUPHORBIACEAE
7		*Antrocaryon micraster*		ANACARDIACEAE
8		*Dracaena mannii*	Asparagus tree	AGAVACEAE
9	CANOPY	*Elaeis guineensis*	Oil Palm	ARECACEAE/PALMAE
10		*Pycnanthus angolensis*	Wild Nutmeg	MYRISTICACEAE
11		*Ctenolophon englerianus*		CTENOLOPHONACEAE
12		*Tricoscypha arborea*		EUPHORBIACEAE
13		*Alstonia boonei*	Stool wood	APOCYNACEAE
14		*Cleistofolis patens*		ANNONACEAE
15		*Fleroya ledermannii*	Abura	RUBIACEAE
16		*Cyclodiscus gabonensis*		LEGUMINOSAE
17		*Albizia adianthifolia*		LEGUMINOSAE
18		*Ficus exasperata*	Sand paper tree	MORACEAE
19	FOREST EDGES/ OPEN CANOPY AREAS	*Musanga cecropioides*	Umbrella tree	EUPHORBIACEAE
20		*Funtumia elastica*	Lagos rubber	APOCYNACEAE
21	POND/WETTER AREAS	*Pterocarpus santalinoides*		PAPILIONOIDEAE
22		*Raphia hookerii*	Wine Palm	ARECACEAE/PALMAE
23		*Anthocleista djalonensis*		GENTIANACEAE
24		*Anthocleista nobilis*	Cabbage tree	GENTIANACEAE
25	EPIPHYTE	*Ficus ovate*		MORACEAE
26	Tree fem	*Oleandra distenta*		OLEANDRACEAE
27	Tree fern	*Phymatodes scolopendria*		POLYPODIACEAE

S/N	ECOSYSTEM	SPECIES NAME	COMMON NAME	FAMILY
	TREES			
28	Tree fern	*Platycerium stemaria*		POLYPODIACEAE
29	Tree fern	*Asplenium africanum*		ASPLENIACEAE
30	Fern	*Diplazium sammatii*		ATHYRIACEAE
31	Fern	*Nephrolepis biserrata*		NEPHROLEPIDACEAE
32	Fern	*Dryopteris spp*		DRYOPTERIDACEAE
33	SHRUB	*Alchornea laxiflora*		EUPHORBIACEAE
34		*Tabernaemontana pachysiphon*		APOCYNACEAE
35		*Coffea canephora*	Wild coffea	RUBIACEAE
36	HERBS	*Costus afer*		COSTACEAE
37		*Starchytapheta indica*		VERBENACEAE
38		*Aframomum spp*		ZINGIBERACEAE
39		*Thalia welwitschii*		MARANTHACEAE
40		*Centrosema pubescens*		FABOIDEAE
41		*Heterotis rotundifolia*		MELASTOMATACEAE
42		*Aspilia africana*	Bush marigold	ASTERACEAE
43		*Chromolaena odorata*		ASTERACEAE
44		*Fluerya aestuans*		URTICACEAE
45		*Ludwigia abyssinica*		ONAGRACEAE
46		*Ludwigia decurrens*		ONAGRACEAE
47		*Vernonia cinerea*		ASTERACEAE
48		*Pepperomia pellucida*		PIPERACEAE
49	GRASSES	*Paspalum vaginatum*		POACEAE
50		*Panicum maximum*		POACEAE
51	SEDGE	*Scleria pterota*		CYPERACEAE
52	CLIMBERS	*Paullinia pinnata*		SAPINDACEAE
53		*Cissus aralioides*		AMPELIDACEAE
54		*Merremia aegyptia*		CONVOLVULACEAE
55		*Tetracera alnifolia*		DILLENIACEAE

S/N	ECOSYSTEM	SPECIES NAME	COMMON NAME	FAMILY
	TREES			
56		*Ipomoea involucrata*		CONVOLVULACEAE
57		*Calamus deeratus*	Rattan palm	PALMAE
58	ORCHIDS	*Bulbophyllum inflatum*		ORCHIDACEAE
59		*Bulbophyllum imbricatum*		ORCHIDACEAE
60		*Calyptrochilum christyanum*		ORCHIDACEAE
	AQUATIC MACROPHYTE			
61	Floating A/M	*Lemna paucicostata*		LEMNACEAE
62		*Wolffia arrhiza*		LEMNACEAE

Source: Field survey, 2013 and 2016

The vegetation is fairly stratified into two layers: the canopy layer and the emergent layer. The Canopy layer was observed to be thick and accounting for 70 – 90% of the total ground cover. Tree density reaches 549 (– 650) – 723 trees per hectare. Mature areas were observed around VG 2, 3, 9, 10, 11, and 14. Less dense areas were found at VG 4, 17, and 18 with tree density ranging between 460 and 544 trees / ha. Average height of canopy trees in the study area is 28 meters. The Emergent layer comprises fairly distributed very tall trees emerging above the canopy for up to 15 meters. This is quite low when compared to the height of the Emergent layer in lowland tropical rain forests which ranges between 45-(55)-80 meters in height.

Tree diameter at breast height (dbh) is mostly between 0.7 meters and 2 meters for most emergents in the vegetation of the study area. A few species like *Pycnanthus angolensis* have dbh below 0.7 meters. Dominant emergent species in this habitat include timber hard woods: Ekki (*Lophira alata*) 8 trees/ha, *Irvingia gabonensis* (3 trees/ha), *Staudtia stipitata, Spondianthus preussii, Brachystegia eurycoma,* and *Antrocaryon micraster*; and soft woods like *Ceiba pentandra* (reaching 45 m in height) 5 trees/ha, and *Alstonia boonei* (2 trees/ha). Canopy trees include *Elaeis guineensis* (63 trees/ha), *Pycnanthus angolensis, Spondianthus preussii, Alstonia boonei, Cleistofolis patens, Fleroya ledermanii* (27 trees/ha; sometimes slightly gregarious), *Ctenolophon englerianus, Cyclodiscus gabunensis, Tricoscypha arborea, and Albizia adianthifolia* (in disturbed areas).

The forest floor is mostly shaded and water logged consisting of few ferns, and herbaceous species including *Selaginella sp, Dryopteris sp, Diplazium sammatii, .Paspalum vaginatum, Thalia welwitschii, and Heterotis rotundifolia. Common Epiphytic ferns and Orchids identified from the study area include Oleandra distenta, Phymatodes scolopendria, Platycerium stemaria, Asplenium africanum, Nephrolepis biserrata, Bulbophyllum inflatum, Bulbophyllum imbricatum, and Calyptrochilum christyanum.*

Areas around VG 18 and VG C03 have been depleted by logging and farming activities into more or less open canopy forest regrowths, farmlands, and bush fallows (Plate 4.2c). Average height of vegetation is 3.5 meters with canopy species reaching 12 meters and having very low canopy tree density. Saplings of Oil palm dominate while *Spondianthus preusii, Fleroya ledermanni, Musanga cecropioides, Anthocleista nobilis, Pycnanthus angolensis*, and *Ricinodendron heudelotii* are common tree species. The relics of the original vegetation here include *Ceiba pentandra* and *Lophira alata* reaching heights of over 40 meters, doting the landscape. Common shrubs and herbs of this fallow and road side vegetation include *Alchornea laxiflora, Paspalum vaginatum, Costus afer, Panicum maximum, Anthocleista nobilis, Tabernaemontana pachysiphon, Chromolaena odorata* and several common weeds of agricultural farmlands.

Raffia Swamp

Based on species association and dominance patterns the Raphia swamp is a sub ecological unit within the swamp forest habitat with near homogenous species composition. The Raffia swamp is an area of swamp forest dominated by the *Raphia sp*. Within the study area, the raffia swamp is that of *Raphia hookeri*. This vegetation type was found at VG C1, 14, and 15. The vegetation height reaches 13 meters. Tree density is about 370 trees per ha. A thicket of *Alchornea laxiflora* occurs on the margin to a height of 1.8 meters. Few saplings of the following species were sighted within this vegetation and on the margins: *Fleroya ledermannii, Ficus vogeliana, Ficus exasperata, Pycnanthus angolensis, Anthocleista djalonensis, Anthocleista nobilis,* and *Tabanaemontana pachysiphon*. The water loving shade fern *Dryopteris* sp is a dominant aquatic macrophyte occurring in open canopy and riparian parts of the study area. Patches of the Raffia swamp forest are common and indicate perennial water logged soils.

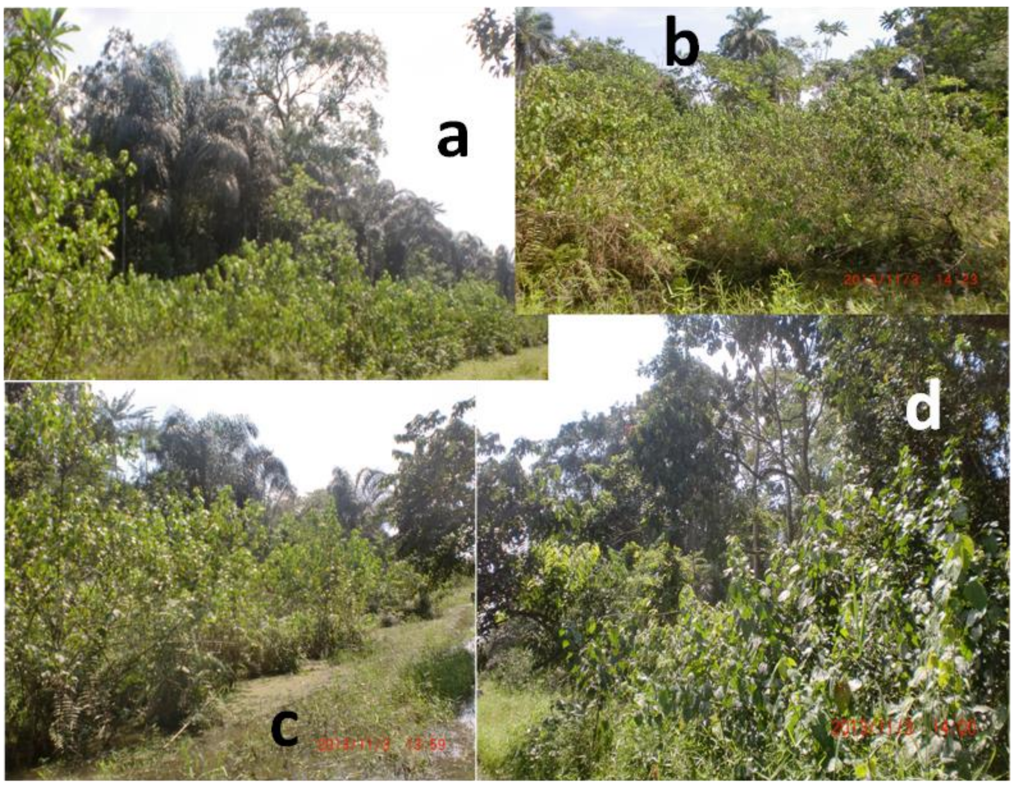


Plate 4.2c: Raphia swamp and road side vegetation

a. Raphia swamp; b. Open canopy area; c, d. road side vegetation.

Source: Field Survey 2013 and 2016

Road side vegetation in the Raffia swamp area occurs as an alteration of the original vegetation composition and ecosystem. This community is about 15 m wide and cuts into the sampling circumference at 2 O'clock, from the direction of VG 18 and 19 down to the proposed well location. This road is the old access road constructed by SPDC, now over grown by hydrophytes. Shrubby tangles occur along the margins of this more or less perennially flooded path with a species codominace of *Alchornea laxiflora* and *Dryopteris sp* in a two layered vertical profile. Its upper layer reaches 2.2 meters in height while the lower stratum is just about 1 meter. Water loving *Anthocleista nobilis* dots the vegetation up to a density of 350 trees per ha. Dense mat of *Paspalum vaginatum* dominates the footpath on the road side.

Agricultural Farm Lands

Farm settlements/camps are a common sight in the VG C3, 18 areas. It was observed that the locals encroach on drier areas of the vegetation, especially along the forest tracks and margins to establish very luxuriant agricultural plantations (Plate 4.2d). The arability of the land is explained by the fact that the significant level of productivity and high humidity in this ecosystem, promotes wet and well drained soils with high humus content from slowly decomposing leaf litters. Plantation agriculture involves many small commercial holdings for cultivation of *Musa paradisiaca* (plantain) which thrives well there. The farms are typically less than half an acre with tree density of 970 trees per hectare. Other agricultural activities include palm fruit harvesting (from the wild) and palm oil milling. On most of the farm settlements, a traditional oil mill is installed in the plantation for processing palm fruits which are temporarily stored in the mud house on the farm.

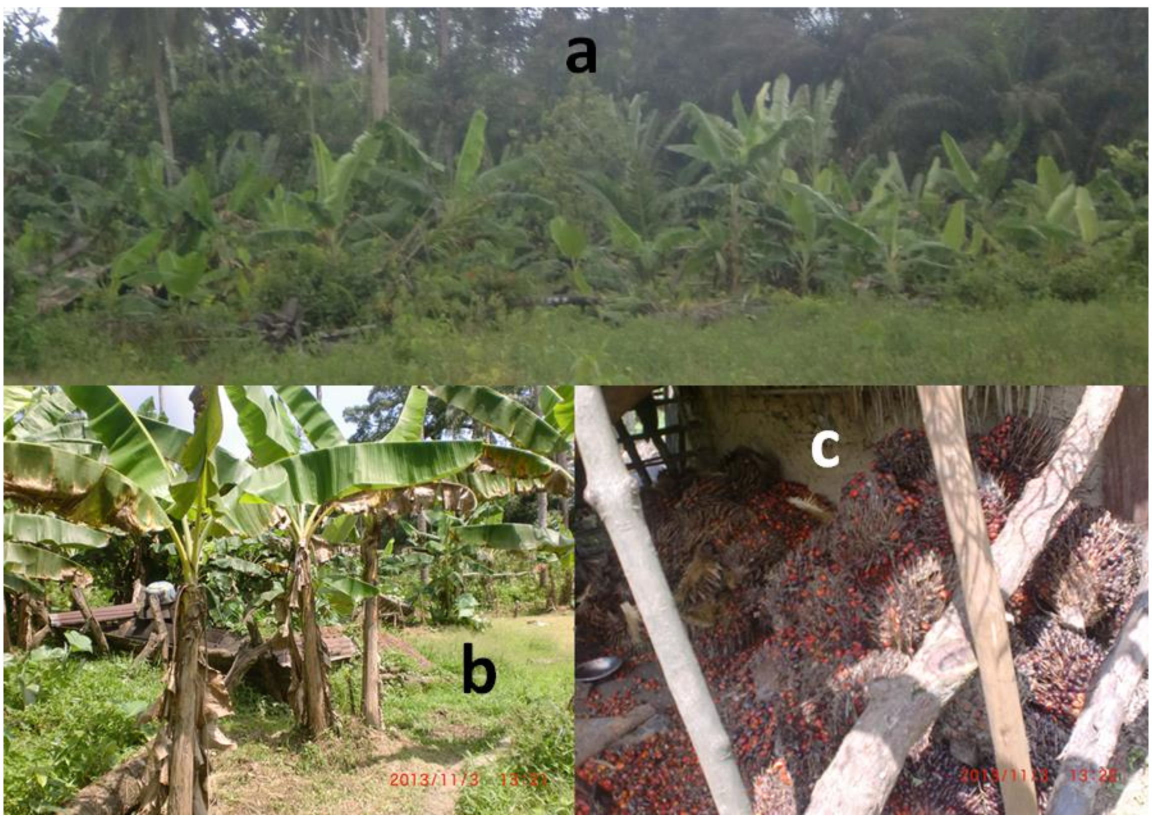


Plate 4.2d: A typical farm settlement/camp within the study area

a. traditional oil mill on the plantain farm; b. Palm fruit storage/rest house.

Sacred Grove/Forest

A portion of the forest in the study area is protected and designated as a religious and culturally sensitive area at VG 1. It is called a sacred forest and is regarded as the centre of Iseni (Ofoni). It hosts a shrine which is believed to be inhabited by a deity who oversees the land and its people. The forest consists of a grove of protected vegetation occupying about an acre of land. The vegetation is observed to be typically open canopy forest whose canopy is dominated by oil palms growing gregariously as well as rubber trees in some areas (Plate 4.2e). A *Klainedoxa gabonensis* tree locally called *Okhwran* is at its center.

Plate 4.2e: Sacred forest grove at Iseni

Ethnobotanical Uses of Plants

Lumbering occurs in this area. The swampy portions of the earth road that penetrates the vegetation area to a point, is reinforced with barks (from palm trees) to facilitate passage of timber trucks. However, this activity is said to occur mostly during the dry season when flooding is reduced. Other uses of timber resources are in boat making, and domestic fuel wood. Common non-timber forest products here include oil palm expressed to produce palm oil. Table 4.7d shows the list of timber and non-timber forest products that are provided by the habitat. The fresh water swamp terrain of the Niger Delta is a sensitive area as the heavy rains and floods tend to remove the loose soil sediments if there were no vegetation to help hold them together. Sheet erosion is thus put in check as well as loss of land to the major water bodies in the area. Vegetation here also helps sustain the wildlife as monkeys and other arboreal animals easily find a home up in the forest canopy away from the flooded floor, while reptiles take refuge on the mesh of stilt roots. Because of the prevailing watery medium, it will be very easy for chemical pollutants to spread on the surface over large areas, as well as enter the biological food chain and biogeochemical cycle. It is thus very important to maintain the ecological balance and prevent a cascade of events that will result in both loss of flora and fauna, apart from loss of land area and livelihoods for the indigenes of this area.

Table 4.7d: Ethno-botany of the major plant species in the study area

SPECIES NAME	ECONOMIC / ETHNOBOTANICAL USES
Elaeis guineensis	Fruits: staple soup base, Palm Oil, Palm kernel oil (soap, vegetable oil), Palm kernel cake; sap juice: wine; basket, thatch, broom making etc. Locally extracted Kernel oil used as pomade especially for new born, and ointment generally. treating cough etc.
Spondianthus preussii	Commercial hard and heavy wood. Bark: poison for rodents, fishing and hunting even elephants (in other parts of Africa).
Fleroya ledermannii	Furniture, pulp and paper making.
Tricoscypha arborea	Fuel wood, and poles.
Ceiba pentandra	Soft wood: Carvings, light construction, ply wood, veneer, particle boards, hand dug canoe ; Kapok; bee tree; Medicinal: in preparations for leprosy, Dysmenorrhoea, hypertension, fever, wound healing, hypertension, etc.
Dracaena mannii	Source of Dyes and stains
Alstoni aboonei	(Stool wood) Soft Light wood. Carvings, light construction: canoe; medicinal: Asthma, rheumatic pains, Snake poison. Cure veneral diseases. Antimalarial, aphrodisiac, Antidiabetic, antimicrobial and antipyretic properties.
Cyclodiscus gabonensis	Leaf: concoction for treating inflammation of the vagina and uterus.
Pycnanthus angolensis	Medicinal: Skin infections; seed: spice/additive; Leaves and stem: Diabetes 1 & 2. Bark decoction: treat wound, arthritis, leprosy, stomach ulcer, and antidote for poisoning.
Staudtia stipitata	Timber: Durable termite resistant; flooring, cabinet, decorative veneers
Lophira alata	Commercial Hard wood: One of the hardest and most resistant wood species
Musanga cecropioides	Medicinal: leprosy
Anthocleista djalonensis	Cabbage tree: abortifacient, skin infections, antipyretic, antidotes
Ficusexasperata	Abortifacient, diuretic, Anticonvulsant. Leaves: Palm oil processing. Wound healing.
Funtumia elastica	Bark powder: medicinal, Powerful antioxidants; asthma, pulmonary diseases
Raphia hookerii	Sap juice drink; frond: thatch
Paullinia pinnata	Medicinal roots and leaves: anti oxidant, Vasorelaxant

Plate 4.2e: Patterns of forest resource utilisation/exploitation in Iseni. A: Palm Oil Mill; B: Planks from the forest; C: Lumbering for fuel wood and land conversion; D: Twigs harvested for fuel wood.

Phytopathology

The state of health of the overall vegetation appeared quite normal from the perspective of the reference points; a disease epidemic was not encountered in the vegetation.

Plant Tissue Analysis

The data obtained provide base line information on the possible impact (direct or indirect) of oil and gas activities on the physiological and phytochemical balance required for plant survival in any vegetation system. Chemical elements screened for comprise heavy metals and phytonutrients, so as to ascertain the state of health and level of contamination (if any) in plants of the study area.

The elements are divided into the essential and non essential heavy metals. Five non-essential and potentially toxic heavy metals (Aluminium, Arsenic, Barium, Mercury, and Vanadium) screened for, were not present above detectable (0.001 mg/kg) concentrations. Lead, Chromium, and Cadmium, were however present in all the samples (Table 4.7e). All the trace heavy metals were present with the exception of Cobalt, which did not occur in detectable concentrations (0.001 mg/kg). Cadmium levels were normal and fell in the range of 0.01 mg/kg to 1.22 mg/kg while the mean concentration was 0.72 mg/kg. Chromium levels in the samples were at normal levels for plant tissue (Fifield and Haines, 2000). Concentrations of Pb were in normal trace levels (Alloway, 1995). The sequence of concentration of the eight heavy metals found in leaves sampled is Fe > Mn> Ni > Cr > Cd > Cu > Zn >Pb.

Table 4.7e: Summary of the heavy metal concentrations in plant tissue sampled from the study area, and normal concentration standards (mg/kg).

ELEMENTS	MIN	MAX	AVERAGE	STANDARDS
Aluminium	<0.001	<0.001	<0.001	
Arsenic	<0.001	<0.001	<0.001	
Barium	<0.001	<0.001	<0.001	
Cadmium	0.004	1.22	0.72	< 5.30*
Chromium	1.32	12.85	6.45	0.01 – 14***
Cobalt	<0.001	<0.001	<0.001	
Copper	1.90	10.58	4.90	5 – 12***
Iron	93.30	1124	370.48	< 300 **
Lead	0.05	1.37	0.59	< 30 *
Manganese	19.49	112.40	52.73	20 – 240**
Nickel	1.19	27.06	11.74	< 10 ***
Vanadium	<0.001	<0.001	<0.001	
Zinc	0.86	5.82	2.46	12 – 60 ***
Mercury	<0.001	<0.001	<0.001	

*Alloway, 1995; ** Dobermann and Fairhurst, 2000; ***Fifield and Haines, 2000

The trace heavy metals measured include Iron whose concentration in the leaves ranged from 93.3 mg/kg to 1124 mg/kg; mean Iron concentration was 370.48 mg/kg. Leaves sampled from VG 1, 3, 5, and 12 showed elevated levels of Iron (300 – 500mg/kg) (Dobermann and Fairhurst, 2000). The mean concentration of Zinc, 2.46 mg/kg, indicates zinc deficiency in the plants sampled (Alloway, 1995). Copper levels ranged between 1.9 mg/kg and 10.58 mg/kg. Most of these samples (nine) have concentrations below the lower limit while five samples from VG 1, 6, 14, C1, and C3 had Copper levels within the normal range (Fifield and Haines, 2000). Nickel levels in samples from VG C2 and C3 were within the lower threshold of toxicity in plant (Fifield and Haines, 2000). Manganese was present in the leaves sampled at an average concentration of 52.73 mg/kg. Concentrations ranged from 19.49 – 112.40 mg/ kg which are within normal levels for plants (Dobermann and Fairhurst, 2000).

4.7.8: Wildlife Studies

Wild life study of the proposed project area is considered in this section.

Species Inventory

Field observations during this study showed the presence of three major categories of wildlife: mammals, reptiles, and birds. A total of thirty two (32) species of wild life have been identified. It was observed that the wildlife of the Iseni field is dominated by mammals which have a total of twenty (22) species belonging to 14 different animal families. The members of the Family Viverridae especially the crested genet, along with walter's duikers, squirrels, mona monkeys, white bellied pangolin, and marsh mongoose are very common in the study area. A sizeable stock of the putty nosed monkey is present in the study area while the white throated monkey alluded to at the Ogara axis is not known to the area. Pattern of exploitation is dominated by hunting with guns and traps (Plate 4.3a).

Plate 4.3a: Major forms of wildlife exploitation in the study area

Source: Field Survey 2013 and 2016

Table 4.8a: Checklist of wildlife species in the study area

S/N	MAMMALS		STATUS		
	ORDER PRIMATES		Local	IUCN	Dcr 11
	Family Cercopithecidae (monkeys)				
1	Mona Monkey	*Cercopithecus mona*	Abundant	LC EWA	2
2	Red eared Guenon	*Cercopithecus erythrotis camerunensis*		VU	
3	White-nosed monkey	*Cercopithecus nictitans*	Threatened	LC	
4	Niger Delta Red Colobus monkey	*Procolobus epieni*		CR	
	Family Lorisidae				
5	Bosmann’s Potto	*Perodicticus potto*	Common		
	ORDER PHOLIDOTA				
	Family Manidae (scaly anteaters)				
6	Tree/White Bellied Pangolin	*Manis tricuspis*	Abundant	NT	
7	Long tailed/Black-bellied pangolin	*Manis tetradactyla*	Common	LC	1
	ORDER CARNIVORA				
	Family Viverridae				
8	African Civet	*Civettictis civetta*	Very Common	LC	2
9	Crested genet	*Genetta cristata*	Abundant	VU	
	Family Herpestidae				
10	Marsh Mongoose	*Atilax palidunosus*	Common	LC dcrn	2
	ORDER SIRENIA				
	Family Trichechidae				
11	West African Manatee	*Trichechus senegalensis*	Common	VU	
	ORDER ARTIODACTYLA				
	Family Suidae				
12	Red River Hog (Bush Pigs)	*Potamochoerus porcus*	Abundant	LC	-
	Family Bovidae Subfamily Bovinae				
13	Marsh Buck	*Tragelaphus spekii*	Abundant	LC	1
14	BushBuck / Sitatunga	*Tragelaphus scriptus*			
	Family Bovidae – Subfamily Cephalophinae				

S/N	MAMMALS		STATUS		
15	Walter's Duiker	*Philantomba walteri*	Abundant		
16	Water Chevrotain	*Hyemoschus aquaticus*	Common		
	ORDER RODENTIA				
	Family Thryonomidae				
17	Greater Cane rat / Grass cutter	*Thryonomys swinderianus*			
	Family Cricetidae (Pouched Rats)				
18	Emin's Giant Rat	*Cricetomys emini*			
	Family Sciuridae				
19	African (Green) Bush Squirrel	*Paraxerus poensis*	Endangered		
	Family Anomaluridae – (scaley-tailed flying squirrels)				
20	Flying Squirrel	*Anomalurus spp*			
	Family Hystricidae				
21	Bush tailed porcupine	*Atherurus africanus*			

Source: Field survey, 2013 and 2016

Table 4.8b: Checklist of Reptile species in the study area

S/N	REPTILIA		STATUS		
	ORDER SQUAMATA		Local	IUCN	Dcr 11
	Family Boidae				
1	African Rock Python	*Python sebae*			
	Family Elapidae				
2	Black Cobra	*Naja melanoleuca*			
	Family Varanidae				
3	Nile Monitor Lizard	*Varanus niloticus varniloticus*			
4	Ornate/ forest monitor Lizard	*Varanus niloticus var ornatus*			
	ORDER TESTUDINES				
	Family Pelomedusidae				
5	West Afr. Mud Turtle	*Pelusios castaneus*			

S/N	REPTILIA		STATUS		
6	Yellow tortoise Land based	*****			
	ORDER CROCODYLIA				
	Family Crocodilidae				
7	Dwarf crocodile	*Osteolaemus tetraspis*		VU	

Source: Field survey, 2013 and 2016

Table 4.8c: Checklist of Aves species in the study area

S/N	AVES		STATUS		
	ORDER PSITTACIFORMES		Local	IUCN	Dcr 11
	Family Psittacidae				
1	Congo African Grey Parrot	*Psittacus erithacus*			
	ORDER CUCULIFORMES				
	Family Cuculidae				
2	Senegal Coucal	*Centropus senegalensis*			
	ORDER FALCONIFORMES				
	Family Accipitridae				
3	Yellow Billed Kite	*Milvus aegyptius* parasites	Common		
	ORDER PASSERIFORMES				
	Family Pycnonotidae				
4	Common Bulbul	*Pycnonotus barbatus*			
	ORDER CORACIIFORMES				
	Family Bucerotidae				
5	African Pied Hornbill	*Tockus fasciatus*	Common		

Source: Field survey, 2013 and 2016

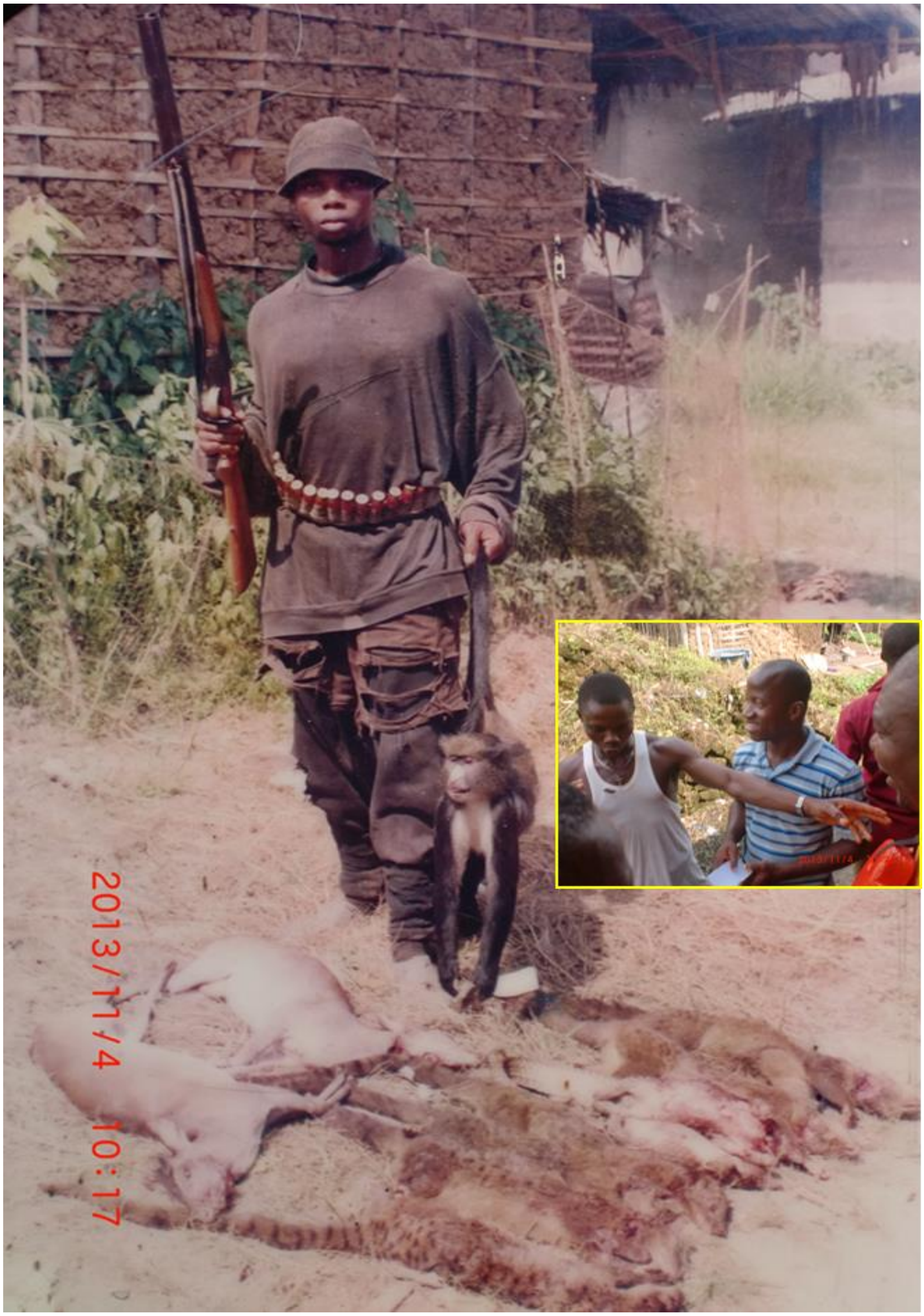


Plate 4.3b: Mr.Godbless Onayoma (a skilled local hunter) in his typical hunting regalia proudly displaying his game from a single night's expedition
Source: Field Survey 2013

Inset: Interview of Mr. Godbless as he describes the wildlife of the study area; and how he killed two Walter's duikers "with one bullet".

Plate 4.3c: Birds sighted during the study
Source: Field Survey 2016

Identification Concerns

A very clear description of several species was provided by an experienced hunter interviewed. However, generic statements and vague references were made to some species of mammals and birds. For instance, he was able to give very impressive descriptions of the monkey species in the study area one of them was described as black with “white nose”.He claimed that there are four types of squirrel around but could only differentiate them based on size and some local names. He also gave a generic name ‘Civet cat’ for the closely related crested genet and the actual civet cat; although he called them different native names. He confirmed that there were no buffalos in the area and dispelled claims of lions and tigers. He described an amphibian that is most likely to be Manatee which some persons present claimed was hippo (Pygmy). Crocodiles (totem) were reported to be present in a boundary lake just outside the study area. He also claimed to have killed Chimpanzees from that area (Ayemaibeni – southern Ijaw) too: although he made some facial descriptions and comparison with humans in distinguishing a Chimpanzee from a gorilla claiming that a Chimpanzee had a short tail.

4.7.9: Sediment Quality

The physico-chemical, heavy metals content and microbiological characteristics of the sediment samples collected from the proposed well and existing wells area, (2013) and the proposed Ramp/Jetty area (2016) are presented in Table 4.9a.

Physico-Chemical Characteristics

Textural Characteristics

The particle size of the sediment samples showed clay (66.80 - 77.60%) > silt (15.20 - 21.10%) > sand (7.20 - 12.60%). The observed high clay and silt contents of the sediment samples reflects a muddy terrain common to some parts of the Niger Delta region. Textural characteristics were not determined in previous studies conducted within the proposed project influence zone for comparison. Clay and organic matter content of sediment as earlier mentioned for soil, have direct influence on other physical and chemical characteristics, including reserve of exchange bases and the interaction, dynamics of trace metals and organic pollutants in sediment. Hence, maximum soil/sediment capacity for heavy metals and organic pollutants are adjusted according to these soil/sediment macro-characteristics (Lacatusu, 2000; DPR, 2002). The permeability, porosity and bulk density of the sediment samples ranged from 0.05 - 0.13 cm/s, 44 – 59% and 0.98 - 1.20 gcm-3 respectively. The significance of these parameters to sediment quality is as discussed for soil.

pH

The pH values of the sediment samples were in the acidic range with mean values for the proposed Iseni appraisal well (5.12±0.24) existing Iseni wells (4.88±0.04) and Jetty/Ramp area (5.52±0.16).The mean pH of the control stations for the proposed Iseni appraisal well, existing Iseni wells was 5.42±2.77 and the Jetty/Ramp was 5.85±3.38. The low pH condition of the sediment is common with the freshwater terrain of the Niger Delta area and may affect metal speciation and enhance metals' solubility and possible leaching into the water column. There was no significant difference between the pH of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). High sediment acidity has been attributed to combination of possible oxidation of pyrite (FeS_2) in the sediment to produce sulphuric acid, depleted calcium level or increased aluminium concentration in sediment (Odu, 1996; Aiyesanmi, 2006). Sediment pH values recorded in the current study are consistent with what was earlier reported for the field (Iseni Appraisal Well project, SPDC EIA, 2012), but lower than the value (6.70) reported for Odon/Ogara/Okpokunou, SPDC EIA (2010).

Redox Potential

There was no significant variation between the redox potential of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean redox potentials of the sediment samples for the proposed Iseni appraisal well (123.5±12.02mV) existing Iseni wells (122.5±4.95mV) and Jetty/Ramp (95±7.55mV). The ORP value indicated high oxidative condition of the sediment, possibly responsible in part to the observed low pH values recorded. It also shows the capacity of the sediment to accommodate aerobic degradation of organic waste.

Conductivity

There was no significant variation between the electrical conductivity (EC) of the proposed Iseni well and existing wells area with that of the control. Electrical conductivity was not measured in Jetty/Ramp area.The mean EC of the sediment for the proposed Iseni appraisal well was 44.28±15.54 µS/cm for the existing Iseni wells was 52.41±12.74 µS/cm and the control stations was 40.34±27.44 µS/cm. The electrical conductivity of the sediment solution ranged between showed low dissolved ions in the sediment solution. Higher conductivity values of 139.25 µS/cm and 353.38 µS/cm were reported for the Iseni Odon/Ogara/Okpokunou fields respectively in previous studies. The low dissolved ions in the sediment solution will reduce contribution of dissolved ions concentration into the water column through sediment re-suspension. However, some of the ions may be beneficial or otherwise to benthic organisms

Total Organic Carbon

There was no significant variation between the total organic carbon (TOC) of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean TOC of the sediment for the proposed Iseni appraisal well (0.425±0.06%), existing Iseni wells (0.47±0.17%) and Jetty/Ramp (0.99±0.77%) was low. The mean TOC of the control stations in proposed Iseni appraisal and the existing Iseni wells was 0.31±0.16 and in the Jetty/Ramp area was 1.1±0.65.Total organic carbon contents of the sediment samples were considered low in spite of the high silt content. The bulk of organic carbon in sediment samples composed of humic substances and degraded plant and animal materials. Many important sediment properties as earlier mentioned for soil also depend to some degree on the quality of organic carbon present (Margesin and Schinner, 2005), hence pollutants concentrations in sediment are normalised with the organic carbon content in conjunction with clay content (DPR, 2002).

Nutrients

There was no significant variation between the nitrate concentration of the proposed Iseni well and existing wells (2013) and the Jetty/Ramp area (2016). The mean nitrate concentration of the sediment for the proposed Iseni appraisal well(1.145±0.25mg/kg), existing Iseni wells (0.06±0.01mg/kg) and Jetty/Ramp (1.08±0.21mg/kg). The mean nitrate concentration of the control stations in proposed Iseni appraisal and existing wells was 0.05±0.03mg/kg while the control station values for the Ramp/Jetty area was 1.12±0.68mg/kg.Nitrogen and phosphorus serve as nutrient to benthic floral and some bacteria in sediment. Higher concentration can lead to emission into water column especially under condition of low pH, thus leading to nutrient enrichment. Most soluble forms of nitrogen in sediment are the nitrate, nitrite and ammonium ions. Their mean concentrations in the sediment samples ranged from 0.065±0.02mg/kg and 0.06±0.01mg/kg nitrite in proposed well and existing well areas and 0.66±0.10mg/kg and

1.09±0.29mg/kg ammonium ions in proposed well and existing well areas respectively. Ammonium and nitrite concentrations were not reported in the Ramp/Jetty area.

Exchangeable Cations

Exchangeable cations (Na, K, Ca, and Mg) were higher in the Ramp/Jetty area than the proposed and existing wells area. The observed cations values reflect a freshwater environment. The exchangeable acidity and cation exchange capacity of the sediment samples ranged from 1.32 - 2.57 cmol/kg and 3.47 - 6.46 cmol/kg respectively. Cation exchange capacity show the potential of sediment to exchange the exchangeable cations with other metals, especially heavy metals, thus reducing their bioavailability and toxicity potential.

Oil and Grease, and Hydrocarbons

The oil and grease concentration, THC and TPH contents of the sediment samples were very low. The mean THC of the sediment was greater in the proposed Iseni appraisal well(0.36±0.25mg/kg) and the existing Iseni wells area (0.23±0.06mg/kg) than the Jetty/Ramp area (<0.001mg/kg). The mean oil and grease was greater in the proposed Iseni appraisal well(0.48±0.29/kg) and the existing Iseni wells area (0.32±0.10 mg/kg) than the Jetty/Ramp area (<0.001mg/kg).The values for the control stations were 0.29±0.15 mg/kg and <0.001mg/kg for the proposed well/existing wells area and Jetty/Ramp area respectively. The mean TPH in the proposed Iseni appraisal well (0.105±0.04mg/kg) and the existing Iseni wells area (0.07±0.01mg/kg) than the Jetty/Ramp area (<0.001mg/kg). The observed very low concentrations of TPH compared to THC shows that their sources are predominantly biogenic, with little or no anthropogenic input. While PAHs recorded very low concentration from <0.01 – 0.02 mg/kg and BTEX concentrations were below instrument detection limits (<0.001 mg/kg) in all the sampled areas. Results from previous studies in the zone, however, showed higher THC concentrations of 6.11 mg/kg (Iseni Appraisal Well project, SPDC EIA, 2012) and 64.54 mg/kg (Odon/Ogara/Okpokunou, SPDC EIA, 2010). Hence, the lower values obtained in this study is an indication that the sediment can self purify by natural attenuation. The THC values obtained was lower than 50 mg/kg DPR Target value.

Heavy Metals

Some heavy metals were higher in the Ramp/Jetty area (Fe, Zn, Cu and Cd) than the proposed wells and existing wells area. Other metals (Hg, V, Co and As) did not show any significant variation between the proposed well and existing wells area and the Ramp/Jetty area. The occurence and levels of Fe as it were, is more of lithological or crustal origin as high iron level has been reported for most Nigerian sediment (Odu, 1996). Generally, the presence of metals in river sediments originates from several sources and they are present in different forms. Most of the metals in their stable state are derived from natural weathering, erosion and anthropogenic activities. The order of concentrations of the heavy metals with measurable concentrations in the sediment samples were: Fe >> Zn >> Pb > Cr > Mn > Ni > Cd > Cu. The concentrations of these metals from the control stations were also within the ranges obtained in the proposed project area.

Table 4.9a: Summary of sediment physicochemistry in the Study Area. Means highlighted are significantly different

Parameters	SPDC, 2013a (Dry season)			SPDC, 2016b (Wet season)		P value	Sig.
	Proposed Iseni Appraisal Well (x±SD)	Existing Iseni Wells (x±SD)	Control (x±SD)	Around the Jetty/Ramp (x±SD)	Control (x±SD)		
pH	5.12±0.24	4.88±0.04	5.42±2.77	5.52±0.16	5.85±3.38	0.980	Non sig.
EC (µS/cm)	44.28±15.54	52.41±12.74	40.34±27.44				
THC (mg/kg)	0.36±0.25	0.23±0.06	0.13±0.074	<0.001			
TOC (%)	0.425±0.06	0.47±0.17	0.31±0.16	0.99±0.77	1.1±0.65	0.104	Non sig.
NH4(mg/kg)	0.66±0.10	1.09±0.29	0.65±0.39				
NO2(mg/kg)	0.065±0.02	0.06±0.01	0.05±0.03				
NO3(mg/kg)	1.145±0.25	1.5±0.37	1.38±0.71	1.08±0.21	1.12±0.68	1.000	Non sig.
AV.P(mg/kg)	0.88±0.08	0.86±0.13	0.73±0.38				
O&G(mg/kg)	0.48±0.29	0.32±0.10	0.29±0.15	<0.001	<0.001		
Na(mg/kg)	0.245±0.05	0.29±0.04	0.4±0.20	69.14±41.63	84.77±49.24	0.000	Sig.
K(mg/kg)	0.45±0.03	0.405±0.05	0.61±0.31	8.77±3.07	15.66±9.36	0.000	Sig.
Ca(mg/kg)	0.825±0.13	1.08±0.13	1.23±0.65	19.591±1.84	30.81±17.86	0.000	Sig.
Phenol(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Mg(mg/kg)	0.95±0.52	2.10±0.22	1.14±0.76	52.64±13.25	68.77±40.56	0.000	Sig.
EA	2.43±0.20	1.96±0.45	1.42±0.75				
ECEC(mg/kg)	4.9±0.17	5.81±0.92	4.81±2.47				
TPH(mg/kg)	0.105±0.04	0.07±0.01	0.05±0.03	<0.001	<0.001		
PAH(mg/kg)	0.015±0.01	0.01±0	<0.01	<0.001	<0.001		
R.P, (mV)	123.5±12.02	122.5±4.95	108.33±55.76	95±7.55	89.5±51.87	0.084	Non sig.
Clay (%)	73.5±5.80	70.7±1.70	69.73±35.07	52.73±42.78	76.15±44.18	0.207	Non sig.
Silt(%)	16.7±2.12	20.45±0.92	19.37±10.02	12.33±10.07	17.35±10.07	0.582	Non sig.
Sand(%)	9.8±3.68	8.85±0.78	10.9±5.58	34.93±52.72	6.5±5.00	0.000	Sig.
Permaebility(cm/s)	0.09±0.06	0.09±0.03	0.10±0.05				
Porosity (%)	51.5±10.61	52±4.24	53±26.66				
Bulk density (g/cm3)	1.09±0.16	1.14±0.06	1.16±0.58				
Total .N (%)	0.21±0.05	0.23±0.06	0.22±0.11				
Al(mg/kg)	<0.01	<0.01	<0.01				
Fe(mg/kg)	129.75±4.60	120.2±11.74	86±43.47	1632.52±173.06	1188.66±706.25	0.000	Sig.
Cr(mg/kg)	1.23±0.17	1.72±0.76	0.76±0.40	6.39±5.53	6.33±3.72	0.137	Non sig.
Cd(mg/kg)	0.15±0.10	0.52±0.14	0.06±0.03	5.53±1.45	9.10±5.45	0.000	Sig.
Ni(mg/kg)	0.9475±0.22	1.261±0.05	0.91±0.45	3.88±1.70	3.59±2.12	0.308	Non sig.
Pb(mg/kg)	2.06±0.11	1.94±0.24	1.46±0.74	<0.001	<0.001		
Zn(mg/kg)	32.03±6.03	32.53±7.18	6.51±3.39	59.27±40.5	76.71±44.91	0.000	Sig.

Parameters	SPDC, 2013a (Dry season)			SPDC, 2016b (Wet season)		P value	Sig.
	Proposed Iseni Appraisal Well (x±SD)	Existing Iseni Wells (x±SD)	Control (x±SD)	Around the Jetty/Ramp (x±SD)	Control (x±SD)		
Hg(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
V(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Co(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
As(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Cu(mg/kg)	0.14±0.06	0.18±0.02	0.06±0.03	10.02±1.64	9.10±5.45	0.000	Sig.
Ba(mg/kg)	<0.01	<0.01	<0.01	0.002±0.001	<0.001		
Mn(mg/kg)	1.27±0.41	1.04±0.34	0.59±0.31				
Benzene(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Toulene(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Ethyl Benzene(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		
Xylene(mg/kg)	<0.01	<0.01	<0.01	<0.001	<0.001		

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

P>0.05 = Not significant; P<0.05 = Significant;

Sediment Microbiology

There was no significant spatial differences between the microbial counts (THB, TF, HUB and HUF) of the proposed Iseni well area and existing wells area and Ramp/Jetty area (Table 4.9b).Control values in both areas (wells and Ramp/Jetty) showed no significant differences in values with sample stations.The mean percentage HUB for the proposed well area, existing wells area and Ramp and Jetty were 0.008%, 0.004% and 0.00005% respectively. The control values for well area and Ramp/Jetty area were 0.003% and 0.00005%. The results indicated that the percentage HUB populations were very low and suggestive of an environment that had little exposure to hydrocarbons of petroleum origin. The very low concentrations of TPH, PAH and BTEX compounds in the study area supports this observation. The predominant bacteria species isolated from the sediments included *Staphylococcus sp, Bacillus sp., Pseudomonas sp,* and *Escherichia coli.* The predominant fungi isolated from the study area included *Mucor sp. Penicillium sp, Cladosporum sp.*

Table 4.9b: Summary of the sediment microbiology. Means highlighted are significantly different

Parameters	SPDC, 2013a (Dry season)			SPDC, 2016b (Wet season)		P value	Sig.
	Proposed Iseni Appraisal Well (x±SD)	Existing Iseni Wells (x±SD)	Control (x±SD)	Around the Jetty/Ramp (x±SD)	Control (x±SD)		
THB (cfu/g)	4.36 $x10^7$±0.54 $x10^7$	3.7 $x10^7$±0.65 $x10^7$	3.81 x 10^7 ±1.91 x 10^7	3.66 x 10^7 ±0.14 x 10^7	3.19 x 10^7 ±1.85 x 10^7	1.000	Non sig.
TF (cfu/g)	1.9 $x10^5$±0.11 $x10^5$	1.63$x10^5$±0.49 $x10^5$	1.38 x 10^5±0.71 x 10^5	1.70 x 10^5±0.20 x 10^5	1.27 $x10^5$±0.74 x 10^5	1.000	Non sig.
HUB (cfu/g)	2.05 x 10^5±0.11 $x10^5$	1.75 $x10^5$±0.40 $x10^5$	1.49 x 10^5±0.77 x 10^5	2.13 x 10^2±0.16 x 10^2	1.90 x 10^2±1.09 x 10^2	0.000	Sig.
HUF (cfu/g)	0.68 $x10^3$±0.12 $x10^3$	0.49 $x10^3$±0.28 $x10^3$	0.34 x 10^3±0.19 x 10^3	0.86 x 10^2±0.17 x 10^2	0.53 x 10^2±0.32 x 10^2	0.000	Sig.

4.7.10: Surface Water Quality

The statistical summary of physico-chemical parameters of the surface water samples from Iseni field are presented in Table 4.10a, while the details are shown in **Appendix 5.** Generally, most of the parameters determined showed no significant difference ($p>0.05$) across the sampling stations (proposed well, existing wells and Ramp/Jetty areas, except TDS, conductivity, total alkalinity nitrate and hardness.

Colour

The colour of the surface water around the proposed Iseni Wells compared favourable with the control stations as the mean values were 5.25±1.26 Pt/Co units and 5±3.06 Pt/Co units. Similarly, the mean values around the proposed Jetty/Ramp were not significantly different ($p=0.615$) when compared to the 2013 values. The similarity maybe attributed to the fact that both samples were obtained during the Wet season. Aiyesanmi *et al*., 2006 reported similar trends.

Temperature

The mean temperature values around the proposed Iseni Appraisal Well, Existing Iseni Wells and control stations (2013) were not significantly different ($p=0.998$) when compared to the values around the Jetty/Ramp (2016). In the Iseni Appraisal Well Project, 2013, the mean values were 29.43±0.78 ºC, 28.95±16.72 ºC and compared favourably ($p>0.05$) with the control stations (28.63±14.33 ºC). Similarly, the mean temperature values in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were 27.8±0.26 ºC and 27.5±15.88 ºC around the proposed Jetty/Ramp and Control stations respectively.

Electrical Conductivity, Total Dissolved Solids and Salinity

The levels of Electrical conductivity, Total Dissolved Solids (TDS) and Salinity around the Iseni Appraisal Well Project, 2013 were 82.19±0.18 µS/cm, 48.35±0.10 mg/l, 10.16±1.48 mg/l (Proposed Iseni Appraisal Well); 68.6±42.18 µS/cm, 40.35±24.82 mg/l, 7.895±4.60 mg/l (Existing Iseni Wells) and 69.40±39.94 µS/cm, 40.83±23.49 mg/l, 7.05±3.83 mg/l (Control). There were significant differences in the levels of electrical conductivity ($p=0.000$) and TDS ($p=0.000$) when compared to the levels around the Jetty/Ramp in the Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The variance maybe attributed to the influx of salinity related materials from the Forcados river. The mean values around the Jetty/Ramp and control stations were: 39.27±1.08 µS/cm, 19.63±0.54 mg/l ¸ 10.61±2.35 mg/l; 38.35±22.15 µS/cm, 19.18±11.08 mg/l ¸ 11.03±6.37 mg/l. The levels of these salinity related parameters are within the ranges reported for fresh water ecosystems (RPI/NNPC, 1985).

Total Suspended Solids and Turbidity

The mean Total suspended solid (TSS) around the proposed Iseni well and existing wells were 8.96±0.27mg/l and 8.77±5.07mg/l respectively. No significant variation ($p=0.861$) was observed when compared to the TSS values around the Jetty/Ramp as mean values were 5.67±1.15mg/l. The TSS values in the control stations compared favourably with the study area (Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016). RPI/NNPC (1985) reports a range of 1.2 to 397 mg/l for TSS in waters of southern Nigeria. The TSS values within the project area are generally within the RPI/NNPC (1985) values.

Turbidity, which defines the clarity of water is a function of the suspended solids concentration. Turbidity values measured around the proposed Iseni well and existing wells were 69.26±20.90 mg/l and 7.11±4.16 mg/l and were significantly different ($p<0.05$) from values in the control station (32.90±27.31mg/l). Similarly, the turbidity levels around the proposed Jetty/Ramp and control stations were significantly lower ($p=0.000$) compared to the Iseni Appraisal Well Project, 2013. The variance maybe attributed to influx of materials from the Forcados river to surface water bodies around the proposed Iseni well and existing wells.

pH

The pH of the surface water was slightly acidic in the proposed well area and existing well area and slightly alkaline in the Ramp/Jetty area. The values were 6.48±0.16 in the proposed well area, 6.02±3.48 in the existing well area and 8.00±0.2 around the proposed Ramp/Jetty area. Using the *chi square goodness of fitness test, ratio 1:1*¸ there was no remarkable variation ($p=0.903$) in the ph of surface water bodies around the proposed well area and existing well area and around the Ramp/Jetty area. The control stations however compared favourably in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016. The pH values measured are within previous levels recorded in the Niger Delta (RPI/NNPC, 1985). Low values of pH are common in Nigerian inland waters and are attributed to input of humic and decaying organic materials from forested catchment (Akpan, *et al*., 2002).

Alkalinity

The alkalinity in the proposed well and existing wells area was higher ($p=0.000$) than that of the Ramp/Jetty area. The mean alkalinity values were 17.93±3.29 mg/l and 11.76±6.99 mg/l around the proposed appraisal well and existing wells respectively. The control stations compared favourably ($p>0.05$) with the study area. Furthermore, the mean alkalinity values around the proposed Jetty/Ramp and control stations were 0.34±0.04 mg/l and 0.29±0.17mg/l. Alkalinity values of 20 to 200 mg/l are typical for freshwater (Radojevic & Bashkin, 1999).

Total Hardness, Calcium and Magnessium

The hardness of the surface water around the proposed appraisal well and existing wells were at variance ($p=0.051$) with the levels around the Jetty/Ramp. The mean values in the Iseni Appraisal Well Project, 2013 were 5.04±0.50mg/l and 6.36±3.79mg/l for the proposed appraisal well and existing wells. Similarly, the mean hardness levels were 9.33±1.15mg/l and 14±8.33mg/l around the Ramp/Jetty and control stations. The levels in the control stations in the Iseni Appraisal Well Project, 2013 and Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016 were generally similar and showed no variation.

Hardness in water comprises the determination of calcium and magnesium as the main constituents with magnesium ions contributing more to the measured hardness in this study. The mean calcium concentrations in the proposed well and existing wells area was 1.18±0.19mg/l and 1.96±1.21 mg/l. The calcium concentration compared favourably ($p=0.392$) with the concentrations around the Jetty/Ramp as mean values were 2.58±0.20mg/l and 3.6±2.14mg/l around the Jetty/Ramp and control stations. These values corroborated with the levels of hardness in the surface water bodies. The concentration of magnesium followed the same trend as no significant variation ($p=0.200$) were observed around the proposed appraisal well and existing wells compared to the Ramp/Jetty. Surface waters with hardness less than 50 mg/l are considered soft (Radojevic & Bashkin, 1999). Soft waters have low capacity to buffer against acidic contamination. Low hardness of the waters may be associated with increasing intensity of rainfall and flooding in the area as well as natural geological formation poor in carbonates.

Sulphate (SO_4^{2-})

The concentration of sulphates in surface water bodies around the proposed appraisal well and existing wells were 1.88±0.3mg/l and 2.88±1.89mg/l. The concentration in the control stations (2.2±1.15mg/l) did not differ significantly ($p>0.05$). There was no significant variation ($p=0.881$) in the concentration of sulphates in surface water bodies around the Jetty/Ramp. The surface water concentrations are typical of fresh water bodies as concentration of 2 to 80mg/l have been reported for fresh water bodies in Souther Nigeria (RPI/NNPC, 1985).

Phosphate (PO_4^{3-})

Phosphate concentrations within the study area were similar. Phosphate concentrations for the proposed well and existing wells area was 0.03±0.01mg/l and 0.05±0.03mg/l. The concentration of phosphates in surface water bodies around the Jetty/Ramp and control stations were not significantly different ($p=0.651$) when compared to those around the proposed appraisal well and existing wells. The observed level of phosphate in the water body indicates that the water was not contaminated with this plant nutrient. High concentration has been implicated in excessive nutrient enrichment (eutrophication) of surface water body, with the attendant unrestricted growth of water weeds. Most natural waters have phosphate levels ranging from 0.01 to 0.05 mg/l (Mills, 2013).

Nitrate (NO_3^-)

Nitrate is the most completely oxidised state of nitrogen commonly found in natural water and all natural ecosystems need it as an essential nutrient for primary production. Nitrate concentrations in the surface water around the proposed well and existing wells was 0.74±0.19mg/l and 1.00±0.58mg/l. The concentration in the surface water bodies around the Ramp/Jetty were lower (p=0.012) compared to the proposed appraisal well and existing wells. The mean concentration of nitrates was 0.05±0.03mg/l and 0.07±0.05mg/l around the Jetty/Ramp and control stations. In the study area, NO_3^- was higher than NH_4^+, indicating an oxidation reaction with little or no anthropogenic pollution and organic matter decomposition. This also agrees with the observed positive OPR values.

Other Anions

Other anions determined in the water samples were sulphide (S^{2-}) and cyanide (CN^-) with concentrations below instrument detection limits (<0.001 mg/l).

Dissolved Oxygen (DO)

The mean DO levels in the surface water bodies around the proposed well and existing wells area were 5.25±0.44mg/l and 5.05±2.92mg/l. No significant variation (p=0.901) was observed in the DO levels around the Jetty/Ramp as mean values were 4.33±0.74mg/l and 4.2±2.50mg/l around the Jetty/Ramp and control stations. The control stations compared favourably (p>0.05) with the study area. Typically, the concentration of DO in surface water is usually less than 10 mg/L. The DO concentration is subject to diurnal and seasonal fluctuations that are due, in part to variations in water temperature, photosynthesis by green algae, salinity and pollution resulting from both natural and anthropogenic activities (Aiyesanmi et al., 2006). Dissolved oxygen is an important environmental parameter for the survival of aquatic life. Studies have shown that 4 - 5 mg/L of DO is the minimum amount that will support a large, diverse fish population (DWAF, 1996).

Biochemical Oxygen Demand and Chemical Oxygen Demand

The mean BOD_5 was 0.81±0.10mg/l around the proposed well and 0.84±0.48mg/l around the existing wells area. Similarly, the BOD_5 levels around the Jetty/Ramp were generally similar (p=1.000) to the levels around the proposed well and existing wells. The mean BOD_5 levels around the Jetty/Ramp were 1.42±0.18mg/l and 1.05±0.61mg/l. Furthermore, the COD levels around the proposed appraisal well and existing wells were 2.03±0.24mg/l and 2.09±1.21mg/l. No significant variation (p=0.801) was observed in the COD levels around the Jetty/Ramp. Under normal environmental conditions, the background COD values are expected to be higher than the BOD5 for any given sample because COD includes both biodegradable and non-biodegradable substances. COD is typically less than 20 mg/L in unpolluted water whereas BOD5 contains only the bio-degradables with values less than 5 mg/L in unpolluted natural waters (Oyakhilome *et al.*, 2012). Hence, COD and BOD are important indicators of the overall water quality (Osibanjo, 1996; EPA, 2001).

Oil and Grease and Hydrocarbons

Oil and grease, THC, BTEX and PAHs were very low and below the equipment detection limits (< 0.001).

Metals

Natural waters contain very small quantities of several metals including iron (Fe), cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu), barium (Ba), nickel (Ni), vanadium (V), zinc (Zn), manganese (Mn) and mercury (Hg). Their presence in natural waters is a combination of contribution from weathering of rocks and minerals, direct waste dumping/dumpsite leachates and industrial effluents. Farming activities could also contribute to the levels of some metals in surface water through run-off. Some of these metals, called essential or micronutrients are required by plants and animals in trace or minute but critical quantities for normal healthy growth and reproduction. Others like Ba, Cd, Hg and Pb have no known essential function and, like the essential trace metals, cause toxicity above certain tolerance level (Laws, 1981). Metals generally are toxic in relatively high concentrations, non-biodegradable and easily assimilated and bio-accumulated in aquatic organisms. The concentrations of these metals determine in surface water in the study area were generally very low, below instrument detection limit (<0.001), except Fe, Cr and Zn that showed values which are below their maximum allowable concentrations in potable water (Table 4.10a).

Table 4.10a: Summary of the physicochemical Properties of Surface water in the Proposed and Existing Well area, (2013) and the Proposed Jetty/Ramp area (2016). Means highlighted are significantly different

Parameters	SPDC, 2013a (Dry season)			SPDC, 2016b (Wet season)		P value	Sig.
	Proposed Iseni Appraisal Well (x±SD)	Existing Iseni Wells (x±SD)	Control (x±SD)	Around the Jetty/Ramp (x±SD)	Control (x±SD)		
pH	6.48±0.16	6.02±3.48	6.37±3.23	8±0.2	7.8±4.50	0.903	Non sig.
Temp (ºC)	29.43±0.78	28.95±16.72	28.63±14.33	27.8±0.26	27.5±15.88	0.998	Non sig.
TDS (mg/l)	48.35±0.10	40.35±24.82	40.83±23.49	19.63±0.54	19.18±11.08	0.000	Sig.
EC(µS/cm)	82.19±0.18	68.6±42.18	69.40±39.94	39.27±1.08	38.35±22.15	0.000	Sig.
DO(mg/l)	5.25±0.44	5.05±2.92	5.9±2.96	4.33±0.74	4.2±2.50	0.901	Non sig.
Colour	5.25±1.26	5±3.06	5±2.63	2.67±1.15	2±1.53	0.615	Non sig.
T.Alkalinity (mg/l)	17.93±3.29	11.76±6.99	11.37±6.44	0.34±0.04	0.29±0.17	0.000	Sig.
Redox potential (mV)	79.25±20.17	73.5±43.09	70±36.82	66.67±4.16	67±38.73	0.336	Non sig.
BOD_5(mg/l)	0.81±0.10	0.84±0.48	0.77±0.39	1.42±0.18	1.05±0.61	1.000	Non sig.
Salinity(mg/l)	10.16±1.48	7.90±4.60	7.05±3.83	10.61±2.35	11.03±6.37	0.763	Non sig.
COD(mg/l)	2.03±0.24	2.09±1.21	1.94±0.97	3.54±0.44	2.63±1.52	0.801	Non sig.
Turbidity(mg/l)	69.26±20.90	7.11±4.16	32.90±27.31	2.73±0.35	3.58±2.07	0.000	Sig.
O&G(mg/l)	0.20±0.17	0.13±0.08	0.24±0.13	<0.001	<0.001		
CO_3(mg/l)	<0.001	<0.001	<0.001				
CN(mg/l)	<0.001	<0.001	<0.001				
H_2S(mg/l)	<0.001	<0.001	<0.001				
THC(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
TSS(mg/l)	8.96±0.27	8.77±5.07	7.73±3.88	5.67±1.15	8.50±4.93	0.861	Non sig.
NH_4(mg/l)	0.16±0.04	0.41±0.27	0.12±0.06				
NO_2(mg/l)	0.0023±0.003	0.011±0.01	0.002±0.001				
NO_3(mg/l)	0.74±0.19	1±0.58	0.76±0.39	0.05±0.03	0.07±0.05	0.012	Sig.
PO_4(mg/l)	0.03±0.01	0.05±0.03	0.03±0.02	0.09±0.02	0.06±0.04	0.651	Non sig.
SO_4(mg/l)	1.88±0.3	2.88±1.89	2.2±1.15	1.19±0.19	1.20±0.69	0.881	Non sig.
Hardness(mg/l)	5.04±0.50	6.36±3.79	4.45±2.37	9.33±1.15	14±8.33	0.051	Non sig.
Ca(mg/l)	1.18±0.19	1.96±1.21	1.27±0.72	2.58±0.20	3.6±2.14	0.392	Non sig.

Parameters	SPDC, 2013a (Dry season)			SPDC, 2016b (Wet season)		P value	Sig.
	Proposed Iseni Appraisal Well (x±SD)	**Existing Iseni Wells (x±SD)**	**Control (x±SD)**	**Around the Jetty/Ramp (x±SD)**	**Control (x±SD)**		
Na(mg/l)	2.94±0.40	4.65±3.28	3.90±2.00	1.46±0.36	1.16±0.67	0.308	Non sig.
K(mg/l)	1.64±0.12	2.37±1.44	1.71±0.93	0.68±0.14	0.47±0.28	0.819	Non sig.
Mg(mg/l)	3.74±0.49	6.05±4.27	4.40±2.26	0.61±0.12	1.03±0.61	0.200	Non sig.
Phenol(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Al(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Ba(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Co(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Mn(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Cu(mg/l)	0.003±0.001	0.01±0.003	<0.001	<0.001	0.003±0.002		
Fe(mg/l)	0.012±0.003	0.01±0.01	0.002±0.001	0.01±0.002	0.002±0.001		
Cr(mg/l)	<0.001	<0.001	0.01±0.005	0.002±0.002	0.002±0.001		
Cd(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Ni(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Pb(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Hg(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
V(mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001		
Zn(mg/l)	0.12±0.003	0.13±0.09	<0.001	0.001±0.001	0.001±0.001		
Ag(mg/l)	<0.001	<0.001	0.09±0.05				

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

Surface Water Microbiology

The mean THB population in the surface water samples was 3.67 x 10^3±0.63 x 10^3 cfu/ml for the proposed well and existing wells area and 3.13x10^7±0.06 x10^7 cfu/ml for the proposed Ramp/Jetty area (Table 4.10b). The TF population for the propsed well and existing wells area was 1.02 x10^2±0.24 x10^2 and 8.9 x10^4±1.3 x10^4 cfu/ml for the proposed Ramp/Jetty area.. The mean HUB population was 1.88 x10^2±0.49 x10^2cfu/ml for the propsed well and existing well area and 2 x102±0.10 x102cfu/ml for the propsed Ramp/Jetty area. . The mean percentage HUB for the proposed well and existing well area was 5.1% and for the proposed Ramp/Jetty was 0.00006%. This result suggested that the heterotrophic bacterial population within the proposed well and existing well area had been exposed to hydrocarbons of petroleum origin though in very small amounts. However the heterotrophic bactyerial population within the proposed Ramp/Jetty area had not been exposed to hydrocarbons of petroleum origin. The low TPH , PAH, BTEX oil and grease concentrations give support to these observations. The total coliform counts of the proposed Ramp/Jetty area were higher than that of the proposed well and existing wells area. This result showed the influence of human activities in the latter area compared with the former. The coliforms include the fcal coliforms which are indicators of human fecal contamination of water.The predominant bacteria isolated from the surface water included *Esherichia coli, Bacillus sp, Pseudomonas sp, Streptococcus sp, Klebsiela sp, Staphylococcus sp Enterobacter sp and Micrococcus sp.*

Table 4.10b: Microbiological Properties of Surface water in the Proposed and Existing Well area, (2013) and the Proposed Jetty/Ramp area (2016). Means highlighted are significantly different

Parameters	SPDC, 2013a (Dry season)		SPDC, 2016b (Wet season)		p value	Sig.
	Study area (x±SD)	Control (x±SD)	Study area (x±SD)	Control (x±SD)		
THB cfu/ml	$3.67 \times 10^3 \pm 0.63 \times 10^3$	$2.66 \times 10^3 \pm 1.38 \times 10^3$	$3.13 \times 10^7 \pm 0.06 \times 10^7$	$2.99 \times 10^7 \pm 1.72 \times 10^7$	0.000	Sig.
TF cfu/ml	$1.02 \times 10^2 \pm 0.24 \times 10^2$	$0.87 \times 10^2 \pm 0.50 \times 10^2$	$0.89 \times 10^5 \pm 0.13 \times 10^5$	$0.66 \times 10^5 \pm 0.38 \times 10^5$	0.000	Sig.
HUB cfu/ml	$1.88 \times 10^2 \pm 0.49 \times 10^2$	$1.86 \times 10^2 \pm 0.97 \times 10^2$	$2 \times 10^2 \pm 0.10 \times 10^2$	$1.84 \times 10^2 \pm 1.06 \times 10^2$	1.000	Non sig.
HUF cfu/ml	0.14 ±0.03	0.15 ±0.08	0.67 ±0.21	0.44 ±0.29	1.000	Non sig.
TCC MPN/100ml	5.17±2.14	2.67±1.63	133.33±40.41	50±30.55	0.000	Sig.

a: Iseni Appraisal Well Project, 2013

b: Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

4.7.11: Hydrobiology

This section of the report discusses the occurrence, abundance and diversity of the plankton (phytoplankton and zooplankton) and the benthic organisms.

Phytoplankton

The phytoplankton represents primary producers in the aquatic ecosystem, since they are autotrophs, fixing solar energy for photosynthesis, and using carbon dioxide, water and mineral nutrients to produce organic matter and oxygen. A great diversity of phytoplankton exists in both fresh and brackish/marine water. The types commonly found in the fresh and brackish waters include members of the division Chlorophyta (green algae), Cyanophyta (blue –green algae or Cyanobacteria) and the Bacillariophyta (diatoms) (Opute, 1991).

Iseni Appraisal Well Project, 2013

The data on phytoplankton abundance and distribution obtained from the study area is presented in Table 4.11a. The phytoplankton flora comprised seventeen taxa distributed into three divisions namely Bacillariophyta (diatoms), Chlorophyta (Green algae) and Cyanophyta (Blue green algae). The Phytoplankton community was dominated by the Bacillariophyceae, which had eight species and accounted for about 47.1% total phytoplankton number in the study area. The Chlorophyceae and Cyanophyceae each was represented by six and three species respectively and accounted for 35.2% and 18.6% respectively. This composition showed that the phytoplankton communities were typical freshwater species.

The Bacillariophyta, comprising both pinnate and centric forms of which Coscinodiscus dominated in both density and ubiquity, followed by Flagillaria sp and Surirella elegans. The least occurring species was the *Fragillaria javanica, Eudorina elegans, Spirogyra dubia* and *Lyngbyia majuscule*. The *Fragillaria javanica*, *Eudorina elegans*, *Spirogyra dubia* were found in only one location each. The green algae were dominated by *Closterium* and *Spirogyra,* while *Microcystis aeruginosa* was the dominant species among the blue-green algae.

In terms of spatial variation, stations 1 recorded the highest number of species (9 species in the location) while stations 4 and 7 recorded the least abundance of 3 species per location. In terms of spatial variation in cell density, station 2 recorded the highest density of 330 x10^3 cells/m^3 followed by stations 3 (260 x 10^3 cells/m^3) and 1 (210 x 10^3 cells/m^3) respectively. Stations 4 and 5 recorded the least density of 45 x 10^3 cells/m^3 for both locations.

Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

Nineteen phytoplankton species were recorded from the study stations. They were made up of 11 species of Bacillariophyta (the diatoms), 7 species of Chlorophyta (green algae), and 1 species of Cyanophyta (blue greens). The species composition, density and distribution are presented in Table 4.11b. The diatoms were dominant in terms of species richness and overall density. The

Chlorophyta ranked second in order of dominance. The other divisions were poorly represented during the study. The total density was highest in station WS2, followed by WS1, and lowest in WS Control 1. Bacillariophyta had the highest density in all the stations.

Table 4.11a: Checklist, density (cells/m^3 x 10^3) and distribution of phytoplankton in the study area. (2013) (Dry season)

TAXA	**SAMPLING STATIONS**								
	WS1	**WS2**	**WS3**	**WS4**	**WS5**	**WS6**	**WSc1**	**WSc2**	**WSc3**
BACILLARIOPHYTA									
Asterionella glacialis	25	80							10
Coscinodiscus centralis	5	40	40	20	25	55	10	25	10
Cyclotella menaghiniana	10	80				50			
Diatoma elongatum			10			10			
Fragillaria construens			120		10	10			
Fragillaria javanica			20						
Surirella elegans	30				25	25	40		5
Synedra sp		55				10			
CHLOROPHYTA									
Closterium monoliferum	25							25	
Closterium sp			45		10				
Eudorina elegans	40								
Spirogyra communis	55	15	30			100			20
Spirogyra dubia			40						
Volvox africana	15			15					5
CYANOPHYTA									
Anabaena sp		40						55	
Lyngbia majuscule	5						55		
Microcystis aeruginosa		20		10				10	
Total No. of Species	9	7	7	3	4	7	3	4	5
Density (No. x 103/ m-3)	210	330	260	45	45	200	105	90	50
Diversity (H')	1.9629	1.8077	1.8082	1.0609	1.3216	1.7575	0.9303	1.2567	1.4708
Evenness (E)	0.8934	0.9290	0.9292	0.9657	0.9533	0.9032	0.8468	0.9065	0.9139

Table 4.11b: The species composition, density and distribution of phytoplankton in the study area (2016) (Wet season)

TAXA	SAMPLING STATIONS				
	WS1	**WS2**	**WS3**	**WS Control 1**	**WS Control 2**
DIVISION BACILLARIOPHYTA					
Anomoeneis serians	16	16	8	16	
Aulocosira granulata	64	64	16	8	16
A. granulata var *angustissima*	16	64	32	80	32
Asterionella glacialis	8	16	16		16
Coscinodiscus sp	8	8	8	32	8
Cyclotella menaghiniana	8	32		32	
Cymbella affinis	32	32	16	32	16
Fragillaria construens	16	32	64	16	
Navicula sp	8	32	16		8
Nitschia occicularis	16	8	16		
Surirella elegans	8	8	32		
DIVISION CHLOROPHYTA					
Closterium acerosum	16	32	32		16
C. gracile	32	32	16	8	8
Eudorina sp	64	40	16		16
Micrasterias alata	16		16		
Microspora sp	16	8	16	16	
Spirogyra communis	40	16	16		
Volvox africana	16		16		8
DIVISION CYANOPHYTA					
Microcystis aeruginosa		16	16	16	
Total No. of Species	18	17	18	10	10
Density (No. x 10^3/ m^{-3})	400	456	368	256	144
Diversity (H’)	2.837	2.613	2.877	1.623	1.811
Evenness (E)	2.642	2.637	2.743	2.053	2.197
Species Richness (d)	0.914	0.931	0.949	0.891	0.954

Ecological Indices

Iseni Appraisal Well Project, 2013

In this study, the Shannon Wiener Index (H) and Evenness Index (E) were used to assess diversity of the species distribution. Stations 1, 3 and 2 has the highest diversity of 1.9625, 1.8082 and 1.8077 respectively, while stations 7, 4 and 5 has the least diversity (0.9303, 1.0609 and 1.3216) respectively. These showed a strong correlation between the species density and diversity. Species diversity measures the overall ecological stability of an ecosystem. Fragile ecosystems normally have low species diversity and low evenness, which are indicative of perturbations. High diversity indices are indicative of ecologically stable ecosystems with resilience to perturbations. The observed occurrence, abundance and diversity of phytoplankton in the surface water around Iseni field in the current study were consistent with what were earlier reported for the field (Iseni Appraisal EIA, 2012) and adjacent Odon/Ogara/ Okpoknou EIA (2010) in previous studies.

Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

The diversity indices used were the Shannon Wiener index (H^1), which provides information on the total number of species as well as the abundance or density of organisms in each station, the Evenness index (which assesses the equitable distribution of individuals among the species), and the Margalef's species richness index which relates the total number of species with the total abundance. The Shannon Wiener diversity was highest in WS3, followed by WS1 and WS2.

Zooplankton

Zooplankton is a term collectively applied to the microscopic floating or weakly swimming animals within the water column. According to life history patterns, the zooplankton community may be holoplanktonic (i. e. those organisms that spend their entire life cycle as zooplankton). Zooplankton feeds on phytoplankton and are in turn fed on by fish. They are good biological indicators of water quality. Their sensitivity to environmental factors, both natural and artificial, makes them of considerable significance in pollution and environmental impact assessment studies.

Species Composition, Density and Spatial Distribution

Iseni Appraisal Well Project, 2013

In this study, twenty-two zooplankton taxa were recorded as shown in Table 4.11c. They comprised the Copepods which was made up of 45.5% of the total zooplankton occurrence, the Cladocerans and Rotifers contributed 27.2% each respectively. Among the Cladocerans, the families Chydoridae, Daphnidae and Moinidae were represented, of which Moinidae was the most dominant, while Chydoridae was the least dominant. The preponderance of Copepods species in the water body, both in occurrence and distribution may be due to the intrusion of brackish water into the environment. The water body were composed of cosmopolitan species dominated by the cyclopoid Copepods. Nauplius larvae were found in all the station. The total density varied widely among the stations. The density was highest in station 3 followed by stations 8 and 5, while station

4 has the least density followed by stations 2 and 9. The total number of taxa followed the same pattern of variation as in density.

Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

The zooplankton were represented in the study area by twenty two (22) species of which 8 were Cladocera, 8 Copepoda, and 6 Rotifera, (Table 4.11d). The Copepoda dominated the zooplankton community both in terms of species richness and density, and were closely followed by Cladocera and the least rotifers. The highest density of zooplankton occurred in WS2 followed by WS Control 1 and WS3. The cyclopoid copepods and cladocerans were dominant.

Table 4.11c: Checklist, density (individuals/m^3) and distribution of zooplankton in the study stations. (2013) (Dry season)

TAXA	SAMPLING STATIONS								
	W1	W2	W3	W4	W5	W6	W7	W8	W9
CRUSTACEA									
CLADOCERA									
CHYDORIDAE									
Alona holdeni	20						10		
Alona sp	40				10	20			
DAPHNIDAE									
Ceriodaphnia cornuta						20			
Daphnia longispina		10	40				50		
MOINIDAE									
Daphnia sp		10	20						
Moina sp			80		60		60	100	20
SUB CLASS									
ORDER									
DIAPTOMIDAE									
Tropodiaptomus			10				10		
Thermodiaptomus	10		20						
ORDER									
CYCLOPIDAE									
Calanus sp.		20			20				
Thermocyclops crassus	10								
Thermocyclops negletus									
Tropocyclops prasinus			20		20				
Metacyclops minutus			10						
Microcyclops rubellus						10			
Microcyclops varicans			10						
Nauplus larva	60	40	100	20	80	40	40	100	40
ROTIFERA									

TAXA	SAMPLING STATIONS								
	W1	W2	W3	W4	W5	W6	W7	W8	W9
ASPLANCHNIDAE									
Asplanchnopus				40					
ORDER PLOIMA									
BRACHIONIDAE									
Brachionus	10			20					
Brachionus falcatus									10
Brachionus sp.			20						
FILIDAE									
Filinia sp									10
LECANIDAE									
Lecane luna			10				10		
Total No. of Species	6	4	11	3	5	4	6	3	4
Density (No. x 103/ m-	150	80	300	60	190	90	170	240	80
Diversity (H')	1.52	0.98	1.80	0.63	1.35	1.27	1.401	1.028	0.86
Evenness (E)	0.85	0.70	0.75	0.57	0.84	0.91	0.782	0.936	0.62

Table 4.11d: The species composition, density and distribution of zooplankton in the study area (2016) (Wet season)

TAXA	**SAMPLING STATIONS**				
	WS1	**WS2**	**WS3**	**WS Control 1**	**WS Control 2**
ARTHROPODA					
CRUSTACEA					
CLADOCERA					
CHYDORIDAE					
Chydorus sphaericus	10	30			40
BOSMINIDAE					
Bosminopsis deitersi	20	170	30	40	70
Bosmina longirostris	10	20			
CHYDORIDAE					
Alona holdeni		20			40
FAMILY DAPHNIDAE					
Ceriodaphnia cornuta	20	30		30	
MOINIDAE					
Moina micrura	10	20			

TAXA	SAMPLING STATIONS				
	WS1	**WS2**	**WS3**	**WS Control 1**	**WS Control 2**
SIDIDAE					
Diaphanosoma excisum	10			30	20
Diaphanosoma sarsi		40			
SUB CLASS COPEPODA					
ORDER CALANOIDA					
FAMILY DIAPTOMIDAE					
Tropodiaptomus laurentii		10		30	70
Thermodiaptomus galebi	20				160
Paracalanus sp.		10			10
ORDER CYCLOPOIDA					
CYCLOPIDAE					
Thermocyclops crassus		20			10
T. neglectus		50			
Tropocyclops prasinus	20	90	100	40	20
Microcyclops varicans		30	52	10	
LAVAL FORMS					
Copepod nauplius			10		
PHYLUM ROTIFERA					
CLASS MONOGONONTA					
ORDER PLOIMA					
Asplanchnopus brightwelli		80			30
FAMILY BRACHIONIDAE					
Brachionus patulus		10	10		10
Keratella cochlearis					10
FAMILY LECANIDAE					
Lecane leontina	10	30		10	
Lecane luna		90			
Lecane curvicornis	20	10			10
Total No. of Species	10	18	5	7	13
Density (No. / m^3)	150	760	202	190	500
Diversity (H')	2.246	2.532	1.278	1.84	2.137
Evenness (E)	0.975	0.876	0.794	0.946	0.833
Species Richness (d)	1.796	2.563	0.7535	1.144	1.931

Ecological Indices

Iseni Appraisal Well Project, 2013

Diversity and species distribution were assessed using the Shannon Wiener Index (H') and Evenness Index (E). Stations 3 and 1 has the highest diversity of 1.802 and 1.5292, while stations 4 and 9 has the least diversity (0.6365 and 0.8664) respectively. These showed a strong correlation between the species density and diversity. Species diversity measures the overall ecological stability of an ecosystem. Fragile ecosystems normally have low species diversity and low evenness, which are indicative of perturbations. High diversity indices are indicative of ecologically stable ecosystems with resilience to perturbations.

Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

The diversity of zooplankton was generally low in the study area. The general diversity was highest in WS2, followed by WS1 and lowest in WS3. Low diversity is an indication of ecosystem instability. The relatively lower evenness value obtained for WS3 indicates the concentrated dominance of few species (like the cyclopoid *Tropocyclops prasinus)* in the community.

Macrobenthic Fauna

The benthic fauna are the bottom dwelling organisms. Majority of them are found living in or on the bottom sediment as infauna, while others live on the surface either attached to different types of substrates (sessile) or as mobile benthic inhabitants. The use of macrobenthic fauna in environmental monitoring programmes and impact assessment studies is well-documented (Tsui and McCart, 1981; Ogbeibu and Victor, 1989; Ogbeibu and Oribhabor, 2002).

Iseni Appraisal Well Project, 2013

The benthic invertebrate fauna were made up of 17 species comprising 9 species of Arthropoda, 4 species of Annelida, 2 species of Nematoda and 2 species of Mollusca. The Percentage contribution by species composition of the major macrofaunal taxonomic groups to benthic faunal diversity is shown in Table 4.11e. The Arthropods were the dominant species in terms of distribution and abundance accounting for 56% of the entire macrobenthic fauna. The Annelids group followed accounting for a quarter of the population, while Mollusca and Nematods groups occurred sparingly in the locations sampled. There was a very high disparity in the distribution of these organisms among the different stations.

Iseni Wells Location Preparation (Civil Works, Ramp/Jetty & Access Road) Project, 2016

Ten species of benthic macrofauna were identified in the study area. They comprised 1 species of Nematoda, 4 species of Oligochaeta, 4 species of Insecta and 1 decapod crustacean. The diversity of benthic macrofauna was low in all the stations (Table 4.11f). Unstable substratum does not favour the development of diverse groups of benthic species (Ogbeibu & Victor, 1989; Ogbeibu & Egborge 1995).

Table 4.11e: The species composition, density and distribution of benthic macrobenthic invertebrates in Iseni field (2013) (Dry season)

TAXA	SAMPLING LOCATIONS					
	SD1	SD2	SD3	SD4	SD5	SD6
PHYLUM ANNELIDA						
Class Clitellata						
Order Haplotaxida						
Family Lumbricidae						
Eiseniella tetrahedral		10				
Lumbriculidae						
Lumbriculus sp						
Lumbriculus sp	60	40				80
Family Naididae						
Dero obtuse				40	50	
Nais communis	50	100			20	80
PHYLUM NEMATODA						
Class Secernantea						
Order Doralamida						
Dorylaimidae			10			
Dorylaimus sp.				10		
PHYLUM ARTHROPODA						
Class Insecta						
Order Coleoptera						
Family Dytiscidae						
Hydroporus sp	10					
Order Diptera						
Family Chironomidae						
Chironomus transvaalensis	80	40		100		40
Polypedilum bipustulatum	20	20			40	40
Order Ephemeroptera						
Family Baetidae						
Baetis rhodani	40	80	40			20
Centroptilum sp.		20				20
Cloeon cylindroculum	10	100	10			60
Order Hemiptera						
Family Notonectidae						
Buenoa margaritacea				10	10	
Class Malacostraca						
Order Decapoda						

TAXA	SAMPLING LOCATIONS					
	SD1	SD2	SD3	SD4	SD5	SD6
Family Atyidae						
Potamalpheops monody	20	20				20
Potamalpheops pylorus		10				10
PHYLUM MOLLUSCA						
Class Gastropoda						
Order Heterobranchia						
Family Lymnaeidae						
Lymnaea sp	40	40		20		20
Family Physidae						
Physella sp		10				10
Total No. of Species	9	12	3	5	4	11
Density (No. x 10^3/ m^{-3})	330	490	60	180	120	400
Diversity (H')	2.003	2.188	0.868	1.226	1.237	2.062
Evenness (E)	0.351	0.353	0.212	0.236	0.258	0.344

Table 4.11f: The species composition, density and distribution of benthic macrofauna in the study area (2016) (Wet season)

TAXA	**SAMPLING STATIONS**				
	WS1	**WS2**	**WS3**	**WS Control 1**	**WS Control 2**
PHYLUM NEMATODA					
CLASS SECERNANTEA					
ORDER TYLENCHIDA					
DORYLAIMIDAE					
Dorylaimus sp.	44		88	44	44
PHYLUM ANNELIDA					
CLASS OLIGOCHAETA					
Family Enchytraeidae					
Enchytraeus sp		88	44	88	
Family Lumbricidae					
Eiseniella tetrahedra		396			
Family Naididae					
Nais communis	88	176	44	176	88
Paranais sp.		44			
PHYLUM ARTHROPODA					
CLASS INSECTA					
Order Diptera					

TAXA	SAMPLING STATIONS				
	WS1	**WS2**	**WS3**	**WS Control 1**	**WS Control 2**
Family Chironomidae					
Polypedilum bipustulatum	44	88		88	44
Pentaneura sp.		44			
Order Ephemeroptera					
Family Baetidae					
Baetis rhodani			4		
Centroptilum sp.			8		
CRUSTACEA					
DECAPODA					
Family Atyidae					
Potamalpheops monodi	4	8	4		
Total No. of Species	4	7	6	4	3
Density (No. / m^2)	180	844	192	396	176
Diversity (H')	1.123	1.506	1.327	1.273	1.04
Evenness (E)	0.810	0.774	0.740	0.918	0.946
Species Richness (d)	0.578	0.891	0.951	0.502	0.387

4.7.12: Fisheries

The fishery resource includes all the harvestable fin and shellfish in the water of the study area, and represents complex interactions between the population of fish being harvested, the population of fisher folk and environmental conditions. The fish catch has to do with the quality of fish captured by fisher folk, stock assessment in relation to the species composition, and the quantity and quality of fish. Fishing is the main occupation of inhabitants within the proposed project area. It is carried out at both commercial and subsistence levels. Fish catch in this area, according to response from the fisher folk is average. According to some of the fisher folks interviewed, fish catch has been diminishing over the years due mainly to overfishing and some anthropogenic factors such as refuse dumping on the rivers and increased navigational activities, which has led to disturbances of the fish breeding grounds.

Various aspects of the biology of the species and population or stock as a whole are affected by environmental factors such as temperature, salinity, turbidity, and other physico-chemical parameters. Also significant in proper fisheries management is the knowledge of the habitat or natural environment of the exploited species. Another aspect of resource assessment involves the characterization of the number of fisher folk, harvesting techniques, and catch per unit effort.

Species Composition

Species composition in the area was identified during sampling. Secondary information from fisher-folk as well as from recent studies carried out around the area was used to provide a comprehensive list. The list shows that 34 species belonging to 16 families were found in the aquatic ecosystem in the study area. Dominant fish families identified in catches in the area include *Bagridae*, *Characidae*, *Clariidae* and *Mochokidae*. The Bagrid species included *Chrysichthys nigrodigitatus*, and *Clarotes macrocephalus*, while the *Characidae*, *Clariidae* and *Mochokidae* are made up of *Alestes macrolepidotus, A. longipinis, A. nurse, Clarias anguillaris, C. gariepinus, Parauchenoglanis sp., Synodontis omias, Synodontis clarias* and *Synodontis nigrita*. Other common species include G*nathonemus abadi*, *Labeo senegalensis, Heterotis niloticus*, *Citharinus latus*, and *Gymnarchus niloticus*. The list of commercially important fish species found in the study area together with their taxonomic classification, and their relative abundance, is presented in Table 4.12a. Typical fish species in the study area is shown in Plate 4.4a.

Table 4.12: List of fish species of the study area

Family	Scientific Name	Common Name	Relative Abundance
Bagridae	*Chrysichthys nigrodigitatus*	Silver cat fish	++
	Clarotes macrocephalus	Silver cat fish	+
Channidae	*Channa obscura*	Snakehead	+
Characidae	*Alestes macrolepidotus*		+
	A. longipinis		+++
	A. nurse		+
Cichlidae	*Hemichromis fasciatus*	Tilapia	++
	Sarotherodon niloticus		+
	Tilapia macrocephala		+
	T. melanopleura		+
	T. zillii		++
Citharinidae	*Citharinus citharus*	Moonfish	++
	Citharinus distichodoides		
	Citharinus latus	Moonfish	++
	Distichodus engycephalus	Grass-eaters	++
Clariidae	*Clarias anguillaris*	Mudfish, clariid catfish	+++
	C. gariepinus	Mudfish, clariid catfish	+++
Cyprinidae	*Epiplatys sexfasciatus*	African carp	+
	Labeo sendgalensis		++
Gymnarchidae	*Gymnarchus niloticus*		++
Hepsetidae	*Hepsetus odoe*	African pike	+
Malapteruridae	*Malapterurus electricus*	Electric cat fish	++
Mochokidae	*Parauchenoglanis sp.*		+
	Synodontis omias	Catfish	+
	Synodontis clarias		+++
	Synodontis nigrita	Catfish	+++
Mormyridae	*Gnathonemus abadi*		

Family	Scientific Name	Common Name	Relative Abundance
	Hyperopisus bebe accidentalis		+
	Gnathonemus cyprinoids	Elephant – Snout fish	
Notopteridae	*Papyrocranus afer*	Featherback	+
	Xenomystus nigri	Knife-fish	+
Osteoglossidae	*Heterotis niloticus*	Bony –tongues	++
Polynemidae	*Polynemus quadrifillis*	Shiny-nose	
Polypteridae	*Erpectoichthys calabaricus*		+
	Eutropius niloticus	Butter Catfish, Glass Catfish	++

(+ Low Abundance, ++ Moderate Abundance, +++ High Abundance)

Plate 4.4a: A fisherfolk's basin containing fish species caught and fish bait

Fishing Gear, Landings and Income

Cast nets were the most common fish gears used by the fisher folks followed by fences and basket traps. Traditional pond bailing is also carried out, but this is usually done during the dry season when the level of water would have reduced drastically. The types of fishing gears used by the fisher-folks in the study area, as well as their respective target species, are listed in Table 4.12b.

Table 4.12b: Common fishing gears, target species, landing weight and seasonal availability

Fishing Gear	Fishing Ground/ Season	Target Fish Species	Weight (kg)
Gillnet (Large Mesh)	Wet	Croakers, Catfish	2 - 3
Pond Bailing	Dry	Clarias sp., Channa sp., Xenomystus	Up to 10kg
Gillnet (Small Mesh)	All season	Cichlids, catfish, Snakehead, Synodontis	1 – 4
Cast-net	All season	Mostly young and juveniles	1 - 5
Long Line Hooks	All season	Catfish Shiny-nose	2 – 10 per day
Fences	All season	Mixed Finfish	2 – 1510
Basket Trap (Funnel)	All season	Goby, Tilapia, Shrimps,	0.5 – 2.0 per set of traps

Catch Per Unit Effort Assessment

The cast net and surface set gill nets were used in assessing catch per unit effort at two locations along the river. The average catch per unit effort was low. Interview with fisher folks indicate that sometimes, the day's effort can be fruitless without a single catch. Because of the low catch from the castnet gear, the locals resort mainly to the use of fenced seine nets, traps and hooks for littoral bank edge fishes like *Gymnarchus* sp, which ensures more yields (Plate 4.4b). The net stays up from 4 to 8 hours in the water and sometimes overnight. The fish catch, however, depends on the time, season and the type of net. The fishing season that gives the fisher folks the greatest catch per unit effort is usually October to December. A total number of 66 fishing boats were counted during the fieldwork, with a workforce of 148 persons; giving an average of 2 persons per fishing boat.


Plate 4.4b: Fishing activities consisting of Seine net fencing, use of hooks and basket traps

4.7.13: Social Profile

Proposed Project Environment and the Affected Communities

The identified project affected communities in the Iseni field are Odorubu and Lalagbene. These two communities are from two major ethnic groups. While Odorubu is of the Urhobo ethnic nationality, Lalagbene is of Ijaw ethnic nationality. Each of the community is autonomous with distinct historical attributes. While Odorubu community is under the local government jurisdiction area of Patani Local Government Area and is uniquely the only Urhobo speaking community in the Patani LGA of Delta State; Lalagbene is Ekeremor Local Government Area of Bayelsa State.

Historically, Odorubu community migrated from Ughelli Kingdom and made up of ten (10) families namely – Eselo, Akpeli, Irowo, Eribo, Ariove, Uviado, Olevemo, Olevemo, Emehari, Mmoho and Ntakiri. They migrated and settled in present day Odorubu as a result of fishing activities, palm fruit collecting and farming. On the other hand, Lalagbene community is made up of two (2) families – Emebiri and Ofoyenbiri. Socio-culturally, inhabitants of Urhobo and Ijaw ethnic nationalities have over the years traded and inter-married with other ethnic groups such as Isoko, Kwale and Itsekiri tribes with whom they share common cultural and social affinities with respect to marriage ceremonies, mode of dressing and festivals. The stakeholder's communities to the proposed Iseni project are permanent communities. The communities are rural and linear settlement. The housing pattern, type and structure of the settlements reflect very much a rural setting of the project environment (Plate 4.5a). Houses are built according to family/lineage ties and transportation and communication routes. It's important to know that before now, land was not that an issue...the major influence on the pattern of settlements was basically the kinship/lineage ties and land ownership right.

Plate 4.5a: Iseni project affected communities traversed by a tarred road and internal streets/quarters; also the housing pattern and stock (housing type/quality) showing a typical rural environment

Religion, Customs, Belief System and Heritage

The project affected communities are predominantly Christians by religion. On the average, over 95% of the respondents across the surveyed communities are Christians as against the few who practice the African Traditional Religion (ATR) and Islam. Despite this aggregate picture of religious affiliations, there are sacred shrines such as Okere at Odorubu. Although the people claim that they have embraced Christianity and as such do not attach much importance to idol worshipping, there are a number of such shrines that are still seen in the communities.

These sacred shrines exist either within the community's centre or are located far out in the forests/bushes or close to streams/rivers/water-courses. The field visit for this study showed that traditional places of worships are cultural heritage centres, although not much attention is given to it these days. More often than not, trespasses without the required permission can cause outrage and involved financial reparation. The *"Igbe"* cult or Society and the worship of the water goddess *(Olokun)* are common in the community especially from the Urhobo communities. Seasonal cultural festivals and dances are also held. The Urhobos and Ijaw ethnic nationalities which made up the Iseni Oil Well project affected communities have rich and well established cultural and traditional institutions. The community folklore and songs symbolize its inhabitants, as depicted in the numerous cultural societies of its men and women which practice a healthy competition in folk dances, songs and religious serenades. The people of Urhobo and Ijaw have many things in common, including food, dressing and socio-cultural organizations. Apart from the *''Ogboni* and *Igbe''* cults, several other socio-cultural groups also exist within the communities, showing the Urhobo and Ijaw culture generally. There are the men and women age-grades social clubs in the communities.

Despite the foregoing, these traditional religious and festivals observances are waning in importance. The Christian festivities of Easter and Christmas are more celebrated in the community. There are also churches denominations like The Anglican Church, Catholic Church, Assemblies of God Church, Redeemed Christian Church and Living Faith aka Winners Chapel, Christ Apostolic Church, and white garment churches in the communities. Social maladies such as incest, adultery, stealing, fighting with knife or cutlass, bottles or gun, having sex with a woman in the bush are amongst the customs and beliefs that are prohibited. Offenders are often sanctioned either by payment fines or appeasing the gods and/or ancestors. Polygamy is a practiced form of matrimony. Inheritance is patrilineal and payment of pride price and dowry on girls intended for marriage is a custom among the Iseni Oil Well project affected communities.

Residence and Ethnic Composition of Sampled Population

The 'Urhobos' and Ijaw ethnic group are the dominant ethnic groups among the studied communities. By definition, 'an indigene is a person who was born in a particular place'. According to common understanding in Nigeria and as a matter of government policy, the indigene of any given locality are those persons who can prove that they belong to the ethnic community whose ancestors first settled in the area while everyone else is regarded as a non-indigene, no matter how strong your ties to the community. The socio-economic sample survey reveals that a significant proportion of the communities respondents are indigene, while the minority non-indigene are migrants from Isoko, Kwale, Igbo, Yoruba, Hausa and other parts of the Urhobo and Ijaw community. Here, a significant proportion of the community respondents and by implications the population had spent a greater part of their life in the communities. Analysis of the field data shows that about 75.4% of the respondents in the surveyed community on the average have lived in the communities their whole lives i.e. since birth, while 5.7% have spent over 20 years in the communities. The other fraction of the respondents has spent no less than 10 years in the community. Another 9.5% have also spent between 11-20 years, while less than one-tenth (9.4%) have lived in the communities for between 1 and 10 years. This shows that most of the respondents were mainly 'natives' or indigene of the community who have spent a considerable time of their lives within the communities. There is also evidence of those who migrated to the communities in search of economic opportunities.

Population and Socio-Demographic Characteristics

Population Size, Growth and Distribution

Delta State is one of the nine States that were created in 1991. It was excised from the old Bendel State. At its inception, it had nineteen (19) Local Government Areas (LGAs). Delta State as revealed in 2006 census had a population of 4,112,445, comprises of 2,069,309 males and 2,043,136 females, distributed into about 890,312 households. It also encompasses a landmass or area of over 17,239.24 km and this shows an average density of 238.6 persons per km^2 (NPC 2006). According to the 2006 census, Delta State, like the nation Nigeria, has witnessed much increase in her population The State now has a total population of 4,112,445 and ranks as the 12th most populous State in the country and the 2nd most inhabited among the nine (9) oil producing States that comprises the Niger Delta Region. The population is being estimated to be growing at an annual growth rate of 3.22 just as that of the entire country (FGN, Official Gazette, 2007).

On the other hand, Bayelsa State is one of the nine States created in 1991, excised from the old Rivers State. At its inception, it had eight (8) Local Government Areas (LGAs). Bayelsa State from the 2006 census had a population of 1,704,515, comprises of 874,083 males and 830,432 females, distributed into about 352,025 households. It also encompasses a landmass or area of over 9,415.76 km^2 and this shows an average density of 181.0 persons per km^2 (NPC 2006). According to the 2006 census, Bayelsa State, like the nation Nigeria, has witnessed much increase in her population…with a total population of 1,704,515. Meanwhile, with this population figure, Bayelsa State now ranks the 36th most populous State in the country…and the 9th most inhabited among the nine (9) oil producing States that comprises the Niger Delta Region. The population, you would want to know is being estimated to be growing at an annual growth rate of 2.92 just as that of the entire country (FGN, Official Gazette, 2007). According to the 1991 population census and projected for subsequent years (Table 4.13a), the population of the communities were 1,854 and 4,474 for Lalagbene and Odorubu respectively (NPC, 1991). Using 2.83% growth rate for the 1991 figures, the population of the LGAs shall grow to about 317,447 for Ekeremor and 27,321 for Patani in 2030 (NPC, 1994).

Table 4.13a: Projected Population of Odorubu and Lalagbene Communities 1991 to 2030

Communities/LGA	1991			1996	2002	2006	2015	2030
	Male	Female	Total					
Lalagbene	868	986	1,854	2,194	2598	2,660	3,475	4,774
Odorubu	2,112	2,362	4,474	5,100	5813	6,420	8,385	11,521
Communities Total	2,980	3,348	6,328	7,294	8411	9,081	11,859	16,295
LGA Total (Ekeremor)	64,318	59,642	123,279	147,076	172719.2	176,905	231,038	317,447
LGA Total (Patani)	5,111	5,499	10,610	12,094	13,786	15,225	19,884	27,321
State Total (Bayelsa)	583,744	537,239	1,117,317	1,327,032	1,565,409	1,603,350	2,093,975	2,877,122
State Total (Delta)	1,254,442	1,302,323	2,556,765	2914356	3322060	3,668,958	4,791,659	6,583,739

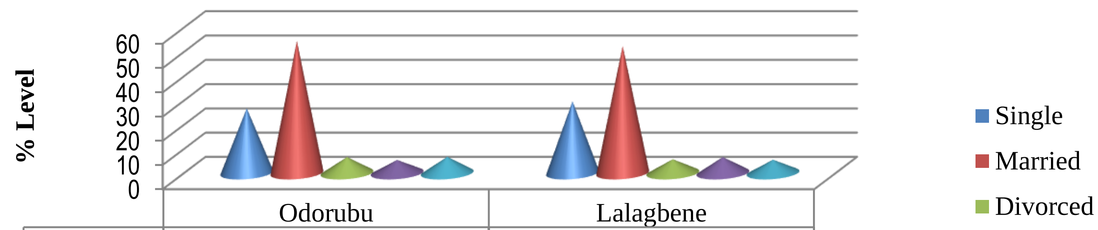
Source: NPC, 1991 and Projected at 2.83% Growth Rate and Base Year is 1991

Natural increases, like excess of births over deaths and migration are the two most known determining factors of population growth in the communities. The population growth may have been influenced by the recent oil exploration activities and entitlements given to the various community leaders. It is therefore, to be expected, that the Iseni Oil Well project affected communities has actually witnessed an increase over the years.

Household Size and Marital Status of Sampled Population

The sizes of families varies from community to community and influenced significantly by the cultural attitude of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. The total of 3,919,364 households were enumerated during the preparation of the Niger Delta Regional Master Plan Development with an average household size of 7.5, but with more than 70% of them having an average of 8 occupants. Large households were found more prevalent in the rural areas (NDDC 2006). The average household size in the region however comes down to 6 persons with considerable variations among the individual States, Local Government Areas and Senatorial districts.

The large household size is ascribed to several reasons in the studied communities in particular and the Niger Delta region as a whole. Marriage is a socio-cultural norm that is highly recognized and those that marry do so sometimes at a relatively earlier age. Some men marry more than one wife (i.e. polygamy) as well as other concubines they keep. On the average, about 53.5% of the sampled respondents are married while about 28.25% are single. Those divorced 6.15%, separated 6% and those living as a widow account to 6.1% (Fig. 4.6a)

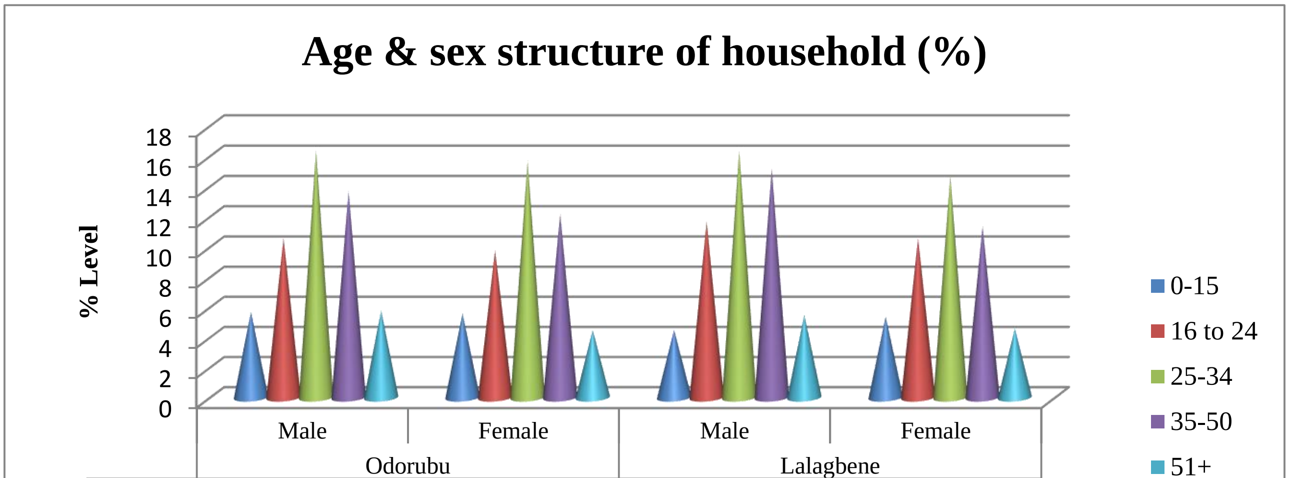


	Odorubu	Lalagbene
Single	26.8	29.7
Married	54.5	52.5
Divorced	6.6	5.7
Separated	5.4	6.6
Widowed	6.7	5.5

Fig. 4.6a: Percentage composition of Marital Status in Odorubu and Lalagbene communities

Household and Population Structure

The household structure of Iseni oil well project affected communities' reflects the patriarchal structure of most Nigerian ethnic groups. Men are typically the head of Nigerian households and there are overwhelmingly more male (93%) heads of households than females (7%) in the Niger Delta. Traditionally, the male is responsible for all the major household decisions. The socio-economic survey of the communities showed households' structural composition to be typically pyramidal; i.e. broad-based with the younger ones predominant and the aged fewest in proportion. On the average, children aged 0-15 years are 10.2% of the household members and children aged 16-24 years (secondary school age) constitute about 21.35% of the population. The age range of 25-34 years is 31.6% and 35-50 years 26.25% (both active working proportion) and the aged (51 years and above) make up 10.2% of the household composition (Fig. 4.6b). What this implies, given this age profile is that the population is young and growing. This places a heavy burden on the adult population, a high dependency ratio as well as a huge potential unemployed human number. There is therefore, the need to provide more training, including vocational education and educational facilities to accommodate this young and growing population.



	Odorubu Male	Odorubu Female	Lalagbene Male	Lalagbene Female
0-15	5.7	5.6	4.5	5.4
16 to 24	10.6	9.8	11.7	10.6
25-34	16.4	15.7	16.4	14.7
35-50	13.7	12.2	15.2	11.4
51+	5.8	4.5	5.5	4.6

Fig. 4.6b: Age and sex structure of sampled households

Sex distribution of the population in the community shows a disproportionate sex structure. The field survey reveal that the males are more in number constituting approximately 67.55% to the females 32.45% of the population, which is in line with the community's' population structure (Fig. 4.6c). According to the 2006 census, the males (71,345,488) out-numbered the females (69,086,302) with the male-female ratio as almost equal at 50.8% males to 49.2% females. Surveys carried out in the course of the Niger Delta Master Plan development process show that there are actually more males (54%) than females (46%) in the Region.

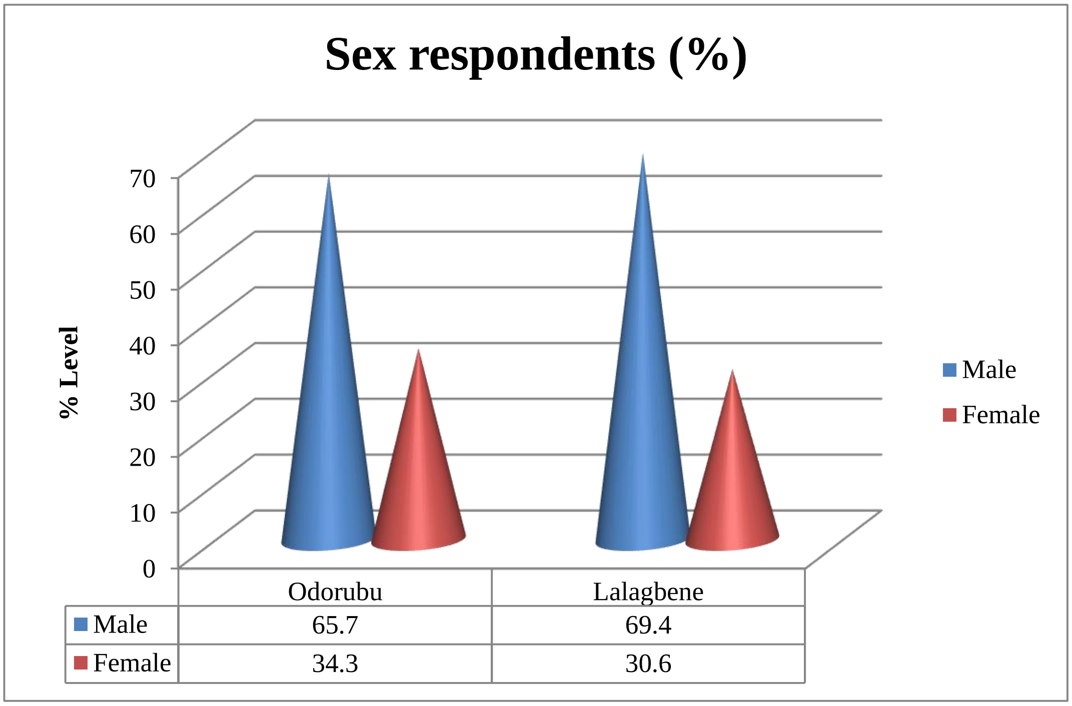
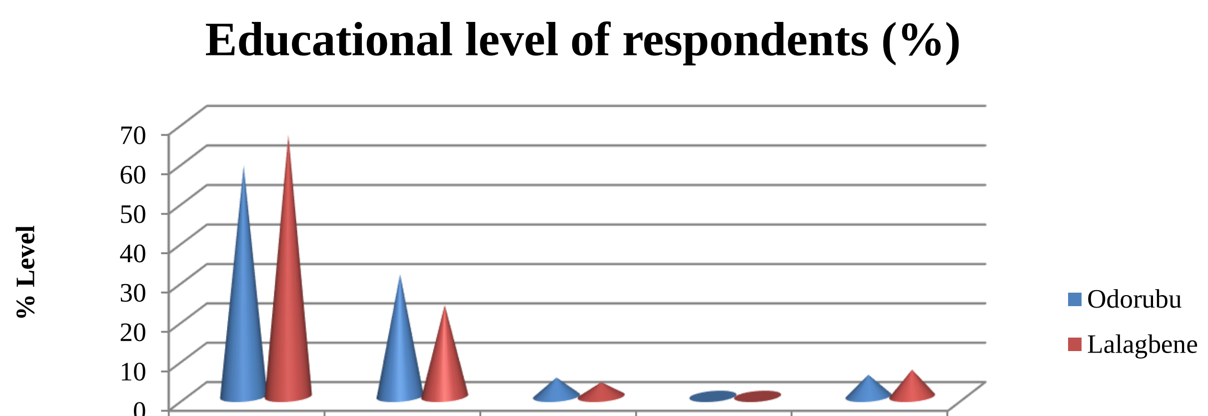


Fig. 4.6c: Age range of respondents

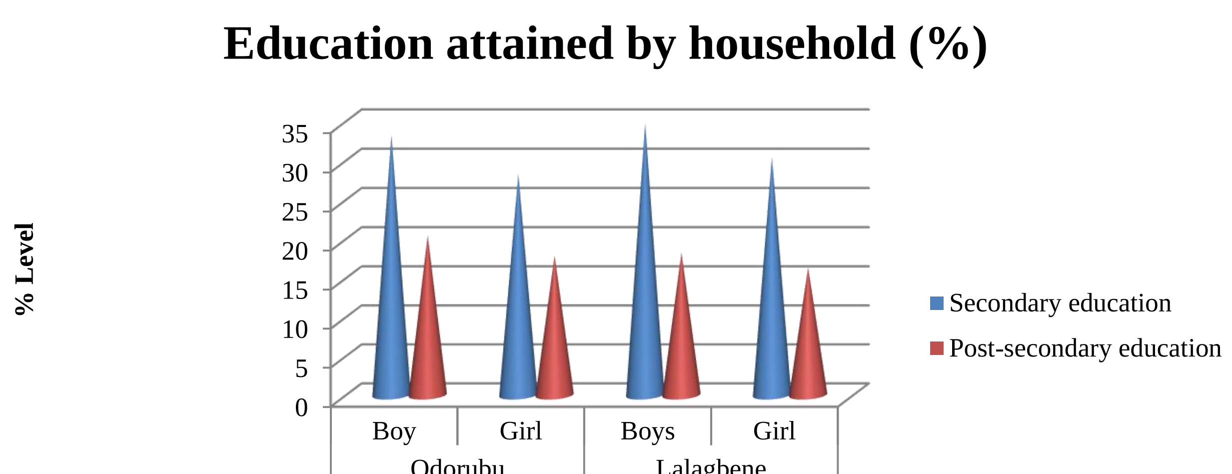
Educational characteristics

Education is a key determinant of the lifestyle and social status of an individual. . Studies have shown that educational achievement is highly correlated with individual health behaviours and attitudes. In the study communities, 93.85% of the total sampled population showed having some form of education, with people having post primary (secondary) educational attainment (62.4%). Also 27.15% of the sampled respondents possessed diploma certificates while 4.2% also have degree while 6.15% do not have any formal educational training (NFE). Meanwhile the possession of degree certificate was found to be lower with no respondents possessing higher degrees beyond the first degree. Literacy and educational attainment of respondents' children in the households showed that about 53.45% of the boys and 46.55% of the girls are presently attending various schools within and outside the community**.** Analysis further showed that 63.45% of the household have secondary education while 36.55% have post-secondary education.



	WASC/SSCE	Diploma	Degree	Master/Ph.D	None at all
Odorubu	58.6	31.1	4.8	0	5.5
Lalagbene	66.4	23.2	3.6	0	6.8

Fig. 4.6d: Education level of respondents



	Odorubu		Lalagbene	
	Boy	Girl	Boys	Girl
Secondary education	33.3	28.3	34.8	30.5
Post-secondary education	20.5	17.9	18.3	16.4

Fig. 4.6e: Education attainment of household

Institutional Arrangements and Traditional Governance

There exist an indigenous political system based on representative participation and fair sharing of power and responsibilities among the community members and age-grade associations. The Urhobo and Ijaw ethnic group are still governed on the principles of gerontocracy; executive, legislative and judicial functions are still vested in the hands of the oldest man and his Council of Chiefs. As a result, majority, if not all of the Urhobo and Ijaw communities, the traditional governance and power structure is organized into hierarchies from the clan level to the individual village/community down to the quarters that constitute each settlement.

The Ovie or Okpako in Urhobo land, and His Royal Highness (The Amanayebo) in Ijaw land, Council of Chiefs/Elders, the Town Union with both Federal (sons and daughters in Diaspora) and Home EXCOs, hardly distinguishable from the well-known CDC in some parts of the Niger Delta, the quarter chairmen, the youth group, and the women's forum respectively constitute the local and traditional administrative structures of the Iseni Oil Well project affected communities. Depending on the clan and the system of administration, the King or clan head is called the Ovie or Orodje or Osuvie, Okobaro, Okpako or Okpara-Uku in Urhobo, while Amanayebo in Ijaw and such title may be hereditary in some clans. While the kingship system maintained a highly centralized type of government with the King assisted by a council of chiefs, the clan head (in the rule by the elders system) is assisted in the day-to-day administration of the polity by titled officers selected from the various age grades recognized in the clan. Due to political expediency and the King in modern day Nigeria, the number of Urhobo and Ijaw clans adopting the Kingship system has increased. Today, the traditional political system operates side by side with the Western system. In some clan where the age grade system is recognized, the men are categorized into four (4) age grades namely – Ekpako, Ivwragha, Otuorere, and Imitete age grades. The grouping is based on age, life achievements, and contributions to the community. The women are also categorized into three (3) age grades – Evweya, Ekwokweya and Emete age grades. The categorisation is based on your child bearing status. The Ekpako and Ekwokweya age grade assist in the day-to-day running of the clan and serve as custodians of the Urhobo culture. While the Imitete and Emete age grade clean and keep the streets tidy, run errands and perform domestic duties. The Otuorere age grade performs heavy duties like bush clearing, building of shrines, construction works, burial and other social services. The working class and warriors belong to the Ivwragha age grade.

In the same vein, in Ijaw land, the traditional power structure include the Clan head (Monarch) and Council of Villages, Village Head (Paramount Chief) and Village Council, Elders/Councils of Chiefs, Community Development Committee (CDC), Women, Youth group, and other community members takes decision collectively with the clan head. The Clan head in Ijaw oversees his clan while the village head takes charge of their respective village and report to the clan head. Also, the Elders Council serves as advisers while the Community Development Committee takes charge of development issue; the youth serve as law enforcers. Also in the traditional power structures, there are several organizations, including those representing social and business interests such as farming, trading and co-operative societies for men, women and youth respectively. The typical traditional power structure is as depicted below:

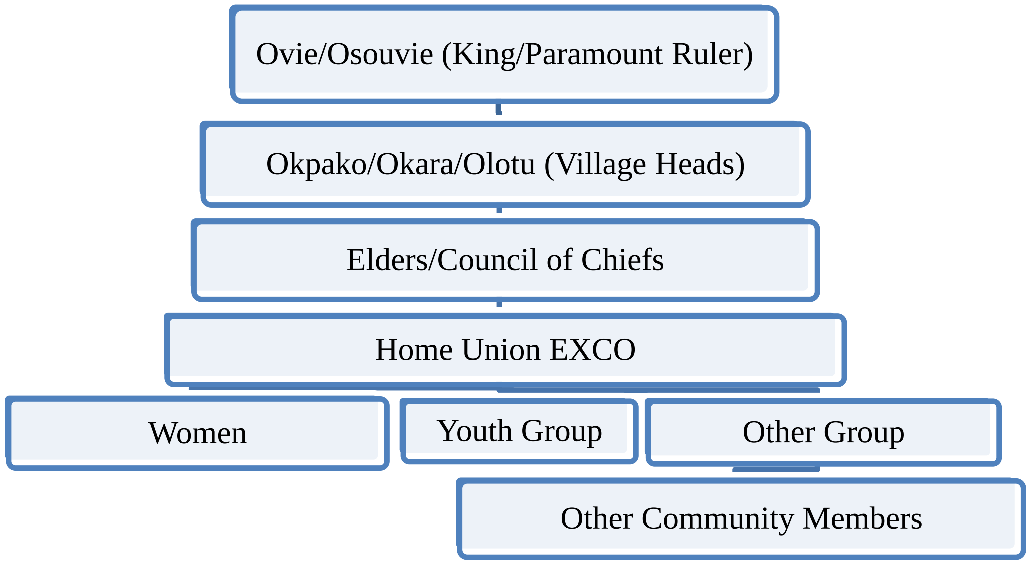


Fig. 4.6f: Typical traditional leadership structures in Odorubu community

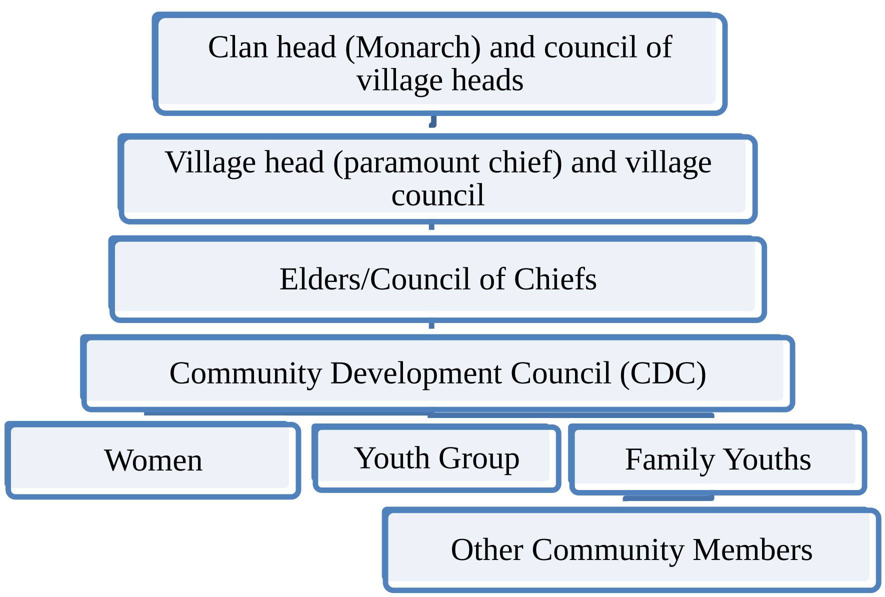


Fig. 4.6g: Traditional leadership structures in Lalagbene community

Conflicts and Conflict Resolution

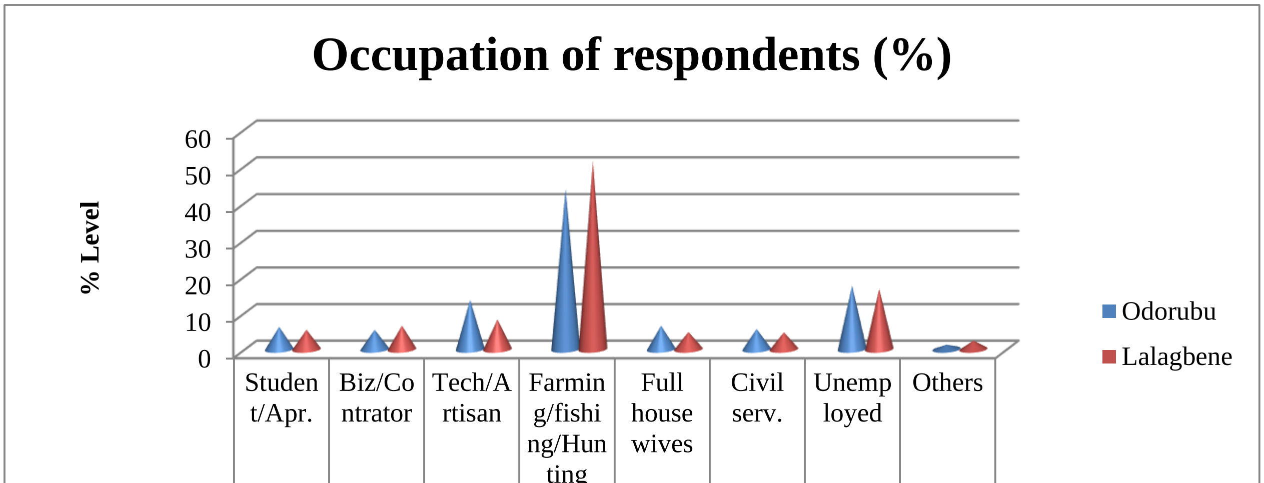
From the preceding narratives, conflicts and contentious issues are often resolved in the community in conjunction with the traditional head *(Ovie/Osouvie) and (Amanayebo)*, the Council of Chiefs/Elders, the Village Heads, Community Development Union or Committees (CDU/CDC), the Youths as well as Women groups. In the case that a community member goes contrary to the law, the issue is handled from the lower organ, youth or women group. When guilt is established sanctions are imposed according to the gravity of the offence. While, smaller crimes could attract payment of fines according to the nature and level of the offence as well. Serious cases involve meting out serious punishment and if it is impossible to resolve within the community these are handed over to the police.

Table 4.13b: Traditional Governance/Power Sharing and Community Structure in Iseni Project Affected Communities

Community	Community and Traditional Power Structures
Odorubu (Urhobo)	✓ Community is one of many constituent villages of the Okparabe Clan; the Ovie (king) of Okparabe Kingdom is traditional head of the clan. ✓ The *Okaro* as head of the council of elders oversees traditional and cultural matters of the village while the Town Union with a 10-member EXCO with tenure of 4 years and headed by the president attends to civil affairs of the community. ✓ Committees in charge of several issues, e.g. electricity, water, etc. reconstituted to aid governance. ✓ A taskforce is on ground in place of the youth group *(Uvwie)* while the Ekwokweya*/Emete* (women forum) with speaker as head complements the traditional power structures of the Olota and Alagbabri community. ✓ Decisions are usually taken after detailed deliberation on matters arising at the Town Hall, with all sons and daughters present and with the president presiding.
Lalagbene (Ijaw)	✓ Community is one of the many constituent villages of the clan; the Amanayebo (His Royal Highness) of the Kingdom is the traditional head of the clan ✓ The Royal Majesty (Oversees individual community that makes up the clan ✓ The Council of Chiefs are the Royal Highness cabinet that helps in making decisions in the Kingdom ✓ The CDC Chairman and his cabinet – takes charge of the day-to-day running of the community, ✓ The Youths Presidents and its cabinet – these people helps the community when necessary and enforce the law of the community ✓ The women leader and her cabinet – take care of the community women interest and sometimes assigned to clear the water front.

Occupation/Employment and Income Generating Activities

Responses from questionnaire analysis and Focus Group Discussions (FGDs) revealed that the project affected communities are primarily farmers and fishermen. Formal sector employment , trading, business/contracting, artisanship also forms part of the economic mainstay of the adult inhabitants (male and female). The average response shows that farming/fishing/hunting account for 47.65% of the primary occupation of the people. Also, 5.8% of the populations are student/apprentice, and 5.95% engages in business/contracting. Other economic activities include technical/artisan 10.9% and full housewives 5.6%. Also 5.15% of the sampled population are civil servants, 17.05% are said to be unemployed and others 1.85%. The 17.05% unemployed rate in the studied communities shows that employment issues are of serious concern in the project affected communities.



	Student/Apr.	Biz/Contrator	Tech/Artisan	Farming/fishing/Hunting	Full house wives	Civil serv.	Unemployed	Others
Odorubu	6.2	5.4	13.6	43.9	6.5	5.6	17.5	1.3
Lalagbene	5.4	6.5	8.2	51.4	4.8	4.7	16.6	2.4

Fig. 4.6h: Respondents occupation in Odorubu and Lalagbene communities

Land Use and Management

Land Ownership/Access and Tenure System

Generally, land is Nigeria's most important long-term resource and in areas where this finite resource is in short supply 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.

Land is a major factor of production for several activities including agriculture and industrial development. It is a finite resource. In other words, it is fixed in supply. Therefore, with a fast growing population as we have it in both States and its constituent council areas; land for all kinds of uses has become smaller with each passing year or even day. Land resource availability is limited in Iseni Oil Well project affected communities due to the fact that it is riverine with very limited land space either for habitation or cultivation. As such, the little available land is held in very high value. Of course, since lands on which oil wells and facilities are located gives huge benefits on the land-owning individual, family or community land tend to be protected by all means. Land in Nigeria falls under four broad ownership classes, depending on of who the law says holds the land in trust for whom. There are individually-owned, family-owned, communally-owned, and government-owned lands. In the communities studied, two forms of land-ownership are common. . These are family land and communal land ownership. Land in the community is owned by the founding families in the community and the power is vested in the hands of the eldest man in the family, while some portions are equally owned by the entire community. This implies that lands are passed down the generations and acquired through family inheritance. In recent times however, giving the fast urbanization of hitherto villages and towns, private ownership of land is increasingly becoming common, through the sale of land especially to non-indigene. Land made available to government and corporations (oil companies) for major public projects/utilities (schools, hospitals/clinics for example) come out of communally owned land as well as lands used by the community to set-up civic centre/town hall, markets, schools, places of religious worship).

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

Agricultural Produce/Fisheries and Productivity

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

Plate 4.5b: Plantain displayed for sale; Harvested palm fruit; Pelagic resource (periwinkles); & Forest resource product (Ogbolor) in the project affected communities

Market system

Even Although, the livelihood system is mainly subsistent, excess produce from the farms and fisheries are often taken to the markets for sale to earn incomes. Each of the community studied has a daily market. In addition there is a market that holds in Odorubu every eight (8) days. In the communities, market goods/articles can be found on display in numerous stores along the major streets and roads (Plate 4.5c).

Plate 4.5c: Typical market and display of goods at project affected communities

Traders in the communities with known market days also take their products to nearby markets like the ones that are held in Sagbama, Warri, Bomadi and Ughelli market.

Income Levels

Income is an important variable that influences socioeconomic status of individuals and its distribution pattern has the potential of influencing other demographic variables. As a result of poor record keeping, personal income levels of self-employed rural households are always difficult to determine. The result being that income levels of household members in the community are not easily determined. However, questionnaire analysis, though subject to some uncertainties could suffice. The income levels found to be meagre and variable had majority (34.65%) earning N10, 001–20,000 in a month, 34.45% of the population had income in the bracket of N20,001-50,000, and 14.5% earn less than N10,000. Meanwhile 10.6% earn between N50001-N80000 and 5.8% earn N80000 and above.

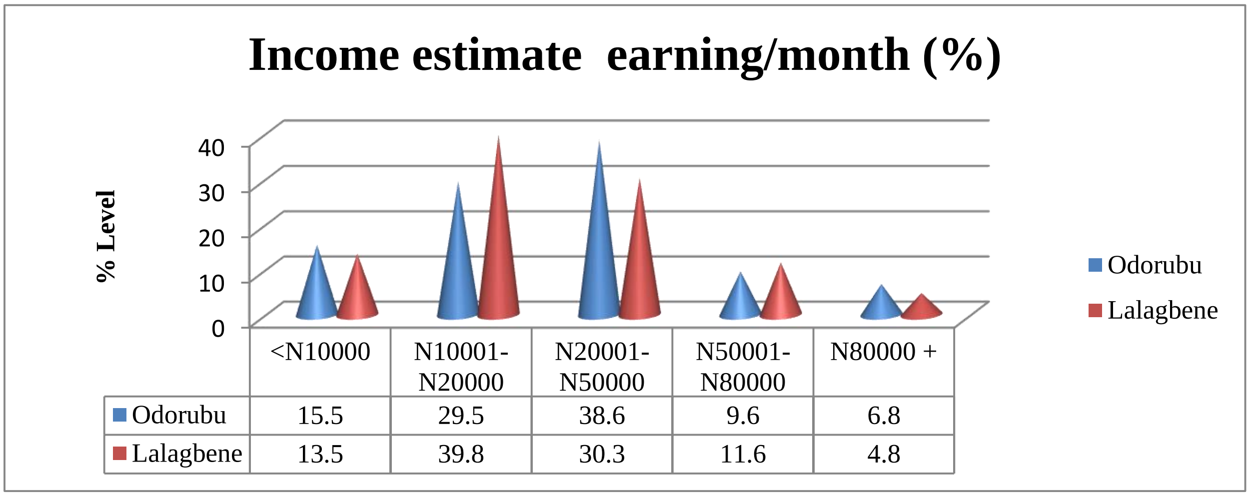


Plate 4.5d: Respondents income estimate/month

Infrastructure Quality of Life

The level of infrastructure and amenities available and functional in any area or community has direct relationship with the quality of life in a given area, and therefore the willingness of people to live and remain there. Again, it influences other socio-cultural and economic variables in the area. As important as income levels, availability and access to infrastructural basic necessities of life are to the measurement of quality of life. However, our rural areas have always been found to be deficient in this respect. More often than not, some infrastructures can be found, but these usually have low capacity, are either non-functional or in awful situation, which needs some form of rehabilitation. The Iseni project study environment and constituent communities are generally lacking of basic amenities. Educational institutions available are inequitably distributed and the few available are lacking basic teaching and learning materials, including teachers. Access to potable water, primary health care services are almost at zero and electricity is non-existent and even transports means to access Lalagbene community are difficult while Odorubu is fortunate to fall along the Ohoro-Bomadi road which can easily be accessed by road.

(a) Educational Facilities

The two project affected communities have government owned primary and secondary school except Lalagbene which have only primary school but no secondary school. The Lalagbene community children and wards go for their secondary education at the neighbouring communities and town like Ofoni, Sagbama and Bomadi etc. However, these primary schools need upgrading and staffing with appropriate incentives to enable the staff put in their best in educating the pupils. There is no post primary institution in Lalagbene community. The low number of educational institutions or facilities in the area may be responsible for the generally low level of literacy in the community as well as high school drop-out.

Table 4.13c: Summary of Infrastructures and Social Amenities Available in Iseni Oil Well Project Affected Communities

Settlement/ Community	Education	Energy/Electricity	Transportation/ Communication	Water & Sanitation	Housing/Others
Odorubu	✓ Has primary school by the Delta State government. ✓ Has a secondary school by the Delta State government	Has access to energy (electricity) through BEDC but supply had since been stopped by BEDC due to the community inability to pay the bulk bill usually given to them.	Accessible to community is via tarred road through Bomadi/Ohoro road	Has no access to potable water supply as at the time of this study. The water borehole available in the community are no longer functional	Housing of moderate to poor quality; predominantly block houses with zinc, plywood/zinc roof.
Lalagbene	✓ Has public primary school by the Bayelsa State government. ✓ No secondary school. The children and wards go to the neighbouring communities for secondary education.	Presence of electrification and powered by generator through the community self-effort but as at the time of field visit it is not functional as the gen is said to be faulty.	Access is only by water through Bomadi jetty.	Has no access to water supply. The available by NDDC is no longer functional. Depends mainly on pure (sachet) water and creek water for those who can't afford pure water always.	Housing of moderate to poor quality; predominantly mud houses with zinc, Mud with thatched roof, with few concrete/block house with zinc roof, and plywood/zinc roof

Plate 4.5d: Available educational facilities in the project affected communities

(b) Electricity Supply ad household energy

One of the communities in the Iseni Oil Well project communities (Odorubu) is connected to the national power grid, presently serviced by the Benin Electricity Distribution Company (BEDC) while Lalagbene is not. The Odorubu community, though connected to the national grid, does not have supply as at the time of this field study. The community is usually given bulk bill which is shared eight hundred naira each per household; however, the community could no longer afford the bill at a point. Consequently, the BEDC disconnected the community power supply and in the past two years, even as at the time of this field visit, power supply has not been restored.

On the other hand, the Lalagbene community through self-effort acquired a 250 KVA Generator that generate and supply power to the entire community but was said to have stopped functioning a week before this field visit due to defect on the generator. This is not unexpected because the percentage of households with electricity in Nigeria according to the most recent national demographic and health survey (NDHS 2008) is 50%. There were more households with electricity in urban areas (85 percent) than in rural areas (31 percent) (NPC and ICF Macro. 2009).

Overall, it is fair to conclude that the two communities do not have functional power supply source. In the absence of this basic amenity, community members who can afford it purchase private generators for personal use and for business (to power electrical appliances, such as refrigerators for cooling of drinks). The local hurricane lantern remain the most reliable means for lighting homes in the studied communities. Firewood (fuel-wood) energy is also used for cooking of foods and processing of fish (smoking).

Plate 4.5e: Harvested/harvesting firewood at Odorubu; 3-4 - Harvested firewood conveyed to Lalagbene community stored for use as primary fuel for cooking in studied communities

(c) Transportation and Communication

As a result of the remote location of the settlements and the physical conditions imposed by nature on the Iseni Oil Well project environment, the development of roads is naturally retarded and hence accessibility to and from the area is highly restraining especially Lalagbene community. Surrounded by water, the community is only accessible through water transportation such as hand-dug canoes (by residents in the villages/fishing camps particularly and for inter/intra community movement) and the popular outboard engine boats usually fitted with various grade of engines. The communities can be accessed from Odorubu and Bomadi. Marine transport to the Lalagbene community and proximate villages is however, difficult, risky and costly; travel time varies from about 50minutes to an hour from Bomadi jetty and about an hour to one and half hour from Odorubu jetty.

Motor cycle, popularly known as (Okada) is also a means of transport at Odorubu. From Odorubu to the jetty is N200 on bike and there are standby ones at the jetty ready to convey passenger coming from riverine communities to Odorubu where they can join road transport especially those going to Bomadi, Ohoro, Ughelli and Warri . A few commercial transport boats ply the creeks at regular intervals. Transport fares are generally exorbitant. For example, a chartered boat from Bomadi jetty to and from Lalagbene is N20, 000 while individual pays N3000 for return trip. The cost of living is generally very high. For instance a bottle of star larger beer is sold for N300, Can beer N250, Minerals drink N150, and Malt drinks N200 while a sachet of pure water is N20.

Access to public communication facilities like the telephone services in the Iseni Oil Well project communities was also found to be greatly limited. The new mode of telephony, the GSM common to most Nigerian communities was found to be less effective in the study area. Connectivity is limited to the MTN network at Odorubu while there is none at Lalagbene; hence resident population has limited access to telecommunication.

Plate 4.5f: 1 - Odorubu community jetty; 2 - Motor cyclist (Okada) waiting for passengers; 3 - Hand paddle canoe at Lalagbene community

(d) Water Supply

Increasing access to improved drinking water is one of the Millennium Development Goals that Nigeria and other nations worldwide have adopted. The source of drinking water is an indicator of whether it is suitable for drinking. Lack of ready access to water may limit the quantity of suitable drinking water that is available to a household, even if the water is obtained from an improved source. Water that must be fetched from a source that is not immediately accessible to the household may be contaminated during transport or storage. Another factor in considering the accessibility of water sources is that the burden of fetching water often falls disproportionately on female members of the household. Finally, home water treatment can be effective in improving the quality of household drinking water.

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

The availability of social infrastructures in the Iseni project communities, including potable drinking water are on ground but not functional. The sources of water for the population include shallow hand-dug wells, the natural rainwater and some of the creeks which have freshwater, for cooking and bathing as well as washing. The project affected communities have water facilities; Odorubu have two, Lalagbene has one but none of these water facilities provide water for the population. Lack of energy to pump the water and poor maintenance culture are the principal reasons for the non-functioning of the facilities. A common sight across the surveyed communities is the presence of containers (tanks, drums, basins and any useful vessel) that are placed outside the dwellings to harvest rainwater. Many households, depending on affordability use sachet (packet) water for drinking; a bag of sachet water is sold for N200 to N300 in the area.

Plate 4.5g: pic 1-2 (Water facilities at Odorubu community); pic 3 (the only water facility at Lalagbene community) which ought to be providing potable water for inhabitants but no longer functional.

(e) Housing Types and Ownership

The available houses in the Iseni project affected communities as at the time of the study were found to be built with unreliable materials such as reeds, thatch and wood/planks with few concrete/block houses with zinc roof. Along the shoreline, especially at Lalagbene, the houses are built on stilts which although fairly durable, are physically very fragile and un-attractive. Over-crowding and poor ventilation is an obvious challenge in the studied area. An average of 5 persons shares a hut (house) of one or two small rooms.

Plate 4.5h: pic.1-8; The housing type and quality in Iseni Oil Well project affected communities (Upper) pic.1-4 Lalagbene and (Lower) pic.5-8 Odorubu) is typical of a rural area; houses constructed of the mud walls with zinc are common as well as mud/thatched roof.

There are significant temporal variations or changes in housing quality across the study environment over the years, except that some renovations have been effected to make the dwellings more attractive and habitable. Thus, a significant proportion of the housing stock (64.5%) is constructed of mud walls with zinc roof. Houses made of wood/plank as walls with zinc roof also constituted some 14.4%, mud walls with thatch roof 12.5%etc. Meanwhile, insignificant proportions (8.6%) are made of concrete/block walls with zinc roof.

The Iseni Project affected communities are very organized social and hospital people. There are however, no dedicated meeting places in the communities; only Lalagbene community was found to have a place for communal gatherings. The Focused Group Discussions for this study at Odorubu was held at the CDC Chairman’s place. As such, the communities use improvised structures and places to receive visitors. Communal activities such as football, dancing, etc. are organized for recreation during festive periods. Common recreational activities among youngsters include football. The Odorubu community and its environs are relatively safe because of presence of a police station and organized vigilante group compared to Lalagbene where there is no police station and no organized form of local security. Government policing institutions are far from Lalagbene and its environs; the nearest one is located at Ofoni and Bomadi.

Plate 4.5i: Iseni Oil Well project affected communities gathering of community members during study

Perceptions, Concerns and Social Needs/Expectations of the Population

The general population in the study communities have mixed feeling on the proposed Iseni Oil Well Project and the expected operational activities as a whole in their area. A good number of those sampled and responses from Focus Group Discussion (FGDs) and key informants' interviews revealed that although, they are aware of the intensions of SPDC to start operation in the oil field but they are aware that such a project would have negative consequences on their environment and advised that due effort should be made to contain the negative consequences. This, according to the community members will help to enhance whatever positive impacts the projects will bring to the affected communities. Some of the listed negative impacts are increase in air/water pollution, influx of people seeking for job opportunities), land take , reduction of farm land, increase in cost of living, adulteration of culture and increase in motor/boat mishaps amounting to about 2.8%.

In spite of the foregoing, the community members belief that the benefits of the Iseni project will be enhanced if the negative impacts are properly mitigated. The identified the following as the expected benefits from the SPDC operation to the project affected community members. These include scholarship award to children and wards, provision of social amenities and renovation of the existing ones, and employment opportunities for the qualified and ready to work youths. The project affected communities when asked of their relationship with SPDC, Odorubu community acknowledged having a very cordial relationship with SPDC but Lalagbene community said otherwise, claiming of being marginalized as an oil producing community. They however, urge SPDC to do more development activities in the community. Community consultation, FGD and responses from the administered questionnaires at Lalagbene indicate that the resident populations are not in any way against the proposed Iseni oil well project and its operations amongst the affected communities.

Further Stakeholders Engagement

A general scouting exercise of the area would be undertaken before the commencement of the road and site preparation operations. The host communities would be informed on road construction and drilling operations during the social license to operate / stakeholder engagements and other subsequent people's fora (people's parliament, community/stakeholder relations committee meeting). Stakeholder consent would be obtained so as to operate in their area, get uninhibited access to living premises in the course of the constructions. Information would also be disseminated to Government agencies and NGOs and subsequently the contractor shall mobilize all necessary personnel, materials and equipment to site. Where contractor intends to use SPDC sites, permission shall be obtained in addition to obtaining formal SPDC's work order for the project. Prior to commencement or deployment of contractor equipment and personnel, SPDC shall carry out pre-mobilization inspection of all items and personnel and ensure appropriate certification of the machineries. Transportation on land will be by diesel-powered 4WD pick-ups and Personnel carriers while in creeks, transportation will be by diesel/petrol powered outboard engine (aluminium and fiber) boats.

4.7.14: Health Profile

This section discusses the health status of the proposed project communities which include Odorubu, Lalagbene and Ofoni. The health conditions of these communities are similar to those of the others in the Niger Delta region.

Demographic profile of the community

The population structure of the three communities is consistent with those of similar communities in the Niger delta (UNDP, 2006). Several members of the communities reside in Yenagoa, Port Harcourt and Warri; those that were permanent in the community were mainly the elderly, farmers, fisher-folks, traders and marine transporters. Almost all the indigenous members of the community have farming and fishing as their primary occupation; lumbering was also noted as sources of income for several members of the community. Farming was mainly carried out during the dry season, and at the bank of the river, because of the seasonal flood that is a perennial problem in the communities. Fishing is however the main occupation in the communities, though it appeared that the average catch has dwindled in the communities in recent years.

Morbidity pattern

The morbidity rates in the two communities, according to the discussants at the focus group discussion sessions held in the community are not different from those of other similar communities in Delta and Bayelsa State, and the rest of the Niger delta region. The commonest causes of ill health in the community were said to be malaria, typhoid fever, upper respiratory tract infections, skin and diarrhoeal diseases. These health problems are similar to the pattern noted in the records of the public health facilities that serve the community; and consistent with the diseases seen in other communities in Nigeria (2008 NDHS). This finding corroborates previous studies in the area (Odon/Ogara/Okpokunou SPDC EIA, 2010; Iseni Appraisal Well Project EIA, 2012).

The results of the water traffic analysis carried out in the community during the field study showed a small traffic of motorized boats, but most households in the community have an average of one dug-out boat, used for commuting and fishing. Water traffic accidents were said to be common, especially between dug-out canoes and speed boats, and during turbulence, but rarely result in fatality. This was attributed to the fact that most people in the communities could swim. However, a water traffic accident had sometime occurred in Ofoni resulting in some fatalities. Prevalence of non-communicable diseases: Like the situation in several rural communities in the Niger delta, the incidences of non-communicable diseases like hypertension and diabetes mellitus are beginning to rise in the two communities. This was indicated during the focus group discussions held in the community, and corroborated by the random measurement of blood pressure, carried out during the field study. Out of a total of 41 adults whose blood pressures were measured during the survey, 11 (26.83%) were hypertensive, as defined using the WHO/ISH criteria of systolic blood pressure greater than or equal to 140 mmHg and/or diastolic blood pressure greater than or equal to 90 mmHg. A study carried out in Barako, a rural community in Rivers State in 2010 reported a prevalence of 27.9% (Wokoma and Alasia, 2011). Of a total of 37 adults whose blood pressures were measured during the survey in Ofoni, 9 (24.32%) were hypertensive No member of the communities was able to point to someone that died of cancer, even as they believed that oil exploration and exploitation could cause cancer.

Mortality pattern

The mortality rates of the impacted communities are not higher than those of the neigbouring communities, according to the discussants at the focus group discussion sessions held in the communities. Maternal mortality rate in the communities was said to be comparable to those of the neigbouring communities. Maternal mortality resulting from pregnancy and childbirth rarely occurred. This was attributed to the expertise of Traditional Birth Attendants and Masseurs in the communities and easy access to higher tiers of health facilities in Yenogoa, Warri and Ughelli in the event of emergencies. Maternal mortality rates in all communities were lower than the national average. The causes of the maternal deaths recorded in the communities in the last five years, according to verbal autopsy were: prolonged labour, post-partum haemorrhage, abortion, especially following a teenage pregnancy; and eclampsia. These causes are also consistent with the findings in most other communities in Nigeria (NDHS2008). While the average number of under-five deaths in Lalagbene and Odorubu was put at three per year (approximately 6 per 1,000), that of Ofoni was reportedly 62 (approximately 31 per 1,000). Overall, these rates are lower than the national average of 92 per 1000). The common causes of under-five mortality include: malaria and its complications, especially anaemia and febrile convulsion, gastro-enteritis (diarrhoea and vomiting), acute lower respiratory tract infection; and vaccine preventable diseases, especially measles. These causes are also common in most other communities in south-south Nigeria (NDHS, 2008), but they point to poor environmental conditions, poor health seeking behaviour, and poor standard of health care delivery in the communities. The study shows an improvement in the child and maternal mortality rates as compared with the situation in the previous Iseni study of 2012.

Healthcare Facilities

Availability:

Primary Health Centers: All three communities have a health center that served their primary health care needs, although the services were often not provided on a regular basis. The health centers are however poorly staffed and provide mainly immunization services, and out-patient treatment of some minor ailments. This encouraged the patronage of traditional medicine practitioners like masseurs and Traditional Birth Attendants, who are especially cherished by most members of the communities.

Plate 4.6a: Uncompleted cottage hospital at Odorubu community

***Secondary health care facilities*:** The members of the communities access secondary health care services from the hospitals in Patani and Bomadi, which are about 90minutes travel time from the communities.

Plate 4.6b: Private health facility at Odorubu community

Tertiary health care: For tertiary health care, members of the communities can easily access the Central hospital Warri and the Delta State University Teaching Hospital in Oghara. These tertiary health care facilities have at least a thousand in-patient beds between them, and provide services in almost all specialties of medicine, including emergency care, orthopedics, medical and surgical care, and at a cost that is affordable to a large proportion of the citizenry. Medical Emergency Evacuation System: There was no formal medical emergency evacuation system in all the host communities. Members of the communities make their own private arrangement in conveying their sick for appropriate treatment. Generally, the situation with availability of healthcare facilities remains the same as was found in the Iseni HIA study of 2012.

Plate 4.6c: Ofoni Health Centre

Maternal & Child Health (Neonatal)

Immunisaton Status

The immunization coverage using Oral Polio and Measles vaccination among children were all below the national average as was found in the previous study of 2012 (Fig. 4.7a).

Fig. 4.7a: Immunization status of children in Ofoni community

Knowledge, Attitude, Practices And Behaviour (KAPB)

Presence of risk factors (Use of alcohol and cigarette)

Alcohol and tobacco were commonly used in the Odorubu, Lalagbene and Ofoni like most communities in south-south Nigeria. Alcoholic beverages, including the locally distilled gin called *kai*-kai or *ogogoro,* were freely available, and at all time in the communities. Alcoholic beverages were used during social functions and even in ancestral worship; alcohol is also a ubiquitous solvent for several traditional medicine, ranging from pain relief to aphrodisiac. However, cases of alcoholism were said to be low, in spite of the large number of persons that take alcohol in the communities. Binge drinking was however said to be high in the communities, especially during festive periods and burial ceremonies, when indigenes converge, from all works of life. Smoking is common in the three communities, especially amongst young men. About a fifth of adult males in the communities were said to smoke cigarette, but an average smoker takes at most three sticks of cigarette a day. Women in most of the communities rarely smoke cigarette. This is consistent with the findings in the 2013 Iseni study. Previous studies showed that 60% of adult males, as opposed to about 20% in this study, smoke.

Sexual behaviour

The sexual behaviour of members of the communities can encourage the transmission of sexually transmitted infections, including HIV/AIDS. Polygamy is common, most adult males and single girls in the communities have multiple sexual partners, while fidelity in marriage is for women, as a man is culturally permitted to engage in extra-marital affairs.

The sexual behavior of the communities is not different from that of the other communities of the South-South region of Nigeria. According to 2003 Nigerian National HIV/AIDS and Reproductive Health Survey (FMOH, 2004).The age at first sexual intercourse in the Niger delta region was about the lowest in the country at 16.7 years; lower than the national average of 16.9 years. 20.9% of women in the region had sex with a non-marital partner in the 12 months before the study, which was much higher than the national average of 9%.

15.3% of women aged 15 – 29 years in the region had sex in exchange for gift or favour, compared to 2.8% in the North east zone, and 8.3% in the South east zone. The national average was 6.9%. 5.9% of women aged 15 – 29 years in the region had sex with multiple partners in the 12 months before the study, compared to 1.1% in the North West zone and 2.0% in the South west zone. The national average was 2.7%. 18.2% of women aged 15 – 29 years in the region had at least one non-marital partner, while 2.6% had more than one partner, compared to 1.3% and 0.5% in the North West, and 8.9% and 2.5% in the South-East. The national averages were 7.6% and 1.3% respectively.

Knowledge of HIV/AIDS

Most discussants in the focus group discussions conducted in the communities in the course of this EIA have heard of HIV/AIDS, and could mention at least two routes of transmission of the disease. The knowledge of the routes of transmission of HIV was however noted to be poor. There is therefore a need to educate members of the communities before the commencement of project, especially if massive influx of workers into the communities is expected during the project. It is important to ensure a high knowledge of the routes of transmission of HIV, because oil/gas projects in the Niger delta have been found to increase HIV transmission rate (Nwuche Therefore, there is need to educate members of the community before the commencement of the project, especially if massive influx of workers into the communities is expected during the project (Akani 2006).

Environmental Health Factors

Access to safe drinking water

The sources of drinking water of members of communities

Access to potable water is one of the Millennium Development Goals. Most members of the two impacted communities of the Iseni Well project are able to meet the daily per capita water requirement of 20 – 40 liters, as targeted by goal seven of the Millennium Development Goal for environmental sustainability. Howbeit, most of the water comes from a variety of unimproved sources such river, hand-dug well and rainwater (during the rainy season).

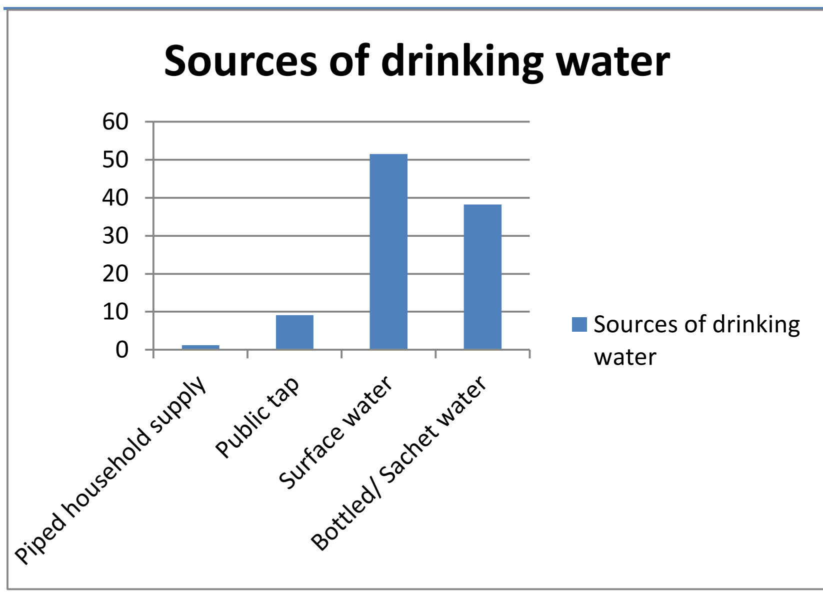


Fig. 4.7b: The sources of drinking water of members of the communities

The sources of drinking water in the Odoboru and Lalagbene communities are as shown in Fig. 4.7b. The main sources of drinking water in the communities include sachet/bottled water, river, borehole and rain. The water situation in the two communities is thus consistent with the findings in similar communities in south-south Nigeria (NDHS 2008); a sachet of water cost as much as N20 in the community, while the boreholes in the communities often break down, such that some members of the community are forced to use water fetched from the river for cooking, bathing and other cleaning purposes. Most community members spent less than 30mins to complete the round trip to the water sources. This is mainly because the public boreholes in the communities were often not reticulated, and those with some reticulation often did not have enough standpipes to adequately serve the needs of members of the communities. Several of the water facilities in the communities were also noted to be non-functional, as at the time of the field study. The water situation in the communities is however consistent with the figures obtained during the 2008 National Demographic and Health Survey. According to the survey, 71.5% of Nigerians residing in the rural areas had access to water within 30 minutes.

Most of the water facilities in the communities were provided by government and its agencies, but this also includes the protected hand-dug well-constructed during the colonial and immediate post-colonial periods, and the hand-pumped well provided by several ad-hoc government water supply programmes. A good number of the water facilities in the communities were also provided by the oil companies, either as part of their social responsibility to the communities, or as part of the remediation for an oil spill. Most of the public water facilities in the communities were however noted not to have any plan for their maintenance, such that they become non-functional few months after they were commissioned.



Plate 4.6d: The various water facilities in the two communities: A hand-pump provided by the government, a private borehole and articulated, but non-functional water facility

Addressing the water problems of the two communities would basically require the institution of a proper management structure for the facilities, since the facilities were mostly already in place (Ordinioha and Adeosun 2008). This would require not only the empowerment of members of the communities, but also the provision of technical support, by the government, its agencies, and/or the oil companies operating in the communities. The Village Level Operation management of Maintenance (VLOM) advocated at the start of the International Drinking Water and Sanitation decade, for the maintenance of water facilities is specially recommended to ensure the sustainability of the water facilities in these communities (WEEL 1998).

Access to potable water was considered a problem by some members of the Ofoni community, in spite of the riverine nature of the community. The main sources of drinking water in the community were sachet/bottled water, river, borehole and rain. Most of the water borehole facilities were provided by the government, its agencies and the oil companies that operate in the area. In previous studies, there was no municipal water supply to Iseni community. However, because of operational and maintenance problems of the community's water facilities, several members of the community fetch the water used for cooking, bathing and other cleaning purposes from the river or depend on rain water.

A: Manual Borehole Pump B: Private owned BoreholeC: MDG water project

Plate 4.6e: Water facilities in Ofoni community

Water quality

Data obtained for surface and groundwater as assessed by the relevant bio-physical experts during the field studies shows that the surface water is slightly acidic and contains an unacceptably high coliform count. This confirms that the surface water in the community is not potable without treatment.

Access to sanitation facility

Access to sanitation facility is one of the Millennium Development Goals. Sanitation facility was defined during the community survey as a private excreta disposal facility that is either a toilet or a latrine, but not an overhung toilet, or a flush toilet without septic tanks that channels it effluents directly into the river. A household access was defined as when a household has a private sanitation facility, or shares a facility with not more than five other households in the building or compound (Billig *et al*, 1999). Most members of the more riverine Lalagbene community have a toilet facility within the recommended 50m distance from their houses, but most of the facilities are the jetty-type (over-hung) toilets that grossly contaminate surface water, and are not technically considered a toilet facility. Most members of the more upland Odorubu community however engage in open defecation. A number of flush toilets were however noticed in some of the modern houses in the communities, especially in the Lalagbene community, where some of the toilets were however noted to be without septic tanks and piped directly into the river. Some members of the Ofoni community had toilet facilities within the recommended 50m distance from their houses. However, due to proximity to the river, defaecation into the river was common practice. A number of flush toilets were, however, noticed in some of the modern houses. This situation may be responsible for the high coliform count recorded in the surface water of the study area.

Housing and vector/pest control:

The housing characteristics of twenty (20) houses located at the center of the two communities were noted during the community survey. There are several houses built with modern building materials in the communities, but several houses were also built with wooden or mud walls and thatch roof, or thatch walls and roof. Some of the houses were also found to be raised from the ground, to safeguard against the seasonal flooding that often plagues most of the communities. These houses were mostly built in the popular traditional architecture, and often without proper windows. The rooms are therefore poorly ventilated and offered little protection against disease vectors and pests, especially as the communities are at the river bank, or close to the forest. The biting nuisance of mosquitoes was so much in the communities that a night sleep was said to be almost impossible without a bed net. According to one of the discussants in a focus group discussion held in Lalagbene community: “mosquito plenty for Lalagbene community. everybody dey sleep with net”. Mosquitoes, tse-tse flies, chrysops and sand flies were the most important insect vectors identified during the field study. Majority of the houses in Ofoni were spacious, with modal walling and roofing materials. Concrete blocks and corrugated iron sheets (zinc) were used and a sizeable number constructed of wattle and daub (mud), some of which were rendered (plastered with cement). Most were well ventilated. The environmental hygiene practice in the community was such that encourages the thriving of disease vectors such mosquito, tse-tse flies, chrysops and sand flies which were the most important insect vectors identified during the field study.

Indoor and outdoor Air quality:

The use of firewood and other bio-mass fuel as domestic fuel is a major cause of indoor air pollution, with wide-ranging health implications (WHO, 2003). Firewood was the commonest source of fuel for domestic use in the two communities. It is also the main fuel used in fish drying, the predominant method of fish preservation in the community. The level of use of firewood in the communities is however consistent with the findings in other Niger delta communities where an average of 73% of the households in the communities was noted to use firewood as their primary energy source (UNDP, 2006). The results of the air quality measurement carried out during the field studies shows that the levels of particulate matter recorded in the communities were within the Federal Ministry of Environment acceptable limit. This is despite the extensive use of firewood in the community. This is commendable, considering that PM_{10} (Particulate Matter with diameter less than 10 microgram) do not just cause nose and throat irritation, but are also capable of lodging deeper into the respiratory tract to trigger off asthmatic attack and even cardiovascular illnesses. According to the 2008

NDHS, 3.5% of under-five children in the Niger delta region (south-south Nigeria) had symptoms of Acute Respiratory Infections compared to 1% in the south-west zone and 1.8% in the south-east zone. The national average was 2.2%.The WHO estimates a 0.74% increase in the daily total number of deaths, and 0.8% increase in the daily total number of hospital respiratory admissions for every 10ug/m^3 increase in SPM (WHO, 2000).

Waste management

The wastes generated in the communities are mainly garbage and other domestic wastes. These wastes are often dumped close to residential accommodation, or at the bank of the river, where they sometimes served for land reclamation and/or shoreline protection. Leaches from the wastes can however become a source of contamination of the water body. Besides, some chemical contaminants from domestic waste may bio-accumulate in aquatic animals and get to humans when such organisms are used for food. It can be concluded from the above findings that the environmental health situation in the Iseni community has not improved since the last study in 2012.

Plate 4.6f: Refuse dumped at the bank of the river

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

Most members of the the communities regularly eat the local staples of cassava, yam and plantain. These are starchy staples that are however complemented with fish and shell foods, the major agricultural produce of the people. Household food security situation in the two communities is good. The prevalence of under-weight under-five children is one of the indicators for goal one of the Millennium Development Goals. The nutritional status of members of the two communities was assessed during the field survey, through the anthropometric measurement of under-five children in the communities. Out of a total of 66 under-five children whose anthropometric measurements were taken during the survey, 7 (10.61%) were found to be under-weight. This level of malnutrition as shown in Fig. 4.7c is lower than the average for communities in the south-south zone, and much better than the national averages. The prevalence of malnutrition is however not only a reflection of the diet and socio-economic status of the people, but also points to the environmental conditions in the communities *(Ruel and Menon 2003).*

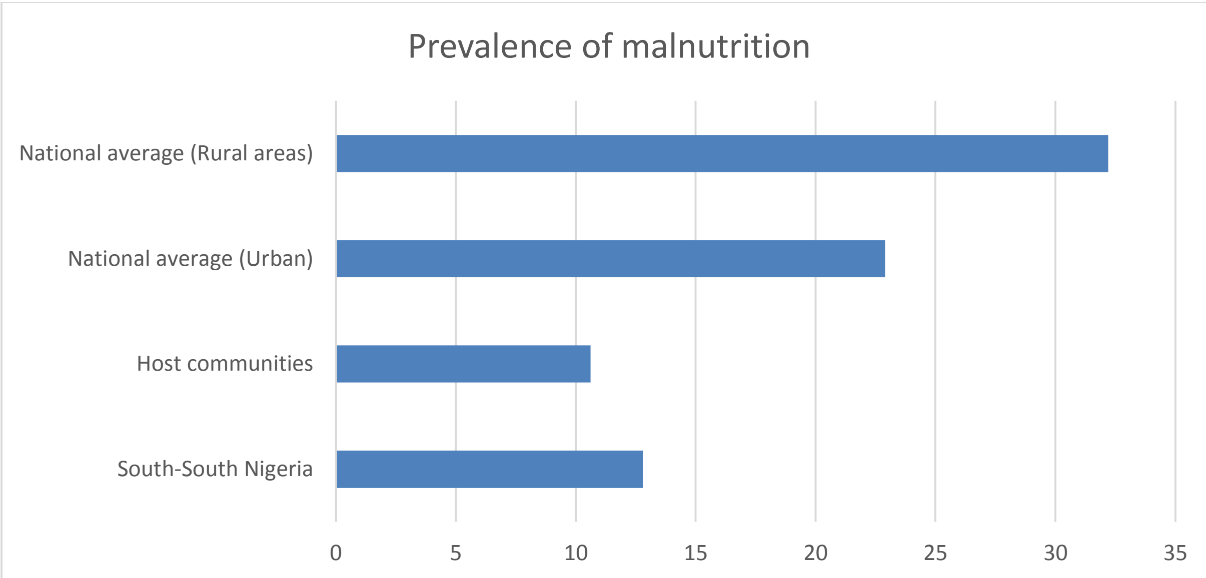


Fig. 4.7c: A comparison of the prevalence of childhood malnutrition

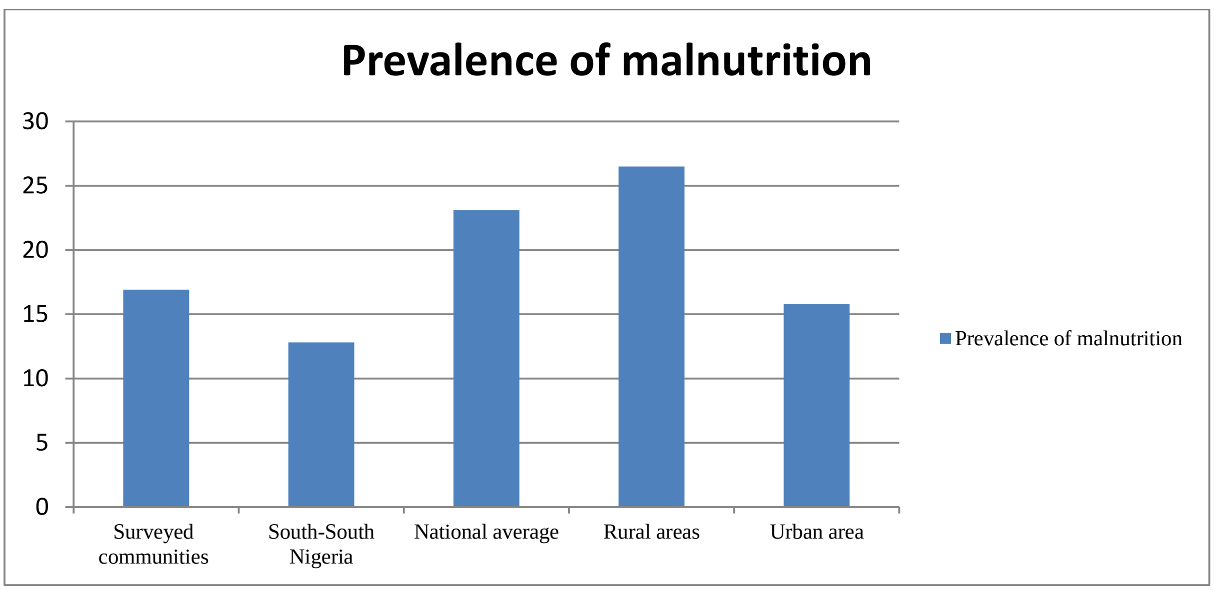


Fig. 4.7d: A comparison of the prevalence of childhood malnutrition

CHAPTER FIVE
ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1: Introduction

The proposed Iseni Appraisal Well, Access Road, Camp site and Ramp/Jetty Construction Project is likely to have biophysical, social and health impacts on the project area. Impacts may be potential impacts (i.e. those that may occur directly as a result of the project/project activities) or associated (indirectly from these project activities). The objectives of the impact assessment are to identify the potential and associated environmental, social and health impacts of the proposed project activities, evaluate the likelihood of occurrence as well as the magnitude and significance of identified impacts. Mitigation measures will then be proffered for the anticipated negative impacts, while measures would be provided for enhancing the positive (beneficial) impacts. Impacts were systematically established to be either significant or not significant. Not significant impacts were screened out. Significant impacts were assessed. Significant impacts may be positive or negative. Negative impacts were further classified as major, moderate, minor or negligible. Mitigation measures are proffered for the identified significant negative moderate and major impacts, while measures are provided for enhancing the positive (beneficial) impacts.

There are several approaches and techniques developed for evaluating potential impacts of any project on the environment. They include the Overlays techniques (McHarg, 1968); Leopold matrix (Leopold *et al*., 1971); Battelle Environmental Evaluation System (Dee *et al*., 1973) Peterson Matrix (Peterson et al., 1974) and ISO 14001 are among the most widely used methods employed for impact assessment. The ISO 14001 method is simple to apply and provides a high level of detail and also relies on limited data. The ISO 14001 method, therefore, is selected for the identification and evaluation of impacts for the proposed Project.

5.2: Uncertainties

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

- The natural variability of the environment, particularly the occurrence of rare events such as floods, unpredictable climate change and natural disasters;
- Inadequate understanding of the behaviour of the environment;
- Inadequate time-tested data for the area being assessed;
- Socio-economic uncertainties (inadequate data for prediction of human response to economic crises). There is always uncertainty in predicting the way a community will respond to the activities of oil companies in their domain.
- Health uncertainties such as the problem of determining the direct causes and effects of diseases, and that of ascertaining the disease vectors that are brought into the project environment by itinerant applicants.

In this study, we have endeavored to use available cost-effective techniques and review of published data to mitigate these uncertainties where possible.

5.4: 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

5.4.1: 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. These impacts include but not limited to the following:

- Noise and vibrations.
- Effects on Ecosystems.
- Effects on Socio-economics
- Effects on People’s Health

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

- FMEnv approved Environmental Impact Assessment for similar projects
- Procedure for Evaluation and Registration of Environmental Aspects, HSE P-04.
- Accompanying Guidelines for SPDC EIA Process, Report Review, SPDC 2004-0002713 Vol iv, 2004.

The identified potential impacts during the different phases of the proposed project are listed in Table 5.1.

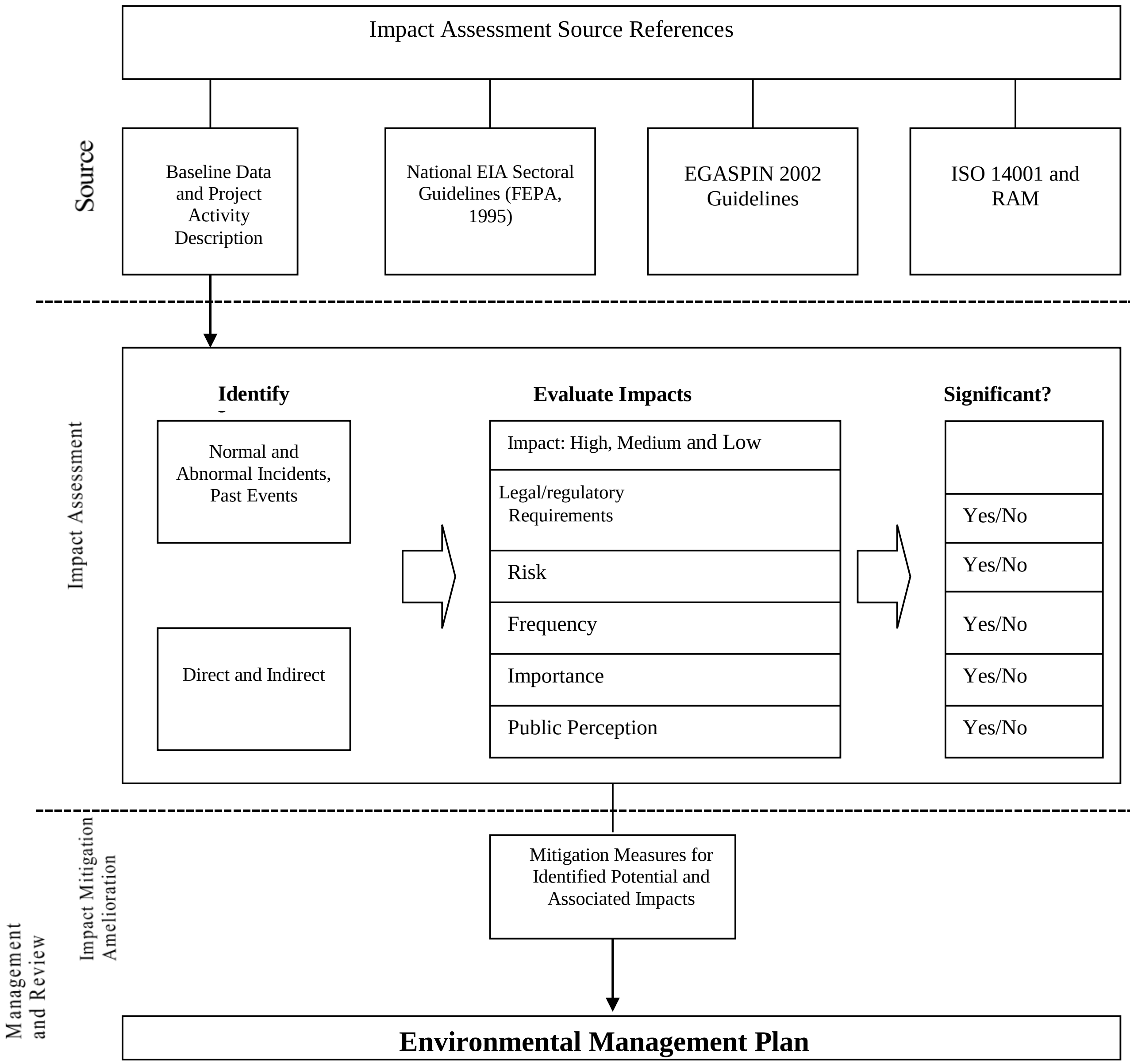


Fig. 5.1: Approach to Impact Assessment

Table 5.1: Checklist of associated and potential impacts of the proposed Iseni Appraisal Well, Access Road Camp site Ramp/Jetty Project

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
Premobilization and Mobilization	• Reconnaissance visit, Land take • Movement and transportation of equipment, personnel and materials	• Movement of Equipment materials and personnel to site by road and water transportation • Employment of labour	• Risk of road transport accidents from increased traffic • Risk of water transport accidents from increased traffic • Potential to disrupt vehicular traffic during movement of large equipment. • Air pollution from increased vehicular movement • Noise pollution from increased vehicular movement • Interference with local water transport and fishing activities due to increased traffic. • Third party agitation (locals, NGOs, etc) • Increased income • Increased pressure on existing social amenities/infrastructure from influx of job seekers • Stimulation of local economy and markets from increased demand for food, and other products in the local market. • Increased social vices and STIs including HIV • Kidnappings • Increase in inflation level • Inter and intra community conflicts • Changes in culture, lifestyle and habits • Loss of land due to land acquisition • Change in Land use • Increase in STDs
Site Preparation for drilling, access road and camp site Ramp/Jetty	• Clearing of vegetation from estimated 14,000.00 m^3 area within existing RoW, and acquired land • Sweeping the existing access route	• Vegetation cover clearing and de-stumping • Employment of labour	• Nuisance from cleared vegetation debris dust • Nuisance and threat to health from noise produced by equipment • Loss of biodiversity • Loss of habitat • Soil degradation • Third party agitation (community, NGOs, etc) • Pressure on community infrastructure (healthcare, housing, recreational etc.) • Stress on existing security structures as a result of influx of job seeker • Decreased access to farms and forest interior

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
			• Enhanced potential for deforestation through increased accessibility • Increase in dust, fumes, and reduction in air quality from equipment and activity Potential increase in erosion • Exposure of project workers to snake bites, insect bites, injuries etc • Increase in breeding grounds for disease vectors and other agents of diseases • Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc) • Opportunity for contracting and employment • Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits • Increase in social vices • Change in local population • Increase in inflation level • Increase in morbidity (including STIs) and mortality • Alteration of drainage pattern in the project area. • Water quality deterioration • Accident
Construction of Campsite	• Excavation • Sand filling with an estimated 40,000.00 m^3 of sand) • Concrete Works • Perimeter Block wall • Installation of Gates	•	• Soil degradation • Third party agitation (community, NGOs, etc) • Pressure on community infrastructure (healthcare, housing, recreational etc.) • Stress on existing security structures as a result of influx of job seeker • Enhanced potential for deforestation through increased accessibility • Increase in dust, fumes, and reduction in air quality from equipment and activity Potential increase in erosion • Exposure of project workers to snake bites, insect bites, injuries etc • Increase in breeding grounds for disease vectors and other agents of diseases • Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc)

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
			• Opportunity for contracting and employment • Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits • Increase in social vices • Change in local population • Increase in inflation level • Increase in morbidity (including STIs) and mortality • Constant lighting • Visual intrusion • Noise
Construction of Access Road	• Sub-grade excavation • Earthworks (Sand filling) • Base Preparation (Soil-Cement Stabilization and crushed rock filling) • Bituminous Surfacing • Installation of culverts	• Alteration of drainage pattern along the roads • Work place accidents • Fragmentation of habitats • Noise	• Soil degradation • Third party agitation (community, NGOs, etc) • Pressure on community infrastructure (healthcare, housing, recreational etc.) • Stress on existing security structures as a result of influx of job seeker • Enhanced potential for deforestation through increased accessibility • Increase in dust, fumes, and reduction in air quality from equipment and activity Potential increase in erosion • Exposure of project workers to snake bites, insect bites, injuries etc • Increase in breeding grounds for disease vectors and other agents of diseases • Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc) • Opportunity for contracting and employment • Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits • Increase in social vices • Change in local population • Increase in inflation level Increase in morbidity (including STIs) and mortality

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
Construction of Concrete Jetty &Concrete Ramp	• Piling Works • Mobilise piling rig to site • Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel schedule 40 casing) • Steel works • Reinforced Concrete works • Steel works (hand rails etc) • Installation of Bollards & Fenders • Dredging Works (Depending on siltation levels)	•	• Degradation of water quality (turbidity, total suspended solids) near the river bank • Loss of aquatic biodiversity and habitat. • Possible riverbank erosion from Jetty construction activities • Soil degradation • Third party agitation (community, NGOs, etc) • Pressure on community infrastructure (healthcare, housing, recreational etc.) • Stress on existing security structures as a result of influx of job seeker • Increase in dust, fumes, and reduction in air quality from equipment and activity Potential increase in erosion • Exposure of project workers to insect bites, injuries etc • Increase in breeding grounds for disease vectors and other agents of diseases • Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc) • Opportunity for contracting and employment • Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits • Increase in social vices • Change in local population • Increase in inflation level • Increase in morbidity (including STIs) and mortality • Noise • Loss of use of river bank • Accidents
Dredging of Forcados river and Sandwining	Acquisition of estimated 320,000.00m^3 of sand from the river bed.	• Removal of sand from Forcardos River for sandfilling of access road and drilling site. • Employment of labour •	• Nuisance from dredging activity due to hampering of free movement and fishing activity. • Degradation of water quality (turbidity, total suspended solids) • Loss of aquatic biodiversity and habitat. • Possible river bank erosion from wrong dredging procedure • Third party agitation (community, NGOs, etc)

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
			• Influx of labour and followers (dependants, bounty seekers, sex workers etc) • Opportunity to indigenes for contracting and employment • Pressure to abandon traditional occupations (farming, fishing, and hunting) for new job opportunities thus provided. • Changes in culture, lifestyle and habits • Increase in social vices • Change in local population size due to influx • Increase in inflation level • Increase in morbidity (from STIs) and mortality • Noise • Constant lighting • Visual intrusion due to pressure of dredger
Flowline laying and Hook-up	• Trenching • Stringing • Cleaning, bevelling and Pipeline bending • Welding • Radiography • Field Joint Coating • Lowering • Inspection, testing and NDT of welds • Cathodic Protection • Backfilling • Hydrotesting • Manifold works • Site Reinstatement • Extension of one of the existing well pads to accommodate manifold and flow line tie-in		• Loss of biodiversity(flora and fauna) including loss of plants of economic value along flowline RoW • Fragmentation of habitats • Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range • Igniting of welding flames red hot metals or flying sparks causing fires/explosion/injuries/loss of lives • Alteration of natural drainage patterns • Opportunity to indigenes for contracting and employment • Third party agitation (community, NGOs, etc) • Influx of labour and followers (dependants
Drilling	• Rig positioning • Boring • Logging • Casing	• Constant lighting • Visual intrusion due to presence of drilling rig.	• Contamination and degradation of soil, groundwater and surface water from drilling wastes and accidental spill • Release of gaseous pollutants including greenhouse gases to the recipient environment from equipment.

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
	• Cementation • Testing • Plugging	• Loss of biodiversity arising from avoidance of the area due to noise and constant lighting	• Noise and vibration from drilling operation with potential to cause localised nuisance and scare away wild life from natural habitat range. • Injuries and death from accidental blowouts • Continuous glare from rig operation at night with potential to scare wild life and affect vegetation physiology. • Inter and intra community conflicts • Increased cash flow and stimulation of local economies within the Community • Increase pressure on community social amenities/infrastructure due to infux • Third party agitation (Community, NGOs, etc) • Increase in social vices • Impact of domestic waste from camp base on the environment and aesthetics. • Constant lighting • Visual intrusion due to presence of drilling rig. • Loss of biodiversity arising from avoidance of the area due to noise and constant lighting
DEMOBILIZATION	ALL PHASES: • site preparation • road construction • dredging • drilling	• Clearing and removal of materials from site • Movement of Equipment (including rig), materials and personnel out of site by road and water transportation • Disengagement of labour	• Environmental nuisance arising from improper disposal of cleared materials • Loss of income for laid-off workers and contractors • Third party agitation (community, NGOs, etc) • Contamination of soil, surface and groundwater • Risk of road and water transport accidents from increased traffic • Potential to disrupt vehicular traffic during movement of large equipment. • Air pollution from increased vehicular movement • Noise pollution from increased vehicular movement • Interference with local water transport and fishing activities due to increased traffic. • Kidnappings
COMMISSIONING		•	• Gas leaks and explosions • Loss of properties/assets and lives from fire/blowout

Project Phase	Project Activity	Environmental Aspects	Potential and Associated Impacts
			• Generation of waste (Pigging waste, domestic waste, metal scraps, plastics) • Work related injury/fatality of workforce • Opportunity for direct and indirect Employment (Unskilled labour) • Gas flaring from well tests
OPERATION AND MAINTENANCE	Well work-over, Gas production	•	• Environmental pollution arising from improper disposal of lubricants and oily debris • Equipment failure and damage leading to injuries/fatality • Revenue generation to government and company • Oil (lubricants, fuels) and Gas leaks (fugitive emissions)
DECOMMISSIONING ,RESTORATION & ABANDONMENT		Dismantling , Evacuation and; Movement of equipment, materials and personnel; disposal of wastes; restoration	• Contamination of soil, surface and groundwater • Road and water traffic accidents • Potential of erosion around abandoned site • Restoration/Remediation

5.4.2: 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.

5.5: 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? (**Fig. 5.2 and Table 5.2**)

- 1 = Low risk
- 3 = Intermediate risk
- 5 = High risk

Consequence		**Increasing Probability**							
Severity	**People**	**Asset**	**Environment**	**Reputation**	**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 injury	No damage	No effect	No impact					
1	Slight injury	Slight damage	Slight effect	Slight impact		**Low**			
2	Minor injury	Minor damage	Minor effect	Minor impact		**Risk**			
3	Major injury	Moderate damage	Moderate effect	Modrate impact			**Medium**		
4	PTD of up to 3 fatalities	Major damage	Major effect	Major impact			**Risk**	**High**	
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact					

Fig.5.2: Risk Assessment Matrix

Table 5.2: Further definition consequence of - 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 neighbourhood
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

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 5.3.

Table 5.3: 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

5.6: Potential and Associated Impacts

The potential and associated impacts of the project from mobilisation to decommissioning and abandonment are presented in Table 5.4.

Table 5.4: Potential and Associated impacts of the proposed Iseni Wells Early Hookup to Domestic Gas Project

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
Pre-mobilization Consultation, Land acquisition and Compensation, Resolution of legacy issues	Increase in project awareness		√	√		√		√		0	1	3	3	3	10	6	H
	Anticipated Loss of land associated resources		√	√		√		√		3	1	3	3	3	13	6	H
	Financial enhancement	√		√		√		√		-	-	-	-	-	-	-	P
	Third party agitation		√	√		√		√		3	1	3	3	3	13	6	H
Mobilization Movement of equipment and personnel Rig movement	Impairment of air quality from emissions of air pollutants including greenhouse gases		√	√		√		√		3	1	1	3	3	11	4	M
	Increase in incidence of STIs including HIV		√		√	√	√	√	√	0	3	3	5	5	16	8	H
	Increase in noise and vibration/levels		√	√		√		√		3	1	3	1	3	11	4	M
	Interference with land transport		√	√		√		√		3	1	3	1	3	11	4	M
	Interference with water transport		√	√		√		√		3	1	3	1	3	11	4	M
	Road and water transport accidents		√	√		√		√	√	3	1	3	1	3	11	4	M
	Increased income	√		√		√		√		-	-	-	-	-	-	-	**P**
	Increased commercial activities	√		√		√		√		-	-	-	-	-	-	-	**P**
	Kidnappings		√		√	√	√	√	√	0	5	3	5	5	21	8	H
	Influx of workers into the host Communities/change in local population	√	√	√		√		√		0	5	3	3	5	16	6	H
	Changes in culture, lifestyle and habits	√	√	√			√		√	0	3	3	5	5	16	8	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Increase in social vices		√	√			√		√	3	5	3	5	5	21	8	H
	Increase in inflation level		√	√			√	√		0	3	3	3	3	12	6	H
	Inter and intra community conflicts		√	√			√	√		3	5	3	5	3	19	8	H
	Pressure on existing infrastructures and utilities		√	√		√		√		0	3	3	5	5	16	8	H
	Third party agitations		√	√		√	√	√		0	5	3	5	5	18	8	H
	Loss of land due to land acquisition		√	√		√		√		3	1	3	3	3	13	6	H
	Change in Land use		√	√		√		√		0	1	3	3	3	10	6	H
	Increase in STDs		√	√		√		√		0	1	3	3	3	10	6	H
Site Preparation for drilling, access road and camp site Ramp/Jetty	Loss of flora and fauna		√	√		√	√	√	√	3	3	3	3	3	12	6	H
	Loss of habitat		√	√		√		√		3	1	1	3	3	11	4	M
	Community unrest		√	√		√	√	√		0	5	3	5	5	18	8	H
	Pressure on existing infrastructure (health, recreational etc.)		√	√		√		√		0	3	3	5	5	16	8	H
	Increased level of noise and vibration with possible hearing loss		√	√		√		√		3	3	1	3	1	11	4	M
	Increase in dust, fumes, and impairement in air quality and noise		√	√		√		√		3	1	1	3	1	9	4	M
	Potential increase in erosion/alteration of drainage pattern		√	√		√		√		0	1	1	1	1	4	2	L
	Soil degradation		√	√		√		√		3	3	3	5	3	17	8	H
	Stress on existing security structures		√	√		√		√		0	3	3	3	3	12	6	H
	Threats to health of workers (snake bites, insect bites, injuries etc)		√	√			√	√		0	3	1	5	5	14	6	H
	Influx of labour and followers (dependants, bounty seekers, CSWs, etc)	√	√	√		√		√		0	5	3	3	5	16	6	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M
	Opportunity for contracting and employment	√		√		√		√		-	-	-	-	-	-	-	P
	Third party agitation		√	√		√	√	√		0	5	3	5	5	18	8	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Traditional occupation (farming, fishing, hunting) could be adversely affected from construction operations		√	√	√	√		√		0	3	3	1	3	10	4	M
	Changes in culture, lifestyle and habits		√	√			√		√	0	1	3	3	5	12	6	H
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Change in local population	√	√	√		√		√		0	3	3	3	3	12	6	H
	Increase in inflation level		√	√		√		√		0	3	3	3	3	12	6	H
	Increase in morbidity (including STIs) and mortality		√	√		√		√		0	3	3	3	5	14	8	H
	Impairement of water quality		√	√		√		√		3	3	3	1	3	13	4	M
	Injury/fatality of workforce and/or third party		√	√		√		√		0	3	3	1	3	10	4	M
	Habitat fragmentation		√	√		√		√		0	3	3	1	3	10	4	M
Construction of Campsite • Excavation • Concrete Works • Perimeter Block wall • Installation of Gates	Soil degradation/compaction		√	√		√		√		3	3	3	5	3	17	8	H
	Third party agitation (community, NGOs, etc		√	√		√	√	√		0	5	3	5	5	18	8	H
	Pressure on community infrastructure (healthcare, housing, recreational etc.)		√	√		√		√		0	3	3	5	5	16	8	H
	Stress on existing security structures as a result of influx of job seeker		√	√		√		√		0	3	3	3	3	12	6	H
	Enhanced potential for deforestation through increased accessibility		√	√		√	√	√	√	3	3	3	3	3	12	6	H
	Increase in dust, fumes, and impairement in air quality and noise from equipment and activity		√	√		√		√		3	1	1	3	1	9	4	M
	Potential increase in erosion		√	√		√		√		3	1	1	3	1	9	4	M
	Exposure of project workers to snake bites, insect bites, injuries etc		√	√			√	√		0	3	1	5	5	14	6	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc)	√	√	√		√		√		0	5	3	3	5	16	6	H
	Opportunity for contracting and employment	√		√		√		√									P
	Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits		√	√	√	√		√		0	3	3	1	3	10	4	M
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Change in local population	√	√	√		√		√		0	3	3	3	3	12	6	H
	Increase in inflation level		√	√		√		√		0	3	3	3	3	12	6	H
	Constant lighting		√	√		√		√		0	1	1	1	3	6	2	L
	Air quality and noise impairment		√	√		√		√		3	3	3	5	3	17	8	H
Construction of Access Road Sub-grade excavation Earthworks (Sand filling) Base Preparation (Soil-Cement Stabilization and crushed rock filling)	Soil degradation/compaction		√	√		√		√		3	3	3	5	3	17	8	H
	Third party agitation (community, NGOs, etc		√	√		√	√	√		0	5	3	5	5	18	8	H
	Pressure on community infrastructure (healthcare, housing, recreational etc.)		√	√		√		√		0	3	3	5	5	16	8	H
	Stress on existing security structures as a result of influx of job seeker		√	√		√		√		0	3	3	3	3	12	6	H
	Enhanced potential for deforestation through increased accessibility		√	√		√	√	√	√	3	3	3	3	3	12	6	H
	Increase in dust, fumes, and impairment in air quality/noise from equipment and activity		√	√		√		√		3	1	1	3	1	9	4	M
	Potential increase in erosion/alteration of drainage patterns		√	√		√		√		0	1	3	3	1	8	6	H
	Habitat fragmentation		√	√		√		√		0	3	3	3	1	8	6	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
Bituminous Surfacing Installation of culverts	Exposure of project workers to snake bites, insect bites, injuries etc		√	√			√	√		0	3	1	5	5	14	6	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M
	Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc)	√	√	√		√		√		0	5	3	3	5	16	6	H
	Opportunity for contracting and employment	√		√		√		√									P
	Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits		√	√	√	√		√		0	3	3	1	3	10	4	M
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Change in local population	√	√	√		√		√		0	3	3	3	3	12	6	H
	Increase in inflation level		√	√		√		√		0	3	3	3	3	12	6	H
	Increase in morbidity (including STIs) and mortality		√	√		√		√		0	3	3	3	5	14	6	H
Construction of Concrete Jetty &Concrete Ramp • Piling Works • Mobilise piling rig to site • Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel	Degradation of water quality (turbidity, total suspended solids) near the river bank		√	√		√		√		0	3	3	3	5	14	6	H
	Loss of aquatic biodiversity and habitat.		√	√		√		√		0	3	3	3	5	14	6	H
	Possible riverbank erosion from Jetty construction activities		√	√		√		√		0	3	3	3	5	14	6	H
	Soil degradation		√	√		√		√		3	3	3	5	3	17	8	H
	Third party agitation (community, NGOs, etc)		√	√		√	√	√		0	5	3	5	5	18	8	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
schedule 40 casing) • Steel works • Reinforced Concrete works • Steel works (hand rails etc) • Installation of Bollards & Fenders • Dredging Works (Depending on siltation levels)																	
	Pressure on community infrastructure (healthcare, housing, recreational etc.)		√	√		√		√		0	3	3	5	5	16	8	H
	Stress on existing security structures as a result of influx of job seeker		√	√		√		√		0	3	3	3	3	12	6	H
	Increase in dust, fumes, and impairement in air quality and noise from equipment and activity Potential increase in erosion		√	√		√		√		3	1	1	3	1	9	4	M
Dredging of Forcados river and Sandwining Acquisition of estimated 320,000.00m^3 of sand from the river bed.	Exposure of project workers to insect bites, injuries etc		√	√			√	√		0	3	1	5	5	14	6	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M
	Opportunity for contracting and employment	√		√		√		√									P
	Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities thus provided Changes in culture, lifestyle and habits		√	√	√	√		√		0	3	3	1	3	10	4	M

Project Activity	**Description of Impact**	**Impact Qualification**								**Impact Quantification**							
		Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	**Impact Rating**
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Change in local population	√	√	√		√		√		0	3	3	3	3	12	6	H
	Increase in inflation level Increase in morbidity (including STIs) and mortality		√	√		√		√		0	3	3	3	3	12	6	H
	Nuisance from dredging activity due to hampering of free movement and fishing activity. Degradation of water quality (turbidity, total suspended solids)		√	√		√		√		0	3	3	3	5	14	6	H
	Loss of aquatic biodiversity and habitat.		√	√		√		√		0	3	3	3	5	14	6	H
	Possible shoreline/bank erosion from wrong dredging procedure		√	√		√		√		0	3	3	3	5	14	6	H
	Third party agitation (community, NGOs, etc)		√	√		√	√	√		0	5	3	5	5	18	8	H
	Influx of labour and followers (dependants, bounty seekers, sex workers etc)	√	√	√		√		√		0	5	3	3	5	16	6	H
	Opportunity to indigenes for contracting and employment	√		√		√		√		-	-	-	-	-	-	-	P
	Pressure to abandon traditional occupations (farming, fishing, and hunting) for new job opportunities thus provided.		√	√	√	√		√		0	3	3	1	3	10	4	M
	Changes in culture, lifestyle and habits	√	√	√		√		√		0	3	3	3	3	12	6	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Change in local population size due to influx	√	√	√		√		√		0	3	3	3	3	12	6	H
	Increase in inflation level		√	√		√		√		0	3	3	3	3	12	6	H
	Increase in morbidity (from STIs) and mortality		√	√		√		√		0	3	3	3	5	14	6	H
Flowline laying and Well Hook-up	Loss of biodiversity(flora and fauna) including loss of plants of economic value along flowline RoW		√	√		√		√		0	3	3	3	5	14	6	H
	Fragmentation of habitats		√	√		√		√		0	3	3	3	5	14	6	H
	Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range		√	√		√		√		3	1	3	1	3	11	4	M
	Igniting of welding flames red hot metals or flying sparks causing fires/explosion/injuries/loss of lives		√	√		√		√		0	3	3	3	5	14	6	H
	Alteration of natural drainage patterns		√	√		√		√		3	1	3	1	3	11	4	M
	Soil erosion and run-off from flowline RoW		√	√		√		√		3	3	3	5	3	17	8	H
	Opportunity to indigenes for contracting and employment	√		√		√		√		-	-	-	-	-	-	-	P
	Third party agitation (community, NGOs, etc)		√	√		√	√	√		0	5	3	5	5	18	8	H
	Influx of labour and followers (dependants	√	√	√		√		√		0	5	3	3	5	16	6	H

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
Drilling • Rig positioning • Boring • Logging • Casing • Cementation • Testing • Plugging	Contamination and degradation of soil, groundwater and surface water from drilling wastes and accidental spill		√	√		√		√		3	3	3	5	3	17	8	H
	Release of gaseous pollutants including greenhouse gases to the recipient environment from equipment.		√	√		√		√		3	1	1	3	1	9	4	M
	Noise and vibration from drilling operation with potential to cause localised nuisance and scare away wild life from natural habitat range.		√	√		√		√		3	3	1	3	1	11	4	M
	Injuries and death from accidental blowouts		√	√		√		√		0	3	3	3	5	14	6	H
	Continuous glare from rig operation at night with potential to scare wild life and affect vegetation physiology.		√	√		√		√		0	3	3	3	5	14	6	H
	Inter and intra community conflicts		√	√		√	√	√		0	5	3	5	5	18	8	H
	Increased cash flow and stimulation of local economies within the Community	√		√		√		√		-	-	-	-	-	-	-	P
	Increase pressure on community social amenities/infrastructure due to infux		√	√	√	√		√		0	3	3	1	3	10	4	M
	Third party agitation (Community, NGOs, etc)		√	√		√	√	√		0	5	3	5	5	18	8	H
	Increase in social vices		√	√			√	√		0	3	3	3	3	12	6	H
	Impact of domestic waste from camp base on the environment and aesthetics		√	√	√	√		√		3	3	3	1	3	13	4	M
	Loss of biodiversity arising from avoidance of the area due to noise and constant lighting		√	√	√	√		√		0	3	3	1	3	10	4	M

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
Well & pipeline testing, Hydrotesting,	Potential for explosion		√	√	√	√		√		0	3	3	1	3	10	4	M
	Discharge of untreated test water into the receiving environment		√	√	√	√		√		0	3	3	1	3	10	4	M
Cathodic Protection	Exposure to radioactive material		√	√	√	√		√		0	3	3	1	3	10	4	M
DEMOBILIZATION	Impairment of air quality by emissions of air pollutants including greenhouse gases		√	√		√		√		3	1	1	5	5	15	6	H
	Noise and vibration nuisance		√	√		√		√		3	1	3	1	3	11	4	M
	Contamination of soil, surface and groundwater		√	√		√		√		3	3	1	3	3	13	4	M
	Injuries and death from blowouts		√	√		√	√	√	√	3	5	1	5	3	17	6	H
	Continuous glare from rig operation		√	√		√		√		1	1	1	1	1	5	2	L
	Inter and intra community conflicts		√	√			√	√		3	5	3	5	3	19	8	H
	Increased income	√		√		√		√									**P**
	Increase pressure on existing social amenities/infrastructure		√	√		√		√		0	3	3	5	5	16	8	H
	Complaints and agitation by locals		√	√		√		√		0	5	5	5	3	18	10	H
	Increased Social vices		√	√		√		√		0	3	3	5	5	16	8	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M
	Pressure on existing waste management system		√	√		√		√		3	3	3	3	1	13	6	H
	Road and water traffic incidents		√	√		√		√	√	5	1	1	3	3	13	4	M

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
	Environmental issues arising from improper disposal of cleared materials		√	√		√		√		3	3	3	3	1	13	6	H
	Loss of employment/income		√	√		√		√		3	5	5	3	5	21	8	H
	Inter and intra Community conflicts		√	√			√	√		3	5	3	5	3	19	8	H
Commissioning	Gas leaks and explosions		√	√			√	√		0	5	3	5	3	16	8	H
	Loss of properties/assets and lives from fire/blowout		√	√			√	√		0	5	3	5	3	16	8	H
	Generation of waste (Pigging waste, domestic waste, metal scraps, plastics)		√	√	√	√		√		3	3	3	1	3	13	4	M
	Work related injury/fatality of workforce		√	√	√	√		√		0	3	3	1	3	10	4	M
	Opportunity for direct and indirect Employment (Unskilled labour)	√		√		√		√		-	-	-	-	-	-	-	P
	Gas flaring from well tests		√	√	√	√		√		0	3	3	1	3	10	4	M
Operation and Maintenance Well work-over, Gas production	Environmental pollution arising from improper disposal of lubricants and oily debris		√	√			√	√		3	5	3	5	3	19	8	H
	Equipment failure and damage leading to injuries/fatality		√	√			√	√		3	5	3	5	3	19	8	H
	Revenue generation to government and company	√		√			√	√		-	-	-	-	-	-	-	P
	Oil (lubricants, fuels) and Gas leaks (fugitive emissions)		√	√		√		√		3	5	3	5	3	19	8	H
DECOMMISSIONING, RESTORATION AND	Contamination of soil, surface and groundwater		√	√		√		√		3	3	1	3	3	13	4	M
	Road and water Transport accidents		√	√		√			√	5	1	1	3	3	13	4	M
	Erosion around abandoned site		√	√		√		√		3	3	1	3	3	13	4	M

Project Activity	Description of Impact	Impact Qualification								Impact Quantification							
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	Impact Rating
ABANDONMENT Flushing of flowlines Vacuum drying of flowlines Capping of flowlines Removal of surface installations Plugging of wells Site restoration Return of land to owner(s)	Impairment of air quality by emissions of air pollutants including greenhouse gases		√	√		√		√		3	1	1	5	5	15	6	H
	Noise and vibration nuisance		√	√		√		√		3	1	3	1	3	11	4	M
	Contamination of soil, surface and groundwater		√	√		√		√		3	3	1	3	3	13	4	M
	Injuries and death from blowouts		√	√		√	√	√	√	3	5	1	5	3	17	6	M
	Continuous glare from rig operation		√	√		√		√		1	1	1	1	1	5	2	L
	Inter and intra community conflicts		√	√			√	√		3	5	3	5	3	19	8	H
	Increased income	√		√		√		√		-	-	-	-	-	-	-	**P**
	Increase pressure on existing social amenities/infrastructure		√	√		√		√		0	3	3	5	5	16	8	H
	Complaints and agitation by locals		√	√		√		√		0	5	5	5	3	18	10	H
	Increased Social vices		√	√		√		√		0	3	3	5	5	16	8	H
	Increase in breeding grounds for disease vectors and other agents of diseases		√	√		√		√		0	1	3	3	1	8	4	M
	Pressure on existing waste management system		√	√		√		√		3	3	3	3	1	13	6	H
	Road and water traffic incidents		√	√		√		√	√	5	1	1	3	3	13	4	M
	Environmental issues arising from improper disposal of cleared materials		√	√		√		√		3	3	3	3	1	13	6	H
	Loss of employment/income		√	√		√		√		3	5	5	3	5	21	8	H
	Inter and intra Community conflicts		√	√			√	√		3	5	3	5	3	19	8	H

Note: H: High, M: Medium, L=Low and P= Positive

High Impact: 93; Medium Impact: 46; Low Impact: 4 and Positive Impact: 12

CHAPTER SIX
MITIGATION MEASURES

6.1: Introduction

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

The mitigation measures proposed are in keeping with the following:

- Department of Petroleum Resources guidelines and standards;
- Environmental laws at national, regional and internal levels
- FMEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management.
- 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 practicable by implementing operational and management measures.

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

6.2: Selected Control Measures

A summary of the mitigation measures is presented in Table 6.1. These measures are recommended to ameliorate all the significant associated and potential impacts identified for the proposed Project.

Table 6.1: Mitigation measures for significant, associated and potential impacts of the proposed project

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
Premobilization Consultation, Land acquisition and Compensation, Resolution of legacy issues	Increase in project awareness	H	• SPDC shall ensure adequate consultation with all stakeholders especially communities.	L
	Anticipated Loss of land associated resources	H	• Land take shall be limited to the minimum required. • SPDC shall ensure consultation is done with the right responsible persons.	L
	Financial enhancement	P	-	P
	Third party agitation	H	• Relevant stakeholders/legacy issues shall be identified. • Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be carried out to understand community perceptions, issues and concerns • Effective liaison/communication channels (CICs) from the communities to the project execution team shall be established.	L
Mobilization Movement of equipment and personnel Rig movement	Impairment of air quality from emissions of air pollutants including greenhouse gases	M	SPDC shall: • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas	L
	Increase in noise and vibration/levels	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used	L

Project Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
			• provision of appropriate PPE	
	Interference with land transport	M	SPDC shall ensure: • regular maintenance of vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	L
	Interference with water transport	M	SPDC shall: • minimize movement during peak hours • SPDC shall notify the community of the movement on the waterways • regular maintenance of water crafts • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	L
	Increased income	**P**	-	**P**
	Increased commercial activities	**P**	-	**P**
	Kidnappings	H	• SPDC shall make adequate security arrangements for its operations. • SPDC shall ensure that members of staff are sensitized on the peculiarity of the project environment.	M
	Influx of workers into the host Communities/change in local population	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid and personnel	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	
	Changes in culture, lifestyle and habits	H	SPDC shall: • Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. Implement good assess control into the campsite	L
	Increase in social vices	H	SPDC shall: • carry out sensitization campaign on HIV, AIDs and other sexually transmitted diseases • regular medical check-ups are conducted for project work force • condoms are provided for workers • ensure restriction of workers to the camp	L
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community	L
	Inter and intra community conflicts	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	L
	Pressure on existing infrastructures and utilities	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers	L
	Third party agitations	H	• SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• Quickly resolve all misunderstandings with third party stakeholders	
	Loss of land due to land acquisition	H	• Land take shall be limited to the minimum required	M
	Change in Land use	H	• Alternative source of income shall be supported through the GMoU initiatives	L
	Increase in STDs	H	SPDC shall: • carry out sensitization campaign on HIV, AIDs and other sexually transmitted diseases • regular medical check-ups are conducted for project work force • condoms are provided for workers • ensure restriction of workers to the camp	M
Site Preparation for drilling, access road, camp site and Ramp/Jetty construction **Construction of Campsite** • Excavation • Concrete Works • Perimeter Block wall • Installation of Gates	Loss of flora and fauna	M	SPDC • shall limit clearing and all earth digging and other activities that may impact flora and fauna to only necessary areas SPDC shall carry out the re-vegetation of cleared area.	L
	Loss of habitat	M	SPDC • shall limit clearing and all earth digging and other activities that may impact habitat to only necessary areas SPDC shall carry out the re-vegetation of cleared area.	L
	Increase in dust, fumes, and Impairement in air quality and noise	M	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L
	Increased level of noise and vibration with possible hearing loss	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used	
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed • Remediate contaminated/polluted soils	L
	Threats to health of workers (snake bites, insect bites, injuries etc)	H	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community use of experts and best practices in its activities to reduce or eliminate breeding grounds for disease vector • ensure the use of PPE • ensure that there is site and camp base clinics/first aid and personnel	L
	Increase in breeding grounds for disease vectors and other agents of diseases.	M	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community • use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors • organize health awareness campaigns • embark on regular fumigation of facilities	L
	Influx of labour and followers (dependants, bounty seekers, CSWs, etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pre-existing facilities • ensure that there is site and camp base clinics/first aid and personnel	M

Project Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
			• ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	
	Community unrest	H	• SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue	M
	Pressure on existing infrastructure (health, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers capture provision of additional infrastructure as part of its GMoU with the community where required	M
	Opportunity for contracting and employment	P	NA	P
	Third party agitation	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M
	Traditional occupation (farming, fishing, hunting) could be adversely affected from construction operations	M	SPDC shall ensure: ▪ intensive enlightenment campaign alternative sources of livelihood ▪ ensure proper management of wastes ▪ ensure vehicles and water crafts are in good working condition ▪ Organise skill acquisition programmes	L
	Changes in culture, lifestyle and habits	M	SPDC shall:	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. • Implement good assess control into the campsite	
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff condoms are provided for workers.	M
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community • Promote alternative sources of livelihood	M
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within regulatory limits • Remediate contaminated/polluted soils as a result of SPDCs activities • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed in line with SPDC waste management policy • carry-out shore protection in areas susceptible to shoreline erosion • use sheet pilling of the area affected. • continuously monitor soil quality to ensure it is within regulatory limits	L
	Increase in dust, fumes, and impairement of air quality	M	SPDC shall: • use only pre-mobbed environmental friendly equipment	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	from equipment and activity Potential increase in erosion		• ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	
	Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE • continuously monitor noise levels to ensure it is within regulatory limits	L
	Pressure on community infrastructure (healthcare, housing, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required	M
	Stress on existing security structures as a result of influx of job seeker	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M
	Exposure of project workers to snake bites, insect bites, injuries etc	H	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			use of experts and best practices in its activities to reduce or eliminate breeding grounds for disease vector • ensure the use of PPE • ensure that there is site and camp base clinics/first aid and personnel	
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors • organize health awareness campaigns • ensure that there is site and camp base clinics/first aid and personnel	L
	Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pr-existing facilities • ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	M
	Opportunity for contracting and employment	P	NA	P
	Pressure to abandon traditional occupations (farming, fishing, hunting) for new Job opportunities	M	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required	L
	Increase in social vices	H	SPDC shall ensure:	M

Project Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
			▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff condoms are provided for workers.	
	Increase in inflation level	H	SPDC shall: ▪ Employ skilled and unskilled labour from the community in line with the local content policy ▪ Encourage skill acquisition in the community	M
	Impairement of water quality	M	• Waste management plans (in line with regulatory guidelines and SPDC procedures) shall be strictly adhered to during all phases of the project. • Wastes shall be segregated at source into color-coded or labelled bins and disposed of in line with a project specific waste management plan. • SPDC shall ensure that sewage wastes in base camps are properly managed. • Safe Handling of Chemicals (SHOC) cards shall be visibly displayed at all sites where chemicals are handled • Fuel, lube oils and chemicals shall be safely stored in containers in bonded areas	L
	Injury/fatality of workforce and/or third party	M	• SPDC shall enforce the use of appropriate PPEs (life jackets, work vests/ goggles etc). • SPDC shall ensure first aid box on site and emergency response and med-rescue/MEDEVAC are in place. • Toolbox meetings shall be held before the start of daily tasks • Awareness shall be created among site workers on the likelihood of exposure to poisonous wildlife & plants. • Trained First Aiders shall form part of the workforce	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• SPDC policy on road traffic journey management shall be adhered to (all journey must be approved, no night journeys, speed limits on land)	
	Habitat fragmentation	M	• Clearing should be limited to areas of operation. • Re-vegetation shall be undertaken after the project work where desirable.	L
Construction of Concrete Jetty &Concrete Ramp • Piling Works • Mobilise piling rig to site • Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel schedule 40 casing) • Steel works • Reinforced Concrete works • Steel works (hand rails etc) • Installation of Bollards & Fenders • Dredging Works (Depending on siltation levels)	Degradation of water quality (turbidity, total suspended solids) near the river bank	H	SPDC shall ensure that : • Water quality is monitored during piling activities	M
	Loss of aquatic biodiversity and habitat.	H	SPDC shall ensure that : • Dredging is reduced to as low as reasonably possible to reduce impact on water quality • use the best available technology (suction dredging) to minimize disturbance to riverbed topography • Water quality is monitored in during the dredging operation • Alternative source of potable water is provided for drinking if water quality is affected by dredging.	M
	Possible riverbank erosion from Jetty construction activities	H	SPDC shall ensure the use of sheet pilling for areas affected.	M
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed • continuously monitor soil quality to ensure changes are insignificant	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Loss of aquatic biodiversity and habitat.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • use the best available technology (suction dredging) to minimize disturbance to riverbed topography • deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	M
	Possible riverbank erosion from Jetty construction activities	H	SPDC shall ensure that: • best practices are employed during dredging to minimize impact on riverbank • use sheet pilling of the area affected.	M
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed • continuously monitor soil quality to ensure changes are insignificant	L
	Third party agitation (community, NGOs, etc)	H	• SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders • Resolve legacy issues if they exist	M
	Pressure on community infrastructure (healthcare, housing, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers capture provision of additional infrastructure as part of its GMoU with the community where required	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Stress on existing security structures as a result of influx of job seeker	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M
	Increase in dust, fumes, and impairement of air quality from equipment and activity	M	SPDC shall: • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L
Dredging of Forcados river and Sandwining	Nuisance from dredging activity due to hampering of free movement and fishing activity.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • dredging time is restricted to times that will have minimal impact on movement and fishing • minimize movement during peak hours • SPDC shall notify the community of the movement on the waterways • regular maintenance of water crafts • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	M
	Degradation of water quality (turbidity, total suspended solids)	H	SPDC shall ensure that : • Dredging is reduced to as low as reasonably possible to reduce impact on water quality • Best practices are employed during dredging to minimize impact on water quality.	M

Project Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
			• use the best available technology (suction dredging) to minimize disturbance to riverbed topography • deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms. • Water quality is monitored in during the dredging operation • Alternative source of potable water is provided if drinking water quality is affected by dredging.	
	Loss of aquatic biodiversity and habitat.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • best practices are employed during dredging to minimize impact on biodiversity • deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	M
	Possible river bank erosion from wrong dredging procedure	H	SPDC shall ensure that: best practices are employed during dredging to minimize impact on riverbank	M
	Third party agitation (community, NGOs, etc)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M
	Influx of labour and followers (dependants, bounty seekers, sex workers etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pr-existing facilities • ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Opportunity to indigenes for contracting and employment	P		P
	Pressure to abandon traditional occupations (farming, fishing, and hunting) for new job opportunities thus provided.	M	SPDC shall ensure: ▪ intensive enlightenment campaign on alternative sources of livelihood	L
	Changes in culture, lifestyle and habits	M	SPDC shall: • Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. • Implement good assess control into the campsite	L
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff condoms are provided for workers.	M
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community	M
Flowline laying and Hook-up • Trenching • Stringing • Cleaning, bevelling and Pipeline bending	Loss of biodiversity(flora and fauna) including loss of plants of economic value along flowline RoW	H	SPDC • shall limit clearing and all earth digging and other activities that may impact flora and fauna to only necessary areas • Carry out remediation of contaminated/polluted sites • carry out the re-vegetation of cleared area.	L
	Fragmentation of habitats	H	SPDC	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
• Welding • Radiography • Field Joint Coating • Lowering • Inspection, testing and NDT of welds • Cathodic Protection • Backfilling • Hydrotesting • Manifold works • Site Reinstatement • Extension of one of the existing well pads to accommodate manifold and flow line tie-in			• shall limit clearing and all earth digging and other activities that may impact habitat to only necessary areas • carry out the re-vegetation of cleared area.	
	Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	L
	Igniting of welding flames red hot metals or flying sparks causing fires/explosion/injuries/loss of lives	H	SPDC shall ensure: • provision of appropriate PPE • ensure Job Hazard analyses is done before activity • Pep talks done before activity • ensure that there is site and camp base clinics/first aid and personnel	L
	Alteration of natural drainage patterns	H	SPDC shall ensure: • Adequate backfilling of trenches • Land excavated only within RoW	M
	Opportunity to indigenes for contracting and employment	P	NA	P
	Third party agitation (community, NGOs, etc)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Discharge of untreated test water into the receiving environment.	M	SPDC shall ensure that; • waste management specifications and guidelines (especially with regards to the discharges into the environment) shall be complied with.	L
	Exposure to radioactivity and release of chemicals	H	SPDC shall provide; • radiation counter to workers for monitoring individual radiation levels. • provide and enforce the use of protective aprons. • ensure that the activity is carried out in accordance with standard procedures	L
Drilling	Contamination and degradation of soil, groundwater and surface water from drilling wastes and accidental spill	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • Remediate contaminated/polluted site(soil/groundwater/surface water) to regulatory standards • ensure wastes are properly managed • Alternative source of potable water is provided if drinking water quality is affected.	M
	Release of gaseous pollutants including greenhouse gases to the recipient environment from equipment.	M	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Noise and vibration from drilling operation with potential to cause localised nuisance and scare away wild life from natural habitat range.	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE • continuously monitor noise levels and ensure they are within regulatory limits	L
	Injuries and death from accidental blowouts	H	SPDC shall ensure: • provision of appropriate PPE • ensure Job Hazard analyses is done before activity • Pep talks done before activity • ensure that there is site and camp base clinics/first aid for its workers.	M
	Continuous glare from rig operation at night with potential to scare wild life and affect vegetation physiology.	H	SPDC shall ensure that night activities are avoided	M
	Inter and intra community conflicts	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M
	Increased cash flow and stimulation of local economies within the Community	P	NA	P
	Increase pressure on community social	M	SPDC shall:	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	amenities/infrastructure due to influx		• provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required	
	Third party agitation (Community, NGOs, etc.)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff and also provide condoms for her workers.	M
	Impact of domestic waste from camp base on the environment and aesthetics	M	SPDC shall ensure: Wastes are subjected SPDC Waste management procedure	L
	Loss of biodiversity arising from avoidance of the area due to noise and constant lighting	M	SPDC shall ensure that night activities are avoided	L
Well & pipeline testing, Hydrotesting,	Potential for explosion	M	• Emergency response procedures shall be put in place	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.	

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
Cathodic Protection	Exposure to radioactive material	M	• SPDC shall ensure that only certified personnel handle radioactive materials. • SPDC shall ensure that radioactive materials are stored safely. • SPDC shall ensure toolbox talks are conducted before the commencement of the job. • SPDC shall ensure appropriate PPEs are used by the workers	
Demobilization	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within acceptable standards	L
	Noise and vibration nuisance	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipments are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	L
	Contamination of soil, surface and groundwater	M	SPDC shall: ▪ ensure the use of experts and best practices in its projects activities ▪ ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards ▪ ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities ▪ ensure wastes are properly managed ▪ Alternative source of potable water is provided if drinking water quality is affected.	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Injuries and death from blowouts	H	SPDC shall ensure: ▪ provision of appropriate PPE ▪ ensure Job Hazard analyses is done before activity ▪ Pep talks done before activity ▪ Adequate MEDEVAC in place in case of accidents	M
	Continuous glare from rig operation	H	SPDC shall ensure: ▪ Avoid night activities	M
	Inter and intra community conflicts	H	SPDC shall: ▪ establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof ▪ Continuously engage third party stakeholders in dialogue ▪ Quickly resolve all misunderstandings with third party stakeholders	M
	Increased income	**P**	NA	P
	Increase pressure on existing social amenities/infrastructure	H	SPDC shall: ▪ provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities ▪ ensure that there is site and camp base clinics/first aid for its workers ▪ capture provision of additional infrastructure as part of its GMoU with the community where required	M
	Complaints and agitation by locals	H	▪ SPDC shall: ▪ establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof ▪ Continuously engage third party stakeholders in dialogue ▪ Quickly resolve all misunderstandings with third party stakeholders	M
	Increased Social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			▪ condoms are provided for workers.	
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : ▪ ensure proper housekeeping at its campsites and work areas ▪ carry out health sensitization for workers and community ▪ use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors ▪ organize health awareness campaigns	L
	Pressure on existing waste management system	H	SPDC shall ensure: ▪ treatment of all waste water to regulatory standards prior disposal ▪ provision of mobile toilets for its work-force ▪ regularly monitor the quality of effluent to ensure that it meets regulatory standards ▪ adhere to its waste management procedure	L
	Road and water traffic incidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water and the need for extra precautions through public enlightenment • Ensure that drivers are trained on defensive driving • compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk • carry out job hazard analyses	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Environmental issues arising from improper disposal of cleared materials	H	SPDC ▪ shall dispose dredge spoils in an environmentally-friendly manner	L
	Loss of employment/income	H	SPDC shall, • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Encourage skill acquisition in the community	L
	Inter and intra Community conflicts	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	L
Commissioning	Gas leaks and explosions	**H**	SPDC shall: • ensure that blowout preventers are installed • ensure provision of adequate firefighting equipment • ensure that emergency response procedures are in place	M
	Loss of properties/assets and lives from fire/blowout	**H**	SPDC shall ensure: • that blowout preventers are installed • provision of adequate firefighting equipment • only skilled personnel and certified equipment are used • hazard identification has been conducted • that emergency response procedures are in place	**L**
	Generation of waste (Pigging waste, domestic waste, metal scraps, plastics)	**M**	• SPDC and contractors shall ensure that all wastes are segregated and managed according to EGASPIN and FMEnv guidelines. • Ensure proper documentation of the quantity of waste from generated site to disposal point.	
Operation and Maintenance Well work-over, Gas production	Environmental pollution arising from improper disposal of lubricants and oily debris	**H**	SPDC shall ensure: • all wastes are properly segregated and contained before disposal • all wastes are properly disposed of and monitored from cradle to grave	**L**

Project Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**
Flowline maintenance & replacement				
	Equipment failure and damage leading to injuries/fatality	**H**	SPDC shall ensure: • 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**
	Revenue generation to government and company	P	NA	P
	Oil (lubricants, fuels) and Gas leaks (fugitive emissions)	H	SPDC shall: • Minimize routine gas venting and flaring • Install scrubbers in their flare stacks	**L**
Decommissioning, Restoration and Abandonment	Contamination of soil	M	SPDC shall ensure that : • Remediate contaminated soil to acceptable DPR target levels	L
	Road and water Transport accidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water and the need for extra precautions through public enlightenment • Ensure that drivers are trained on defensive driving • compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
			• carry out job hazard analyses	
	Erosion around abandoned site	M	SPDC shall • carry-out shore protection in areas susceptible to shoreline erosion • SPDC shall use sheet pilling of the area affected.	L
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within acceptable standards	L
	Noise and vibration nuisance	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE • continuous monitoring of noise levels	L
	Contamination of soil, surface and groundwater	H	SPDC shall: ▪ ensure the use of experts and best practices in its projects activities ▪ ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards ▪ ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities ▪ ensure wastes are properly managed ▪ Alternative source of potable water is provided if drinking water quality is affected. ▪ Remediate and restore the ground water and soil to acceptable DPR target levels for remediation	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Injuries and death from blowouts	H	SPDC shall ensure: ▪ provision of appropriate PPE ▪ ensure Job Hazard analyses is done before activity ▪ Pep talks done before activity ▪ Adequate MEDEVAC in place in case of accidents	M
	Continuous glare from rig operation	H	SPDC shall avoid drilling activities at night	M
	Inter and intra community conflicts	H	SPDC shall: ▪ establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof ▪ Continuously engage third party stakeholders in dialogue ▪ Quickly resolve all misunderstandings with third party stakeholders	M
	Increased income	P	NA	**P**
	Increase pressure on existing social amenities/infrastructure	H	SPDC shall: ▪ provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities ▪ ensure that there is site and camp base clinics/first aid for its workers ▪ capture provision of additional infrastructure as part of its GMoU with the community where required	M
	Complaints and agitation by locals	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	M
	Increased Social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff condoms are provided for workers	M

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : ▪ ensure proper housekeeping at its campsites and work areas ▪ carry out health sensitization for workers and community ▪ use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors ▪ organize health awareness campaigns	L
	Pressure on existing waste management system	H	SPDC shall ensure: ▪ treatment of all waste water to regulatory standards prior disposal ▪ provision of mobile toilets for its work-force ▪ regularly monitor the quality of effluent to ensure that it meets regulatory standards adhere to its waste management procedure	M
	Road and water traffic incidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water and the need for extra precautions through public enlightenment • Ensure that drivers are trained on defensive driving • compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk carry out job hazard analyses	L

Project Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation
	Environmental issues arising from improper disposal of cleared materials	H	SPDC shall dispose dredge spoils in an environmentally-friendly manner	L
	Loss of employment/income	H	SPDC shall, • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Encourage skill acquisition in the community	M
	Inter and intra Community conflicts	H	SPDC shall: • effectively implement the GMoU continuously dialogue with community leadership at all strata	M

Note: H: High, M: Medium, L=Low and P= Positive

CHAPTER SEVEN
ENVIRONMENTAL MANAGEMENT PLAN

7.1: Introduction

Environmental management is concerned with a planned and integrated programme aimed at ensuring that unforeseen and unidentified impacts of a proposed project are contained and brought to acceptable minimum levels. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from mobilization to abandonment .In keeping with SPDC's policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design and will continue throughout the project life cycle.

Environmental management will be carried out in accordance with the provisions of ISO 14001, sections 4.3.2 to 4.3.4, which are reflected in SPDC HSE-MS Manual. The HSE-MS addresses the overall approach adopted for management of HSE risks through the project development phases by the project management team. HSE-MS document provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practices, etc., and demonstrates how the Hazards and Effects Management Process (HEMP) will be applied on the project such that HSE risks are kept As Low As Reasonably Practicable (ALARP). Good environmental management, which is part of SPDC's HSE-MS goals, has the following long term objectives:

- Ensure compliance with Legislations and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified are implemented, a comprehensive EMP was developed (Table 7.2).

7.2: SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislations but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be involved directly or indirectly with their activities. The Environmental Management activities initiated by SPDC are intended to implement the above policy and the policy will be applied to all stages of the decommissioning. The projects' HSE-MS is fully aligned to SPDC's corporate HSE programs.

7.3: Monitoring Objectives

The following monitoring objectives are established:

- to create local data bank on the impacts of project activities on the environment, for future development of predictive models;
- to monitor emissions and discharges at all stages of project development to ensure they meet national standards;
- to determine whether environmental changes are results of development or a result of natural variations;
- to determine the effectiveness of the mitigation measures;
- to determine long term impacts.
- to determine the duration of return to normalcy of the environmental components of the project area .

7.4: Resourcing

Shell Petroleum Development Company (SPDC) considers environmental management as an important aspect of project procedures. Consequently, in any project for which project management team is set up, an environmental specialist always forms an integral part of the team. In this project, an environmental focal point has been appointed to liaise between the engineering project managers and the environmental specialist, consultants as well as advises on all environmental issues in conformity with SPDC's HSE policy. Shell Petroleum Development Company (SPDC) recognizes the need to use external environmental consultants to supplement in-house environmental specialists. To this end, the environmental consultants will continue to provide expert advice to the SPDC environmental managers throughout the Life cycle of this project.

7.5: Environmental Audits

Shell Petroleum Development Company (SPDC) has instituted audit scheme, as part of its programme on environmental management. The scheme is aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management. The audits are focused on areas of project perceived as having the highest environmental impacts. They are carried out annually and reviewed by SPDC environmental audit committee. It is recognized that to be truly effective, these audits need to be conducted within the overall structured management systems. The structured approach is aimed at disseminating information, providing advice and assistance in its application, and at corporate assurance of performance in meeting the environmental requirement/targets.

7.6: Responsibilities and Training

Within SPDC, environmental protection, like safety, is a line responsibility for which staff, at all levels, have accountabilities. An environmental specialist assists the line management with advice on environmental matters, from an expert point of view. However, responsibility and accountability is clearly defined, from senior management who allocate resources and monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace. All staff will be made aware of their responsibilities through induction and training courses as outlined in the projects' HSE-MS document. In addition, procedures, guidelines and notices will advise staff on how to respond in the event of an environmental emergency. The Shell Corporate Environment Department is responsible for monitoring and auditing the environmental activities of this project.

7.7: Waste Management

The Waste Management Plan includes procedures for safe handling, control and disposal of generated waste in accordance with the SPDC procedure. Wastes emanating from operational activities are mainly food wastes, garbage, shrubs/vegetation, waste papers etc. These wastes are handled in compliance with the Petroleum (Drilling & Productions) Regulations, 1969, Sections 25, 36 49 and (b), (c) and (d), which stipulate *inter alia* that:

The licensee or lessee shall adopt all practical precautions, including the provision of up-to-date equipment to prevent the pollution of inland waters, rivers, creeks, water courses, the territorial waters of Nigeria or the high seas by oil, mud or other fluids or substances which might contaminate the water or marine life, and where any such pollution occurs or has occurred, shall take prompt steps to control and, if possible, end it."

The waste management strategy to be adopted in the proposed project has been highlighted in Section 3.7 of chapter three.

7.8: SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislations but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be involved directly or indirectly with their activities. The Environmental Management activities initiated by SPDC are intended to implement the above policy and the policy will be applied to all stages of this project from feasibility to decommissioning. The HSE-MS is fully aligned to SPDC's corporate HSE programs.

7.9: Monitoring Objectives

The following monitoring objectives are established:

- To create local data bank on the impacts of project activities on the aquatic ecosystem, for future development of predictive models;
- To compare effluent quality and quantity with design specifications, impact predictions and regulatory standards;

- To monitor emissions and discharges at all stages of project development to ensure they meet national standards;
- To determine whether environmental changes are results of development or a result of natural variations;
- To determine the effectiveness of the mitigation measures;
- To determine long term impacts.
- To determine the duration of return to normalcy of the environmental components of the project area.

Table 7.1: Environmental Monitoring Plan

Environmental component	ASSOCIATED LIMITATIONS		MONITORING PROGRAMME			
	Regulation/ Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency during Project Life cycle.	Data collection method
Air Quality	DPR EGASPIN III E 4.4.5 Table III-3 National Ambient Air Quality Standards	Daily average mean ($\mu g/m^3$) Total SPM: 60-90 Carbon monoxide: 10 SO_2: 100-150 NO_2: 150 Lead: 0.08ppm	Particulates, NO_2, SO_2, CO, VOC H_2S, NH_3, Noise levels, heavy and trace metals in ambient air	During well drilling and Well location preparation activities	Weekly	In-situ measurement using Air Quality Meters
Soil	Baseline data	-	pH, TOC, Heavy metals (V, Ni, Cr, Fe) and Organics (TPH, PAH)	Around Chemical/Gasoline storage area during well drilling and location preparation activities	Quarterly during Construction phase	Sample collection and analysis in an external approved laboratory.
Surface water (Recipient water)	Baseline data	-	pH, TSS, Turbidity, Heavy metals (V, Ni, Cr, Fe) and Organics (TPH, PAH)	Upstream and downstream of the proposed Jetty area	Quarterly during Construction phase	Sample collection and analysis in an external approved laboratory.
Ground water	Baseline data	-	pH, TSS, Turbidity, Heavy metals (V, Ni, Cr, Fe) and Organics (TPH, PAH)	Around proposed wells during drilling	Monthly during drilling phase	Sample collection and analysis in an external approved laboratory.

Table 7.2: Environmental Management Plan (EMP) for the Cumulative Impact (Iseni Appraisal Well drilling, Hook up of Existing wells, Access Road, Camp site, Ramp/Jetty Project)

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
Premobilization Consultation, Land acquisition and Compensation, Resolution of legacy issues	Increase in project awareness	H	• SPDC shall ensure adequate consultation with all stakeholders especially communities.	L	Stakeholders' engagement reports/agreement	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Anticipated Loss of land associated resources	H	• Land take shall be limited to the minimum required. • SPDC shall ensure consultation is done with the right responsible persons.	L	Site inspection report Vegetation studies report	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Financial enhancement	P	-	P	GMoU Community Engagement reports	Annually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Third party agitation	H	• Relevant stakeholders/legacy issues shall be identified. • Regular consultation with stakeholders (Govt., Community, NGOs, CBOs etc.) shall be	L	Employment records Community Engagement reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			carried out to understand community perceptions, issues and concerns • Effective liaison/communication channels (CICs) from the communities to the project execution team shall be established.				
Mobilization	Impairment of air quality from emissions of air pollutants including greenhouse gases	M	SPDC shall: • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas.	L	• Premob certificates • Maintenance records • Records of compliance with use of PPE	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in noise and vibration/levels	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers	L	• Maintenance and inspection records • equipment work hour record • premob records • PPE issuance and use record.	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPEs.				
	Interference with land transport	M	SPDC shall ensure: • regular maintenance of vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPEs.	L	• Journey management plan • Evidence of community engagement	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Interference with water transport	M	SPDC shall: • minimize movement during peak hours • notify the community of the movement on the waterways	L	• Journey management plan • Evidence of community engagement	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• ensure regular maintenance of water crafts • ensure vehicles and equipment are turned off when not in use • ensure combustion engines are fitted with effective silencers • ensure machinery covers and panels are closed and well fitted at all times • ensure equipment with low noise levels are used • ensure the provision of appropriate PPE				
	Increased income	P	NA	P	Community /Other stakeholder engagement reports	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increased commercial activities	P	NA	P	Community /Other stakeholder engagement reports	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Kidnappings	H	• SPDC shall make adequate security arrangements for its operations. • SPDC shall ensure that members of staff are	M	• Journey management plan, • Security Plan	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			sensitized on the peculiarity of the project environment.				
	Influx of workers into the host Communities/change in local population	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pre-existing facilities • ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	M	• GMoU Implementation records, • Minutes of community engagement meetings.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Changes in culture, lifestyle and habits	H	SPDC shall: • Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. • Implement good assess control into the campsite	L	• Community dialogue records/minutes of meetings • Access control records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Increase in social vices	H	SPDC shall: • carry out sensitization campaign on HIV, AIDs and other sexually transmitted diseases • regular medical check-ups are conducted for project work force • condoms are provided for workers • restriction of workers to the camp	L	• Records of sensitization campaigns • Medical records • Records of condom issuance • Perimeter fence and access control	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community.	L	• Employment records • Skill acquisition seminar records • Alternative livelihood seminars	Annually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Inter and intra community conflicts	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	L	• GMoU Implementation record • Minutes of community engagement meetings.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Pressure on existing infrastructures and utilities	H	SPDC shall: • provide accommodation with necessary amenities at	L	• Evidence of provision of amenities	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required		• employment records, • Community Projects		
	Third party agitations	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M	• GMoU Implementation report • Reports on community engagement meetings. • Employment records	Monthly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Loss of land due to land acquisition	H	• Land take shall be limited to the minimum required	M	Site inspection report GMoU	Annually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Change in Land use	H	• Alternative source of income shall be supported through the GMoU initiatives	L	Site inspection report GMoU	Annually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Increase in STDs	H	SPDC shall: • carry out sensitization campaign on HIV, AIDs and other sexually transmitted diseases • regular medical check-ups are conducted for project work force • condoms are provided for workers • ensure restriction of workers to the camp	M	Reports on community engagement sessions Health Report Site inspection report/tool box meetings	Quartely	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Site Preparation for drilling, access road, camp site and Ramp/Jetty construction Construction of Campsite Excavation Sand filling with an estimated 40,000.00 m^3 of sand) • Concrete Works • Perimeter Block wall	Loss of flora and fauna	M	SPDC • shall limit clearing and all earth digging and other activities that may impact flora and fauna to only necessary areas • shall carry out the re-vegetation of cleared area.	L	• Evidence of biodiversity enlightenment Programmes/studies • Revegetation records. • Environmental Compliance Monitoring Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Loss of habitat	M	SPDC • shall limit clearing and all earth digging and other activities that may impact habitat to only necessary areas	L	• Evidence of biodiversity enlightenment Programmes/studies • Revegetation records.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
• Installation of Gates			• SPDC shall carry out the re-vegetation of cleared area.		• Environmental Compliance Monitoring Reports		
	Increase in dust, fumes, and Impairement in air quality and noise	M	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L	• Environmental Compliance Monitoring Reports, • Premob certificates, • Work inspection report	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increased level of noise and vibration with possible hearing loss	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers	L	• Environmental Compliance monitoring Reports, Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used.				
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed • Remediate contaminated/polluted soils	L	• Environmental Compliance monitoring Reports, • Revegetation Reports, • Waste consignment notes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Threats to health of workers (snake bites, insect bites, injuries etc)	H	SPDC shall : • ensure proper housekeeping at its campsites and work areas	L	Site Inspection Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• carry out health sensitization for workers and community • use of experts and best practices in its activities to reduce or eliminate breeding grounds for disease vector • ensure the use of PPE • ensure that there is site and camp base clinics/first aid and personnel				
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community • use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors • organize health awareness campaigns • embark on regular fumigation of facilities	L	Site Inspection Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Influx of labour and followers (dependants, bounty seekers, CSWs, etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pre-existing facilities • ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	M	• GMoU implementation report • Community engagement report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Community unrest	H	• SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue	M	• GMoU implementation report • Community engagement report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Pressure on existing infrastructure (health, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at	M	• GMoU implementation report	Monthly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required		• Community engagement report		
	Opportunity for contracting and employment	P	NA	P	Employment records and community Engagement reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Third party agitation	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Traditional occupation (farming, fishing, hunting) could be adversely affected from construction operations	M	SPDC shall ensure: • intensive enlightenment campaign alternative sources of livelihood • ensure proper management of wastes • ensure vehicles and water crafts are in good working condition • Organise skill acquisition programmes	L	• GMoU implementation records • Skill acquisition programmes,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Changes in culture, lifestyle and habits	M	SPDC shall: • Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. • Implement good assess control into the campsite	L	• Community engagement records • Access control records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for	M	• Records of enlightenment campaign • Alcohol and drug tests records • Contractors alcohol and drug policy and	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			its staff condoms are provided for workers.		implementation records • Condom issuance records		
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community • Promote alternative sources of livelihood.	M	• Employment records • Skill acquisition seminar records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within regulatory limits • Remediate contaminated/polluted soils as a result of SPDCs activities • ensure that corrective actions are taken where there are risks of soil	L	• Environmental Compliance monitoring Reports, • Revegetation Reports, • Waste consignment notes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			degradation resulting from its project activities • ensure wastes are properly managed in line with SPDC waste management policy • carry-out shore protection in areas susceptible to shoreline erosion • use sheet pilling for the area affected. • continuously monitor soil quality to ensure it is within regulatory limits				
	Increase in dust, fumes, and impairement of air quality from equipment and activity Potential increase in erosion	M	SPDC shall: • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L	• Premob certificates • Maintenance records • Records of compliance with use of PPE • Environmental Compliance Monitoring Reports	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
	Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE • continuously monitor noise levels to ensure it is within regulatory limits.	L	• Environmental Compliance monitoring Reports, Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Pressure on community infrastructure (healthcare, housing, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities. • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as	M	• GMoU Implementation record • Minutes of community engagement meetings.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			part of its GMoU with the community where required				
	Stress on existing security structures as a result of influx of job seekers	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M	• Security Plan • Pep talks, • HSE meetings, • Tool box meetings	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Exposure of project workers to snake bites, insect bites, injuries etc	H	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community • use of experts and best practices in its activities to reduce or eliminate breeding grounds for disease vector • ensure the use of PPE	L	• First aid trainings, Site clinic reports, • Tool box meetings, Job Hazard Analyses Reports, Site inspection reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			• ensure that there is site and camp base clinics/first aid and personnel.				
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community • use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors • organize health awareness campaigns • ensure that there is site and camp base clinics/first aid and personnel	L	• First aid trainings • Site clinic reports, • Tool box meetings • Job Hazard Analyses Reports, • Site inspection reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Influx of labour and followers (dependants, bounty seekers, commercial sex workers, etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pre-existing facilities	M	• GMoU implementation report • Community engagement report	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives				
	Pressure to abandon traditional occupations (farming, fishing, hunting) for new job opportunities	M	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required	L	• GMoU implementation report • Community engagement report	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in social vices	H	SPDC shall ensure: • intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the	M	• Records of enlightenment campaign • Alcohol and drug tests records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			community and among workers • that contractor enforces the alcohol and drug policy for its staff • condoms are provided for workers.		• Contractors alcohol and drug policy and implementation records		
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community	M	Employment records Skill acquisition seminar records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Impairement of water quality	M	• Waste management plans (in line with regulatory guidelines and SPDC procedures) shall be strictly adhered to during all phases of the project. • Wastes shall be segregated at source into color-coded or labelled bins and disposed of in line with a project specific waste management plan. • SPDC shall ensure that sewage wastes in base	L	Environmental Compliance monitoring report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			camps are properly managed. • Safe Handling of Chemicals (SHOC) cards shall be visibly displayed at all sites where chemicals are handled • Fuel, lube oils and chemicals shall be safely stored in containers in bonded areas				
	Injury/fatality of workforce and/or third party	M	• SPDC shall enforce the use of appropriate PPEs (life jackets, work vests/ goggles etc). • SPDC shall ensure first aid box on site and emergency response and med-rescue/MEDEVAC are in place. • Toolbox meetings shall be held before the start of daily tasks • Trained First Aiders shall form part of the workforce • SPDC policy on road traffic journey management shall be adhered to (all journey	L	Competence certification of workforce Emergency response plan HAZID register Pep-talk records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			must be approved, no night journeys, speed limits on land).				
	Habitat fragmentation	M	• Clearing should be limited to areas of operation. • Re-vegetation shall be undertaken after the project work where desirable.	L	Fragmentation index, Biodiversity reports, wildlife migration pattern	Annually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Construction of Concrete Jetty &Concrete Ramp • Piling Works • Mobilise piling rig to site • Set Up Rig, Position, Pitch and drive specified steel (300mm diameter steel	Degradation of water quality (turbidity, total suspended solids) near the river bank	H	SPDC shall ensure that : • Dredging is reduced to as low as reasonably possible to reduce impact on water quality • use the best available technology (suction dredging) to minimize disturbance to riverbed topography • Water quality is monitored in during the dredging operation • Alternative source of potable water is provided for drinking if water quality is affected by dredging.	M	• Environmental Compliance Monitoring Reports, • Site Inspection Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
schedule 40 casing) • Steel works • Reinforced Concrete works • Steel works (hand rails etc) • Installation of Bollards & Fenders • Dredging Works (Depending on siltation levels)	Loss of aquatic biodiversity and habitat.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • use the best available technology (suction dredging) to minimize disturbance to riverbed topography • deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	M	• Environmental Compliance Monitoring Report, • Waste Consignment notes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Possible riverbank erosion from Jetty construction activities	H	SPDC shall ensure that: • best practices are employed during dredging to minimize impact on riverbank • use sheet pilling of the area affected.	M	• Environmental Compliance Monitoring Report, • Waste Consignment notes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Soil degradation	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it	L	• Environmental Compliance monitoring Reports, • Revegetation Reports,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • ensure wastes are properly managed • continuously monitor soil quality to ensure changes are insignificant		• Waste consignment notes • Waste Management Reports		
	Third party agitation (community, NGOs, etc)	H	• SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders • Resolve legacy issues if they exist	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Monthly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Pressure on community infrastructure (healthcare, housing, recreational etc.)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure as part of its GMoU with the community where required	L	Evidence of GMoU implementation	Biaanually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Stress on existing security structures as a result of influx of job seeker	H	SPDC shall: • Establish global memorandum of understanding (GMoU)with host community and implement the content thereof • Continuously engage community stakeholders in dialogue • Quickly resolve all misunderstandings with host community	M	• Security Plan • Pep talks, • HSE meetings, • Tool box meetings	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
	Increase in dust, fumes, and impairement of air quality from equipment and activity	M	SPDC shall: • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	M	• Premob certificates • Maintenance records • Records of compliance with use of PPE • Environmental Compliance Monitoring Reports	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Dredging of Forcados river and Sandwining	Nuisance from dredging activity due to hampering of free movement and fishing activity.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • dredging time is restricted to times that will have minimal impact on movement and fishing • minimize movement during peak hours • notify the community of the movement on the waterways • regular maintenance of water crafts	M	Environmental Compliance Monitoring Report	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE				
	Degradation of water quality (turbidity, total suspended solids)	H	SPDC shall ensure that : • Dredging is reduced to as low as reasonably possible to reduce impact on water quality • Best practices are employed during dredging to minimize impact on water quality. • use the best available technology (suction dredging) to minimize disturbance to riverbed topography • deploy the most appropriate technology	M	Environmental Compliance Monitoring Report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			(silt curtain), to minimize loss of benthic organisms. • Water quality is monitored in during the dredging operation • Alternative source of potable water is provided if drinking water quality is affected by dredging.				
	Loss of aquatic biodiversity and habitat.	H	SPDC shall ensure that: • dredging is reduced to as low as reasonably possible • best practices are employed during dredging to minimize impact on biodiversity • deploy the most appropriate technology (silt curtain), to minimize loss of benthic organisms.	M	Environmental Compliance Monitoring Report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Possible river bank erosion from wrong dredging procedure	H	SPDC shall ensure that: best practices are employed during dredging to minimize impact on riverbank	M	• Site Inspection report • Environmental Compliance	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
					Monitoring Report		
	Third party agitation (community, NGOs, etc)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Influx of labour and followers (dependants, bounty seekers, sex workers etc)	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the pr-existing facilities • ensure that there is site and camp base clinics/first aid and personnel • ensure that local workforce are employed from the project communities in line with Nigerian Content Development (NCD) directives	M	GMoU implementation report Community engagement report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Opportunity to indigenes for contracting and employment	P	NA	P	Employment records and community Engagement reports	Biannully	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Pressure to abandon traditional occupations (farming, fishing, and hunting) for new job opportunities thus provided.	M	SPDC shall ensure: ▪ intensive enlightenment campaign alternative sources of livelihood ▪ Organise skill acquisition programmes	L	• GMoU Implementation record • Minutes of community engagement meetings.	Biannully	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Changes in culture, lifestyle and habits	M	SPDC shall: • Carry out campaigns that promote the community's good cultural practices • Minimize workers' movements outside campsites and work areas. • Implement good assess control into the campsite	L	• Community dialogue records/minutes of meetings • Access control records	Biannully	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers	M	• Records of sensitization campaigns • Medical records • Records of condom issuance	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			▪ that contractor enforces the alcohol and drug policy for its staff condoms are provided for workers.		• Perimeter fence and access control		
	Increase in inflation level	H	SPDC shall: • Employ skilled and unskilled labour from the community in line with the local content policy • Encourage skill acquisition in the community	M	• Employment records • Skill acquisition seminar records, • Alternative livelihood seminars	Biannully	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Flowline laying and Hook-up • Trenching • Stringing • Cleaning, bevelling and Pipeline bending • Welding • Radiography • Field Joint Coating • Lowering • Inspection, testing and	Loss of biodiversity(flora and fauna) including loss of plants of economic value along flowline RoW	H	SPDC • shall limit clearing and all earth digging and other activities that may impact flora and fauna to only necessary areas • Carry out remediation of contaminated/polluted sites • carry out the re-vegetation of cleared area.	L	Environmental Compliance Monitoring Report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Fragmentation of habitats	H	SPDC • shall limit clearing and all earth digging and other activities that may impact habitat to only necessary areas	L	• Site Inspection reports, • Environmental Compliance Monitoring Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
NDT of welds • Cathodic Protection • Backfilling • Hydrotesting • Manifold works • Site Reinstatement • Extension of one of the existing well pads to accommodate manifold and flow line tie-in			• carry out the re-vegetation of cleared area.				
	Noise and vibration from flowline laying operation with potential to cause localised nuisance and scare away wild life from natural habitat range	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE	L	• Environmental Compliance monitoring Reports, • Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Igniting of welding flames red hot metals or flying sparks causing fires/explosion/injuries/loss of lives	H	SPDC shall ensure: • provision of appropriate PPE • ensure Job Hazard analyses is done before activity • Pep talks done before activity • ensure that there is site and camp base clinics/first aid and personnel	L	• Job Hazard Analyses, • Pep talks • Tool box meetings	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Alteration of natural drainage patterns	H	SPDC shall ensure: • Adequate backfilling of trenches • Land excavated only within RoW	M	Site Inspection reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Opportunity to indigenes for contracting and employment	P		P	• GMoU implementation Records • Employment records	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Third party agitation (community, NGOs, etc)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Discharge of untreated test water into the receiving environment.	M	SPDC shall ensure that; • Waste management specifications and guidelines (especially with regards to the discharges into the	L	• Environmental Compliance Monitoring Reports, • Waste consignment	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			environment) shall be complied with.		notes, Effluent discharge reports		
	Exposure to radioactivity and release of chemicals	H	SPDC shall provide; • radiation counter to workers for monitoring individual radiation levels. • provide and enforce the use of protective aprons. • ensure that the activity is carried out in accordance with standard procedures	L	Site Inspection reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Drilling	Contamination and degradation of soil, groundwater and surface water from drilling wastes and accidental spill	H	SPDC shall: • ensure the use of experts and best practices in its projects activities • ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards • ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities • Remediate contaminated/polluted site(soil/groundwater/surf	M	• Environmental Compliance Monitoring Reports, • Waste consignment notes.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			ace water) to regulatory standards • ensure wastes are properly managed • Alternative source of potable water is provided if drinking water quality is affected.				
	Release of gaseous pollutants including greenhouse gases to the recipient environment from equipment.	M	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within regulatory limits	L	• Environmental Compliance Monitoring Reports, • Waste consignment notes	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Noise and vibration from drilling operation with potential to cause localised nuisance and scare away wild life from natural habitat range.	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use	L	• Environmental Compliance monitoring Reports, • Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used • provision of appropriate PPE • continuously monitor noise levels and ensure they are within regulatory limits				
	Injuries and death from accidental blowouts	H	SPDC shall ensure: • provision of appropriate PPE • ensure Job Hazard analyses is done before activity • Pep talks done before activity • ensure that there is site and camp base clinics/first aid for its workers	M	• Site Inspection Reports, • Job Hazard Analyses reports, • Pep Talks, • Tool Box meetings, • Hazard identification Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Continuous glare from rig operation at night with potential to scare	H	SPDC shall ensure: • Avoid night activities	M	• Environmental Compliance Monitoring Reports,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
	wild life and affect vegetation physiology.				• Site Inspection Reports		
	Inter and intra community conflicts	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increased cash flow and stimulation of local economies within the Community	P	NA	P	Employment records and community Engagement reports	Once during drilling	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase pressure on community social amenities/infrastructure due to influx	M	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities	L	Evidence of GMoU implementation	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• ensure that there is site and camp base clinics/first aid for its workers capture provision of additional infrastructure as part of its GMoU with the community where required				
	Third party agitation (Community, NGOs, etc)	H	SPDC shall: • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Continuously engage third party stakeholders in dialogue • Quickly resolve all misunderstandings with third party stakeholders	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers	M	• Records of sensitization campaigns • Medical records • Records of condom issuance	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			▪ that contractor enforces the alcohol and drug policy for its staff and also provide condoms for her workers.		• Perimeter fence and access control		
	Impact of domestic waste from camp base on the environment and aesthetics	M	SPDC shall ensure: Wastes are subjected SPDC Waste management procedure	L	• Site Inspection reports, • Environmental Compliance Monitoring Reports • Waste Consignment notes,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Loss of biodiversity arising from avoidance of the area due to noise and constant lighting	M	SPDC shall ensure that night activities are avoided	L	• Site Inspection reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Well & pipeline testing, Hydrotesting,	Potential for explosion	M	• Emergency response procedures shall be put in place	L	Inspection records Site incident report	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	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	• Environmental Compliance Monitoring Reports, • Waste consignment notes, Effluent discharge reports	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
Cathodic Protection	Exposure to radioactive material	M	• SPDC shall ensure that only certified personnel handle radioactive materials. • SPDC shall ensure that radioactive materials are stored safely. • SPDC shall ensure toolbox talks are conducted before the commencement of the job. • SPDC shall ensure appropriate PPEs are used by the workers	L	Certification of workforce Emergency response plan HAZID register Pep-talk records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Demobilization	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is	L	• Environmental Compliance Monitoring Reports, • Waste consignment notes, • Effluent discharge reports	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			within acceptable standards				
	Noise and vibration nuisance	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used provision of appropriate PPE	L	• Environmental Compliance monitoring Reports, • Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Contamination of soil, surface and groundwater	M	SPDC shall: ▪ ensure the use of experts and best practices in its projects activities ▪ ensure monitoring of soil around its project zone of influence to ensure that it is within acceptable standards ▪ ensure that corrective actions are taken where there are risks of soil degradation resulting from its project activities	L	• Environmental Compliance Monitoring Reports, • Waste consignment notes, • Effluent discharge reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			▪ ensure wastes are properly managed ▪ Alternative source of potable water is provided if drinking water quality is affected.				
	Injuries and death from blowouts	H	SPDC shall ensure: ▪ provision of appropriate PPE ▪ ensure Job Hazard analyses is done before activity ▪ Pep talks done before activity ▪ Adequate MEDEVAC in place in case of accidents.	M	• Job Hazard Analyses, • Pep talks, • Tool box meetings, • Hazard Identification Reports.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Continuous glare from rig operation	H	SPDC shall ensure: ▪ Avoid night activities	M	• Environmental Compliance Monitoring Reports, • Site Inspection Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Inter and intra community conflicts	H	SPDC shall: ▪ establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof	M	• GMoU implementation report, • Reports on community engagement meetings. • Employment records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			▪ Continuously engage third party stakeholders in dialogue ▪ Quickly resolve all misunderstandings with third party stakeholders				
	Increased income	**P**	NA	P	Employment records and community Engagement reports	Once during demobilization phase	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase pressure on existing social amenities/infrastructure	H	SPDC shall: ▪ provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities ▪ ensure that there is site and camp base clinics/first aid for its workers ▪ capture provision of additional infrastructure as part of its GMoU with the community where required	M	Evidence of GMoU implementation	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Complaints and agitation by locals	H	▪ SPDC shall: ▪ establish Global Memorandum of Understanding (GMoU) with host community and	M	• Evidence of GMoU implementation • Continuous engagements,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			implement the content thereof ▪ Continuously engage third party stakeholders in dialogue ▪ Quickly resolve all misunderstandings with third party stakeholders ▪		• Implementation of legacy issues if they exist, • Employment records, • Local content contract records		
	Increased Social vices	H	SPDC shall ensure: ▪ intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers ▪ that contractor enforces the alcohol and drug policy for its staff ▪ condoms are provided for workers.	M	• Records of sensitization campaigns • Medical records • Records of condom issuance • Perimeter fence and access control	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : ▪ ensure proper housekeeping at its campsites and work areas ▪ carry out health sensitization for workers and community	L	• Environmental Compliance Monitoring Report, • Site inspection reports, • Health reports from site clinic	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			▪ use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors ▪ organize health awareness campaigns				
	Pressure on existing waste management system	H	SPDC shall ensure: ▪ treatment of all waste water to regulatory standards prior disposal ▪ provision of mobile toilets for its work-force ▪ regularly monitor the quality of effluent to ensure that it meets regulatory standards ▪ adhere to its waste management procedure	L	• Environmental Compliance Monitoring Reports, • Waste Consignment notes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Road and water traffic incidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water and the need for extra precautions through public enlightenment	L	Premob certificates • Maintenance records • Records of compliance with use of PPE • Maintenance records • Records of vehicles and	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• Ensure that drivers are trained on defensive driving • compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk ▪ carry out job hazard analyses		water crafts, Journey Management Plan, • Pep Talks, Tool Box meetings		
	Environmental issues arising from improper disposal of cleared materials	H	SPDC ▪ shall dispose dredge spoils in an environmentally-friendly manner	L	• Environmental Compliance Monitoring Reports,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
					• Waste Consignment notes.		
	Loss of employment/income	H	SPDC shall, • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Encourage skill acquisition in the community	L	• Evidence of GMoU implementation , • Employment records, • Alternative sources of livelihood programs, • Skill acquisition programmes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Inter and intra Community conflicts	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	L	• Evidence of GMoU implementation • Employment records • Alternative sources of livelihood programs, • Skill acquisition programmes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
Commissioning	Gas leaks and explosions	**H**	SPDC shall: • ensure that blowout preventers are installed • ensure provision of adequate firefighting equipment • ensure that emergency response procedures are in place	M	• Evidences of project emergency response plans • Facility Walk-Through Surveys • Routine health service surveillance	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Loss of properties/assets and lives from fire/blowout	**H**	SPDC shall ensure: • that blowout preventers are installed • provision of adequate firefighting equipment • only skilled personnel and certified equipment are used • hazard identification has been conducted • that emergency response procedures are in place	**L**	• Certification of workforce • Emergency response plan • HAZID register • Pep-talk records • Evidences of project emergency response plans	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Generation of waste (Pigging waste, domestic waste, metal scraps, plastics)	**M**	▪ SPDC and contractors shall ensure that all wastes are segregated and managed according to EGASPIN and FMEnv guidelines. ▪ Ensure proper documentation of the	**L**	Waste consignment note Monitoring of recipient environment in	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			quantity of waste from generated site to disposal point.		line with EGASPIN 2002		
Operation and Maintenance Well work-over, Gas production Flowline maintenance & replacement	Environmental pollution arising from improper disposal of lubricants and oily debris	H	SPDC shall ensure: • all wastes are properly segregated and contained before disposal • all wastes are properly disposed of and monitored from cradle to grave • All effluents are treated to regulatory limits before discharge	L	• Waste consignment note • Drilling mud recovery record • Monitoring of recipient environment in line with EGASPIN 2002	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Equipment failure and damage leading to injuries/fatality	H	SPDC shall ensure: • 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 • Certification of workforce • Emergency response plan • HAZID register • Pep-talk records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Revenue generation to government and company	P	NA	P	Community Engagement reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Oil (lubricants, fuels) and Gas leaks (fugitive emissions)	H	SPDC shall: • Minimize routine gas venting and flaring • Install scrubbers in their flare stacks	L	• Monitoring records of the criteria air pollutants	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
Decommissioning, Restoration and Abandonment	Contamination of soil, surface and groundwater	M	SPDC shall ensure that : • Remediate and restore the ground water and soil to acceptable DPR target levels for remediation	L	• Environmental Compliance Monitoring Reports, • Waste consignment notes, • Remediation reports where necessary, • Environmental Evaluation Reports	Quarterly/every three years (EES)	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Road and water Transport accidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic on land and water and the need for extra precautions through public enlightenment • Ensure that drivers are trained on defensive driving	L	• Premob certificates • Maintenance records • Records of compliance with use of PPE • Maintenance records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk • carry out job hazard analyses		• Records of vehicles and water crafts, • Journey Management Plan, • Pep Talks, Tool Box meetings		
	Erosion around abandoned site	M	SPDC shall • carry-out shore protection in areas susceptible to shoreline erosion • SPDC shall use sheet pilling of the area affected.	L	Site Inspection Reports	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall • use only pre-mobbed environmental friendly equipment • ensure that there is controlled use of all equipment and that equipment engines are turned off when not in use. • ensure use of appropriate PPEs in work areas • continuously monitor air quality to ensure it is within acceptable standards	L	• Environmental Compliance Monitoring Reports, • Waste consignment notes, •	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Noise and vibration nuisance	M	SPDC shall ensure: • regular maintenance of equipment and vehicles • vehicles and equipment are turned off when not in use • combustion engines are fitted with effective silencers • machinery covers and panels are closed and well fitted at all times • equipment with low noise levels are used	L	• Environmental Compliance monitoring Reports, • Premob records • PPE issuance and use record	Weekly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			• provision of appropriate PPE • continuous monitoring of noise levels				
	Injuries and death from blowouts	H	SPDC shall ensure: • provision of appropriate PPE • ensure Job Hazard analyses is done before activity • Pep talks done before activity • Adequate MEDEVAC in place in case of accidents	M	• Job Hazard Analyses, • Pep talks, • Tool box meetings, • Hazard Identification Reports.	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increased income	**P**	NA	**P**	Community Engagement reports	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increase pressure on existing social amenities/infrastructure	H	SPDC shall: • provide accommodation with necessary amenities at the base camp for its workers to reduce pressure on the existing facilities • ensure that there is site and camp base clinics/first aid for its workers • capture provision of additional infrastructure	M	Evidence of GMoU implementation	Biannually	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
			as part of its GMoU with the community where required				
	Complaints and agitation by locals	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	M	• Evidence of GMoU implementation • Continuous engagements, • Implementation of legacy issues if they exist, • Employment records, • Local content contract records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Increased Social vices	H	SPDC shall ensure: • intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and sexual promiscuity in the community and among workers • that contractor enforces the alcohol and drug policy for its staff • condoms are provided for workers	M	• Evidence of GMoU implementation • Continuous engagements, • Implementation of legacy issues if they exist, • Local content contract records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Increase in breeding grounds for disease vectors and other agents of diseases	M	SPDC shall : • ensure proper housekeeping at its campsites and work areas • carry out health sensitization for workers and community • use experts and best practices in its activities to reduce or eliminate breeding grounds for disease vectors • organize health awareness campaigns	L	• Environmental Compliance Monitoring Report, • Site inspection reports, • Health reports from site clinic	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Pressure on existing waste management system	H	SPDC shall ensure: • treatment of all waste water to regulatory standards prior disposal • provision of mobile toilets for its work-force • regularly monitor the quality of effluent to ensure that it meets regulatory standards • adhere to its waste management procedure	M	• Environmental Compliance Monitoring Reports, • Waste Consignment notes,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Road and water traffic incidents	M	SPDC shall ensure: • the creation of awareness amongst local communities on the	L	• Premob certificates • Maintenance records	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
			potential of increase in traffic on land and water and the need for extra precautions through public enlightenment • Ensure that drivers are trained on defensive driving • compliance with SPDC journey management policy for land and water transport • Marine boat quarter master training for boat captains • Boats are pre-mobbed and pre-mobilization/compliance certificate issued • that all personnel for water related operations have certificate of swimming proficiency • the provision of First Aid facilities in all water borne crafts & at sites • the use of PPE at sites • daily pep talk • carry out job hazard analyses		• Records of compliance with use of PPE • Maintenance records • Records of vehicles and water crafts, Journey Management Plan, • Pep Talks, Tool Box meetings		

Project phase/Activity	Description of Impact	Impact Rating	Mitigation measures	Rating after Mitigation	Parameters to be monitored	Monitoring frequency	Responsible party
	Environmental issues arising from improper disposal of cleared materials	H	SPDC shall dispose dredge spoils in an environmentally-friendly manner	L	• Environmental Compliance Monitoring Reports, • Waste Consignment notes,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Loss of employment/income	H	SPDC shall, • establish Global Memorandum of Understanding (GMoU) with host community and implement the content thereof • Encourage skill acquisition in the community	M	• Evidence of GMoU implementation, • Employment records, • Alternative sources of livelihood programs, • Skill acquisition programmes	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv
	Inter and intra Community conflicts	H	SPDC shall: • effectively implement the GMoU • continuously dialogue with community leadership at all strata	M	• Evidence of GMoU implementation • Employment records, • Alternative sources of livelihood programs,	Quarterly	Iseni Project Manager/FMEnv/BSMEnv/DSMEnv

Project phase/Activity	**Description of Impact**	**Impact Rating**	**Mitigation measures**	**Rating after Mitigation**	**Parameters to be monitored**	**Monitoring frequency**	**Responsible party**
					• Skill acquisition programmes		

Note: H: High, M: Medium, L=Low and P= Positive

CHAPTER EIGHT
CONCLUSION AND RECOMMENDATION

This Environmental Impact Assessment Report was carried out in accordance with relevant local, national and international regulations. The methodology applied for the study involved field work, laboratory analyses, review of previous reports and current field data within the area. To achieve this objective, a multi-disciplinary approach was adopted in the assessment of the environmental status and sensitivities of the various biophysical components. The Iseni Appraisal Well, completion of three existing wells and Civil Works (Ramp/Jetty, Access Road and Location Preparation) Project will provide opportunity for access to the Iseni field to realize the gas obligation of SPDC and meet the 3rd party gas off taker schedule. Furthermore, other positive impacts of the proposed project include but not limited to the following: increase in business opportunities, provide Opportunity for direct and indirect Employment (Unskilled labour) and Opportunity for contracting (security and survellience).

The identified adverse impacts were generally short-term and can be prevented, reduced, ameliorated, or controlled if the recommended mitigation measures are implemented. An Environmental Management Plan and a Monitoring Plan have been developed to ensure that the identified potential impacts are reduced to “as low as reasonably practicable” (ALARP). The EMP should therefore form the basis for the actual project implementation and future monitoring of environmental components. The approval of this EIA report for the execution of the proposed project is hereby recommended.

REFERENCES

Akpan, E. R., Offem, J. O. & Nya, A. E. (2002) Baseline ecological studies of the Great Kwa River, Nigeria 1: Physicochemical studies. African Journal of Environmental Pollution and Health 1 (1): 83-90

Aprile, F. (2012). Evaluation of Cation Exchange Capacity (CEC) in Tropical Soils Using Four Different Analytical Methods. Journal of Agricultural Science 4 (6): 278-289

Aiyesanmi, A.F., Ipinmoroti, K.O. and Adeeyinwo, C.E. 2006 Baseline water quality status of rivers within okitipupa southeast belt of the bituminous sands field of Nigeria. Nig. J. Sci. 40, 62–71.

Alloway, B.J. (1995) Heavy Metals in Soils.Second Edn.Blakie and Son, Glasgow. p.368.

Baker, F. and Gourley, C. (2011) Understanding Soil Tests. Department of Environment and Primary Industries, State Government of Victoria, Australia Note Number: AG1425

Chaudhari, P. R., Ahire , D. V., Ahire, V. D., Chkravarty, M. and Maity, S. (2013) Soil Bulk Density as related to Soil Texture, Organic Matter Content and available total Nutrients of Coimbatore Soil. International Journal of Scientific and Research Publications, 3 (2): 1-8 www.ijsrp.org.

Dee N, Baker J, Drobny N, Duke K, Whitman I, Fahringer D. 1973. An environmental evaluation system for water resource planning. Water Resources Research 9: 523–535

DPR (2002). Environmental Guidelines and Standards from the Petroleum Industry in Nigeria, 171pp.

Dobermann A, Fairhurst T (2000). Rice, nutrient disorders and nutrient management.Handbook series.Potash and Phosphate Institute of Canada.p. 191

Doust, H., and Omatsola, E., 1990. Niger Delta, in, Edwards, J. D., and Santogrossi, P.A., eds., Divergent/passive Margin Basins, AAPG Memoir 48: Tulsa, American Association of Petroleum Geologists, p. 239-248

DWAF. 1996. South African Water Quality Guidelines. 2nd Eedition. Volume 6: Agricultural water use: aquaculture, 185p . Published by Department of Water Affairs and Forestry of South Africa.

Evamy, B.D., Haremboure, J., Kamerling, P., Knaap, W.A., Molloy, F.A., and Rowlands, P.H., 1978. Hydrocarbon habitat of Tertiary Niger Delta: American Association of Petroleum Geologists Bulletin, v. 62, p. 277-298

Federal Ministry of Environment Decree 58 of 1988 (1998). Federal Environmental Protection Agency, Lagos.

Federal Ministry of Environment (*Former FEPA*,1991a). National Interim Guidelines and Standards for Industrial Effluent, Gaseous Emissions and Hazardous Waste Management in Nigeria. Federal Environmental Protection Agency, Lagos.

Federal Ministry of Environment (*Former FEPA*,1991b). S.I. 8 National Environmental Protection (Effluent Limitation) Regulations). Federal Environmental Protection Agency, Lagos.

Federal Ministry of Environment (*Former FEPA*,1991c). S.I. 9 National Environmental Protection (Pollution Abatement in industries and Facilities Generating Wastes. Federal Environmental Protection Agency, Lagos.

Federal Ministry of Environment (*Former FEPA*,1991d). National Environmental Protection (Management of Solid and Hazardous Wastes Regulations) (S.I. 15), 1991. Federal Environmental Protection Agency. Lagos.

Federal Ministry of Environment (*Former FEPA*,1992). Environmental Impact Assessment (EIA) Decree No. 86, Federal Environmental Protection Agency, Lagos.

Federal Ministry of Environment (*Former FEPA*, 1994). EIA Procedural Guidelines for Nigeria, Federal Environmental Protection Agency, Abuja.

Federal Ministry of Environment (*Former FEPA*, 1995). Environmental Impact Assessment Sectoral Guidelines. Oil and Gas Industry Projects. Federal Environmental Protection Agency, Abuja.

Federal Ministry of Environment (1999). National Guidelines on Waste Disposal Through Underground Injection. Federal Environmental Protection Agency, Abuja.

FMOH 2004, National Guidelines and Strategies on Infant and Young Child Feeding.

Fifield FW, Haines PJ (2000) Environmental chemistry. Second Ed.Blackwell Science Lt.d. Oxford. pp. 364-375.

Freeze, R.A., and Cherry, J.A. (1979): Groundwater. Prentice Hall, Englewood cliffs, New Jersey, 604p.

Gbile Z. O, Ola-Adams B. A, Soladoye, M. O (1981). Endangered Species of the Nigerian Flora. Nigerian J. For. 8 (1): 14-20.

Hughes, R.H. and Hughes, J. S. (1992). "A directory of African wetlands" Gland, Switzerland, Nairobi, Kenya and Cambridge, UK: IUCN, UNEP, and WCMC.

Iseni Appraisal Well Project (2013). Environmental Impact Assessment of Iseni Appraisal Well Project.

Igbozurike, U, M (Editor)(1981)Land Use and Conservation in Nigeria: Theory, Methodology, Empiricism, Policy. University of Nigeria Press, Nsukka, Nigeria, 1981

Laws, E.A. (1981). Aquatic pollution. John-Willy and Sons, New York, 301 – 369.

Leopold, L. B., F. E. Clarke, B. B. Hanshaw, and J. E. Balsley. 1971. A procedure for evaluating environmental impact. U.S. Geological Survey Circular 645, Washington, D.C.

Margesin R. and Schinner, F. (Eds.) (2005) Manual of Soil Analysis - Monitoring and Assessing Bioremediation. Springer-Verlag Berlin Heidelberg 370p.

McHarg, I. L.: Design A comprehensive highway rote-selection method, with nature. Highway Research Borrad, Washington D. C. Highway Research Record, 246,1-15 (1968).

Mills, G. (2013) Interpretations of selected Water and Wastewater Laboratory Data http://fp1.centurytel.net/GSI/index_files/StudyAids1.htm (August 9, 2013)

NDDC (2006) Niger Delta Development Commission. The Regional Development Master Plan. http://www.nddc.gov.ng/masterplan.html.

Nigerian Demographic and Health Survey (NDHS) 2008

Nelson, D (2002): Natural Variations in the Composition of Groundwater. Groundwater Foundation Annual Meeting, Springfield, Oregun.

Norman Myers, Russel A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca and Jennifer K. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403. 853-858.

Nigerian Demographic and Health Survey (NDHS) 2008

NPC (1998) The National Population Commission (NPC) of Nigeria. Population by States http://www.population.gov.ng/#

Odu. C.T.I. (1996). Pollution and rehabilitation. of wetland soils of Nigeria. Monograph. No 2. Soil Science Society of Nigeria. 107-113.

Ogbeibu, A. E. and Oribhabor, B. J. (2002): Ecological impact of River impoundment using benthic macroinvertebrates as indicators. Water Research. 36: 2427 – 2436.

Ogbeibu, A.E and Victor, R (1989). The effects of road and bridge construction on the bank root macroinvertebrates of a sourthern Nigerian stream. Environ. Pollut. 56: 85-100.

Olobaniyi, S B and Owoyemi, F B (2006): Quality of Groundwater in the Deltaic Plain Sands Aquifer of Warri and Environs, Delta State, Nigeria. Water Resources Journal, Nigerian Assoc of Hydrogeologists.

Olson, David M.; Dinerstein, Eric; Wikramanayake, Eric D.; Burgess, Neil D.; Powell, George V. N.; Underwood, Emma C.; d'Amico, Jennifer A.; Itoua, Illanga et al. (2001). "Terrestrial Ecoregions of the World: A New Map of Life on Earth". *BioScience* 51 (11): 933–938.

Opute F. I. (1991). A checklist of the freshwater, brackish and marine phytoplankton of the Warri/Forcados estuaries of southern Nigeria. *Nigerian Journal Botany* 4: 227 – 254.

Oyakhilome, G. I., Aiyesanmi, A. F. and Akharaiyi, F. C. (2012). Water quality assessment of the owena multi-purpose dam, Ondo State, Southwestern Nigeria. *J. Environ. Protection*, 3, 1–25

Petroconsultants, (1996a). Petroleum exploration and production database: Houston, Texas, Petroconsultants, Inc., [database available from Petroconsultants, Inc., P.O. Box 740619, Houston, TX 77274-0619]. Clarendon Press, Oxford.

PCL Map Collections (1979). Nigeria – Vegetation. University of Texas Austin. Map No. 504014 1979.

Powell, C. B. (1995). Wildlife Study 1. Report submitted to the Environmental Affairs Department, Shell Petroleum Development Company of Nigeria, Ltd.

Reijers, T.J.A., Petters, S.W., and Nwajide, C.S., 1997. The Niger Delta Basin, in Selley, R.C., ed., African Basins--Sedimentary Basin of the World 3: Amsterdam, Elsevier Science, pp. 151-172

RPI (1985) Environmental Baseline studies for the Establishment of control criteria and standards against petroleum related pollution in Nigeria. RPI/TR/84/4/15-7.

Ruel M and Menon P. (2003). *Child care, nutrition and health in the central plateau of Haiti: The role of community, Household, and Caregiver Resources*. Washington, DC. Food and Nutrition Technical Assistance (FANTA) project, Academy for Educational Development: 1 – 250.

Radojevic, M. and Bashkin, V.N. (1999) Practical environmental analysis. The Royal Soc. of Chemistry, Cambridge, UK

Ruel M and Menon P. (2003). Child care, nutrition and health in the central plateau of Haiti: The role of community, Household, and Caregiver Resources. Washington, DC. Food and Nutrition Technical Assistance (FANTA) project, Academy for Educational Development: 1 – 250.

UNDP (2006) United Nations Development Programme. Education: Statistical Profile. Nigeria. http://www.ng.undp.org/content/nigeria.

WHO/ISH (2003) WHO/ISH Guidelines on Hypertension.

Wokoma F.S. and Alasia D.D, (2011). Blood pressure pattern in Barako: a rural community in Rivers State, Nigeria. Niger Health Journal, 11: 8 - 13

APPENDICES
APPENDIX 1
EMP APPROVAL

FEDERAL MINISTRY OF ENVIRONMENT
Environment House
Independence Way South, Central Business District, Abuja - FCT.
Tel: 09-2911 337 . www.environment.gov.ng, ea-environment.org
ENVIRONMENTAL ASSESSMENT DEPARTMENT

FMEnv/CONF/EIA/123:640/Vol.I/84
2nd November, 2016.

The Managing Director,
Shell Petroleum Development Company of Nigeria Limited,
Freeman House, 21/22 Marina,
Lagos State.

ENVIRONMENTAL MANAGEMENT PLAN (EMP) OF THE PROPOSED ISENI WELLS LOCATION PREPARATION (ACCESS ROAD) IN SAGBAMA LOCAL GOVERNMENT AREA, BAYELSA STATE.

Please refer to your request for EMP permit for the above project and the Ministry's letter Ref: FMEnv/CONF/EIA/640/Vol.I/56 dated 20th June, 2016.

2.0 Following the successful conclusion of the evaluation of the project's EMP, I am directed to convey the Ministry's **EMP Approval** for the project subject to the following conditions: -

i. The EMP Approval covers the Iseni wells location preparation (access road) at Sagbama LGA, Bayelsa State.
ii. SPDC shall ensure that the project is implemented according to the specifications.
iii. SPDC shall ensure that all contractors involved in the project implementation are accredited by the relevant regulatory bodies.
iv. SPDC shall ensure that all her commitment as contained in the EMP are adequately followed throughout the project life span
v. The FMEnv and other relevant regulatory authorities shall monitor the implementation of the EMP.

3.0 Congratulations.

J. A. Alonge
Director, Environmental Assessment Dept.
for: Honourable Minister.

Received
Time: 02 NOV 2016
Signature
SHELL OFFICE ABUJA

APPENDIX 2
FIELD SAMPLING TECHNIQUES AND PROCEDURES

Meteorology, Air Quality & Noise

The climatic information is based on the data collected from the study area during the field work to be supplemented by analysis of long term historical data being collected from the NIMET, Oshodi.

Air quality and noise data acquisition activities took place starting from about 8.00am through 5.00 pm daily. Sampling sites were first of all identified on the field map for maximum coverage during the course of the study. The sampling plan was community – based.

This study is designed to, among other things:

(a) Assess and quantify the air quality of the project area.
(b) Evaluate the level of compliance of the measured data with the Federal Ministry of Environment (FMEnv), Department of Petroleum Resources (DPR), and World Health organization (WHO) Statutory limits.
(c) Capture and characterize the meteorological parameters within the study area.
(d) Provide data for epidemiological studies.

ii) Pollution Indicators Monitored.

The following parameters were measured and used as a basis for assessment.

(a) Noise level
(b) Suspended Particulates Matter (SPM)
(c) Nitrogen Dioxide (NO_2)
(d) Sulphur Dioxide (SO_2)
(e) Carbon Monoxide (CO)
(f) Hydrogen Sulphide (H_2S)
(g) Volatile Organic Compounds (VOCs)
(h) Ambient Temperature
(i) Relative Humidity
(j) Wind speed and Direction
(k) Atmospheric Pressure

iii) Sampling Sites

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

(a) Proposed project site
(b) Location of sensitive or vulnerable receptors to the location of the proposed project.
(c) Public safety.
(d) Predominant wind direction at the sampling sites.
(e) Accessibility.

iv) Equipment/Instrument and parameters measured *in situ*

i) Casella CEL 62X Noise meter – for measuring Noise/Vibration.
ii) Sky Master Weather Meter – for measuring Temperature, Atmospheric Pressure, Relative Humidity, Wind speed, etc.

iii) Casella Microdust Pro Aerosol monitoring System - for monitoring Suspended Particulate Matter (SPM).
iv) IBRD MX6 Multi gas meter – for measuring VOC, SO_x, NO_x, CO , H_2S.

Table 2 shows the *in-situ* results for Air Quality, Noise and Climate/Meteorology at all sampling points within the study area.

Soil

Soil sampling started at pre-determined sampling points marked out on the proposed sampling map to ensure adequate spread. Soil samples were taken with a hand-held Soil Auger at the depths of 0-15cm, 15-30cm for top and bottom respectively. Soil colour, texture, consistency, presence or absence of roots and degree of wetness were the major parameters determined. Soil samples were also collected for microbiological studies. Table 1.1 shows the number of samples taken for each environmental component during the fieldwork.

Vegetation

The vegetation study, as carried out, involved *In situ* study to ascertain the vegetation cover types and floral composition. The exercise was carried out at predetermined sampling points spread out according to the sampling rationale approved in the ToR in other to give a proper and thorough assessment of the status of the entire vegetation cover area. A detail of the species baseline for the vegetation is being drawn up. Other parameters studied include structure of the vegetation, species density and distribution, plants of economic importance and indigenous value as well as the patterns of exploitation or utilisation. The vegetation cover was assessed to establish the present pathological conditions in the vegetation community while plant tissue was sampled, at every sampling point, for heavy metal screening in the laboratory: to establish the present phyto-chemistry of the plants in the study area and find out whether there is any pre-existing abnormality or toxicities in this regards. This field report presents a preliminary *in situ* assessment and the methodologies employed during the study.

Sampling Methodology/Procedure

Vegetation Cover Characteristics

Vegetation study was carried out at the established sampling points using transect method and where applicable, random quadrant method. A quadrant delimits an area, with ease of study in mind; for which vegetation cover can be estimated, plants counted, or species listed (Cox, 1990). The sizes of the quadrants (plots of a standard convenient size) used were $100m^2$ for trees, $5m^2$ for shrubs and $1m^2$ for herbaceous species. Standard error of two thirds of all quadrants was used to make accurate estimations (Babour *et al*., 1987). Numerical estimations were done in number of species per Ha.

1 hectare = 10, 000 square meters.

$$\text{Where Density} = \left[\frac{\text{Sum total \# of species ‘A’ in all the quadrats}}{\text{Area of Quadrat X total \# of quadrats}}\right] \text{x} \ \frac{2}{3}$$

The dominant species composition, physiognomy and structure of the vegetation as well as the topography and hydrology are used to describe the ecological unit / habitat type. Information on the important ethno-botanical plants and utilization patterns of the flora was compiled from oral interviews, chance observations, and existing literature.

Plant Pathology

The health status of the vegetation was visually assessed. The state of health of crops and vegetation were noted while infected crops and vegetation were collected and stored in moistened polythene bags for further studies.

Phytochemistry

Samples of dominant plant species were collected at each sampling location, wrapped in well labelled polythene bags and taken for tissue analysis

Wildlife

Materials and Methods

Wildlife characteristics was assessed from random sightings of animals and birds, observation of foot prints, droppings, extent of impact of foraging and other activities on vegetation, and information from local hunters and indigenes (especially for nocturnal animals). Field notes on descriptions of animals and other specimen e.g. Feathers, found in the field were used to verify the identity of the species using standard literature. Pictures of animals common to the region was shown to the locals to further aid their recollection, and bridging the gap in local dialectical names and conventional names. Table 3 shows the species inventory recorded during the study.

Aquatic Studies

Aquatic studies covered the following components specified below:

a. Water Quality
b. Sediment Physico-chemistry
c. Phytoplankton Ecology
d. Zooplankton Ecology
e. Macrobenthic fauna Ecology
f. Fisheries Studies

A total of ten (10) stations were covered for surface water studies of the above listed parameters in Iseni.

Sampling Methodology

Surface water

Water samples were taken at the designated sampling stations within the swampy terrain and creeks. *In-situ* measurements were made for fast changing parameters such as temperature, pH, total dissolved solids (TDS) and conductivity. Table 4 shows the *in-situ* results of Surface Water sampling points within the study areas.

Sediment samples:

An Ekman Grab was deployed at each station to sample for sediment. About 500gm of sediment was collected in cellophane bags for physic-chemistry, 5gms of sediment were collected into cellophane bags for microbiological analysis and another 200gm for THC and heavy metal analysis were collected into aluminum.

Phytoplankton:
Phytoplankton was collected within the aquatic systems within the project area. Plankton net with a mesh size of 55µ to which a vial was attached at the bottom was used in sampling. The net was first lowered to a depth of 2-3m and slowly towed vertically for about 2 minutes. A horizontal tow was achieved by lowering the net to a depth of about 1m and towed at a speed of about 2 knots/hr for two minutes were applicable. The contents of the vial attached at the bottom of the plankton net was emptied into plastic vials and preserved in 4% formalin.

Zooplanktons:
Zooplankton was collected using plankton net with a mesh size of 55µ to which a vial was attached at the bottom. To achieve the objective, the net was first lowered to a depth of 2-3m and slowly towed vertically for about 2 minutes. A horizontal tow was achieved by lowering the net to a depth of about 1m and towed at 2 knots/hr for two minutes were applicable. The contents of the vial attached at the bottom of the plankton net was emptied into plastic vials and preserved in 4% formalin.

Benthos:
Ekman Grab was deployed into each of the sample point within the project area to sample for sediments. The Grab was deployed using an appropriate length of clean polypropylene rope. A composite of three successful grab samples were removed from the Grab using an acid washed plastic scoop, and placed in appropriately labeled, acid washed plastic or glass containers.

Benthic macro fauna were sampled by sieving 0.01 cm^3 of sediments through a 1.0mm mesh sieve in the field, using fresh water. The samples were preserved in 2% formalin solution, and stored in sterilized plastic containers at room temperature and transported to the laboratory.

A summary of the biological samples that were collected from the aquatic medium is presented in Table 5.

Table 2: Summary of biological samples collected

Sample	Preservation technique	No. of samples.
Phytoplankton	2% formalin	9
Zooplankton	2% formalin	9
Benthos	2% formalin	9

Fishing activity was assessed by counting the number of fishermen at work at the time of sampling. The types of gear used by fishermen were observed and their catch examined for fish species and abundance. Fishermen were also interviewed to obtain further information on the attributes of the fisheries of the areas under study. Hydrogeology
A typical hydro geological study entails:

- Routine fielding mapping which was conducted to find the displacement between the borehole points relative to one another.

- Actual borehole drilling to gain insight on the vertical variation of subsurface materials. This informed the drilling of the 10 boreholes in Iseni.

Routine field practice was used in the investigation. Borehole points were already predetermined. Geomatics personnel from SPDC was on hand to geo-reference the points for the drilling crew. Offset points were determined. Parameters of interest were the coordinates and elevations of the BH points as well as their lateral displacement.

Drilling was by manual percussion involving the use of hand auger, pipe range, bailer, casing pipes, water pump etc. For proper logging and stratigraphic display, soil samples were collected from drill cuttings at 1 m interval from surface to depth. Water level measurement was also obtained in all holes along with water samples after flushing. The casings were well capped to serve as reference points in future.

Average depth reached in the boreholes was 10 m. This was considered appropriate in view of the project objective and the hydro geological environment. The in-situ measurements are given in Table 6.

Social Impact Assessment (SIA)

Socio-economic Data Acquisition Approach/Methodology

Community Interaction/Focus Group Discussions (FGDs), Questionnaire.

Administration and Sampling rationale/technique

In line with Scoping Workshop and detailed TOR, you may want to know that settlements/community of primary interest were selected for the socioeconomic study, located within the study area. Ofoni is the identified and visited stakeholders ‘community of the proposed project.

The study approach which generally followed the entire EIA study plan, covered the community with sampling protocol and determined by the relative size and hence population of the affected community.

As a primary technique of data collection, Focus Group Discussions (FGDs) were used to aid data collection. At the end of the FGD sessions/community-wide interaction meetings, structured questionnaires were also administered to a cross section of the community with the help of the community leadership and/or facilitator. As a survey instrument and primary data collection method, the questionnaire was structured such that binary, optional and open-ended questions were asked to solicit the necessary answers from the householder.

APPENDIX 3
COORDINATES
Iseni Appraisal Well Project 2003

SAMPLES	EASTINGS	NORTHINGS
AIR QUALITY		
AQ01	389997.466	118495.907
AQ02	390226.066	118368.907
AQ03	389910.712	118079.358
AQ04	390492.767	118191.107
AQ05	391209.932	119025.611
AQ06	389857.765	119156.309
AQ07	389159.264	118483.207
AQ08		
AQ09	391024.687	117783.967
AQ10	391781.819	118508.607
AQ11	391203.968	119638.910
AQ12	390714.966	116818.338
AQ13	388981.464	119454.759
AQ14	388370.107	118034.266
AQc01	388283.378	120106.731
AQc02	388042.109	116950.845
AQc03	392338.956	119236.324
BOREHOLES		
BH01	390227.200	118498.609
BH02	390035.566	118254.607
BH03	390276.866	118203.807
BH04	391108.718	119169.009
BH05	391184.918	118915.008
BH06	390957.859	118962.793
BH07	388549.663	118133.957
BHc01	388353.228	120284.531
BHc02	387915.109	116817.495
BHc03	392554.857	119141.074

SOIL/VEGETATION		
SS/VG01	390332.145	118307.919
SS/VG02	390721.633	118297.393
SS/VG03	391272.531	118311.428
SS/VG04	391972.320	118299.057
SS/VG05	389527.565	118311.757
SS/VG06	389005.781	118286.866
SS/VG07	388371.862	118305.407
SS/VG08	390130.816	118495.907
SS/VG09	390085.492	120087.184
SS/VG10	390204.776	119616.011
SS/VG11	390177.937	118816.881
SS/VG12	390184.771	118055.278
SS/VG13	390167.227	117672.808
SS/VG14	390146.174	117283.320
SS/VG15	390142.665	116585.049
SS/VG16	388429.012	117956.156
SS/VG17	390981.718	119048.359
SS/VG18	391216.668	118997.558
SS/VG19	391616.719	119321.409
SS/VG20	390511.817	118864.208
SS/VG21	391115.068	118521.308
SS/VG22	391610.369	117848.206
SS/VG23	390721.367	117841.856
SS/VG24	391002.346	117251.740
SS/VG25	389622.815	118794.358
SS/VG26	389464.065	119689.710
SS/VG27	388879.863	118984.858
SS/VG28		
SS/VG29		
SS/VG30		
SS/VG31	390734.067	119657.960
SS/VG32	389953.015	118299.057
SS/VGc01	388410.378	120138.481
SS/VGc02	387902.409	117027.045
SS/VGc03	392402.456	119033.123
SURFACE WATER		
SW/SD01	391819.919	119302.359
SW/SD02	391584.969	118864.208
SW/SD03	388848.113	119696.060
SW/SD04	388619.513	118921.358
SW/SD05	388711.314	118229.820
SW/SD06	388880.986	117356.756
SW/SDc01	388886.213	120070.711
SW/SDc02	388689.363	116298.803
SW/SDc03	392194.570	119721.460

.

ISENI WELLS LOCATION PREPARATION (CIVIL WORKS, RAMP/JETTY & ACCESS ROAD), 2016

Sample	**Description**	**Easting**	**Northing**
AIR QUALITY			
AQ1	Air Quality	392698.66	119856.01
AQ2	Air Quality	394013.113	123259.617
AQ3	Air Quality	397062.701	124958.208
AQ4	Air Quality	393608.486	125314.369
AQC1	CONTROL	392349.801	123544.607
AQC2	CONTROL	394883.065	121926.114
SOIL/VEGETATION			
SS1/VG1	SOIL	392749.46	119970.31
SS2/VG2	SOIL	393066.961	121049.812
SS3/VG3	SOIL	394324.263	122173.765
SS4/VG4	SOIL	393975.013	123354.867
SS5/VG5	SOIL	395706.709	125363.621
SS6/VG6	SOIL	397040.732	125154.039
SS7/VG7	SOIL	393543.166	125433.132
SSC1/VGC1	CONTROL	392597.848	123296.559
SSC2/VGC2	CONTROL	394825.914	122015.014
SURFACE WATER/SEDIMENT			
SWSD1	SURFACE WATER_SEDIMENT	396318.559	123494.997
SWSD2	SURFACE WATER_SEDIMENT	394863.348	124884.062
SWSD3	SURFACE WATER_SEDIMENT	394251.497	125495.913
SWSD4	SURFACE WATER_SEDIMENT	393672.72	126273.128
BOREHOLE			
GW1	BORHOLE	394559.214	123488.217
GW2	BORHOLE	395028.712	123726.508
GW3	BORHOLE	394102.013	124072.418
GWC1	CONTROL	395206.915	122059.464
GWC2	CONTROL		

APPENDIX 4
QUESTIONNAIRES

COMMUNITY/SOCIO-ECONOMICS IMPACT ASSESSMENT STUDIES

GENERAL HOUSEHOLD QUESTIONNAIRE

1. Study No.--------------------------------
2. Interview No-----------------------------
3. Interviewer's No.-----------------------
4. Ward--------------------------------------
5. Ward Code-------------------------------
6. Date of Interview: ---
7. Local Gov't Area: ……………………………………………….
8. State:…………………………………………………………….
9. Settlement:……………………………………………………….
10. Settlement Status: ……………………………………………….

SECTION A

PERSONAL CHARACTERISTICS

PLEASE PROVIDE US SOME INFORMATION ABOUT YOURSELF AND HOUSEHOLD

A.1 Sex of the Respondent. 1. Male ☐ 2. Female ☐

A.2 Age of the respondent: …………………Years.

A.3 What is your marital status:………………………

A.4 State of Origin: ……………..; Ethnic Group:………………..

A.5 Please tell us the number of persons in your household (including yourself)………………….

A.6 Please state the number of persons in your household (including yourself) who fall into the following age categories.

S/No.	Age Categories.	Gender		Total
		Male	Female	
1.	≤ 4			
2.	5 - 9			
3.	10-14			
4.	15-19			
5.	20-24			
6.	25-29			
7.	30-34			
8.	35-39			
9.	40-44			
10.	45-49			
11.	50-54			
12.	55-59			
13.	60-64			
14.	≥ 65			

A.7 What is the highest level of education that you have attained?…………………...

A.8 How many numbers of your household including yourself fall into the following educational categories?

S/No	Education Attained	Gender		Total
		Male	Female	
1.	No Formal Education			
2.	Pre-Primary			
3.	Primary (Uncompleted)			
4.	Primary (Completed)			
5.	Secondary (Uncompleted)			
6.	Secondary (Completed)			
7	Tertiary (Uncompleted)			
8	Tertiary (Completed)			

A.9 Are you employed (Including self-employed), unemployed, retired or a housewife?……………………………………………………………………………

A 9(a). If employed, please what is the title of your job and name of establishment?……………………………………………………………………

A.9 (b) Please give a brief description of your job responsibility in your place of work: ……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………….................................

A.9 (c). Do your engage in any secondary occupation:…………………………….

A.9 (d). If "YES", please state the nature of your occupation..

………………………..…………………………………………………………………
…………..………………………………………………………………………………
……..

A.10 How many number of your household (including yourself) fall into the following employment categories?

S/No	Employment Status	Gender		Total
		Male	Female	
1.	Employed			
2.	Unemployed			
3.	Retired			
4.	Housewife			

A.11 Please estimate your annual income from primary and secondary sources:

1. Primary N…………………..
2. Secondary N…………………..

A.11 (a) To which of the following monthly income categories do your household belong?

1. ☐ Less than 3,000
2. ☐ 3,000-5, 000
3. ☐ 6,000- 9,000
4. ☐ 10,000- 19,000
5. ☐ 20,000-39,000
6. ☐ 40,000-49,000
7. ☐ 50,000-59,000
8. ☐ 60,000-69,000
9. ☐ 70,000-79,000

10. ☐ 80,000-89,000

11. ☐ 90,000 and 100, 000

12. ☐ 100, 000 and above.

SECTION B

ENVIRONMENTAL CONDITIONS AND

NEIGHBOURHOOD QUALITY

B.1 How do you dispose of your household refuse? …………………………………

B.2 What type of toilet system do you use?………………………………………...............................

B.3 What is the source(s) of energy used in cooking for your household?………….........................

B.3 (a): How do you source for this energy requirement? ………………………...............................

B.3 (b): What are the problems encountered in meeting the energy demand of the household? ……………………………………………………………..
......................…………………………………………………………………………………

B.4 Do you have River/Stream/Lake/Pond in your locality?……………………….............................

B.4 (a): If "YES", please state what uses you make of these water resources?

……………………………………………………………………………………….................

B.5 Do you have public water supply in your neighbourhood?………………….

B.5 (a) If 'YES', how regular or otherwise is this?

☐ 1. Very regular

☐ 2. Somewhat irregular

☐

☐

3. Somewhat regular

4. Very regular

B.5 (b) Please give reasons for your answer...

....
....

B.5 (c) How do you rate pipe-borne water supply in your area?

☐ Potable

☐ Somewhat potable

☐ Not potable

.5 (d) Is the water directly connected to your house or within the neighbourhood i.e. 200metres from your house)?

☐ Within the neighbourhood

☐ Directly connected

B.6 If 'No', What is the source of water for your household?………………………..

……………………………………………………………………………………….

B.6 (a) Would you say this water is potable (i.e. good for drinking)?

1. Yes ☐ 2. No ☐

B.6 (b) If 'No', Please explain………………………………….......................................

…………………………………………………………………………………………

B.7 Please tell us the estimated distance to source of water supply meter.

B.8 Do you pay water rates? 1. No ☐ 2. Yes ☐

B.8 (A) IF 'YES', HOW MUCH DO YOU PAY PER ANNUM? N-----------------------

B.8 (b) When last did you pay your water rate (State month/Year)-----------

B.8 (c) If 'No', Why not?………………………………………………...

……………………………………………………………………………………………………

B.9 On the whole, how much of your household income is expended on water supply monthly? N………………………………………

B.9 (a) What percentage of your household monthly income is spent on water acquisition?………………………………………………….

B.10 What is the daily average water consumption by your household? (i.e. how many 20 litres jerry cans used daily/drums)…………litres.

B.11 In your opinion, what are the problems of water supply in your neighbourhood?……………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………..............................

B.12 Please make general suggestions on ways you think the water supply can be improved……………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

B.13 I shall now use some statements to describe your residential neighbourhood/Settlement. Please tell us your satisfaction or dissatisfaction with development/social service provisions in the area.

S/No	Aspects	1.Very Dissatisfied	2.Rather Dissatisfied	3. About Okay	4. Rather Satisfied	5. Very Satisfied
1.	Overall level of living					
2.	Health Delivery					
3.	Housing					
4.	Employment opportunities					

S/No	Aspects	1.Very Dissatisfied	2.Rather Dissatisfied	3. About Okay	4. Rather Satisfied	5. Very Satisfied
5.	Income position					
6.	Availability of potable water					
7.	Electricity provision					
8.	Public transport facilities					
9.	Educational facilities/ Services					
10.	Security of life and property					
11.	General sanitation					
12.	Population of the area					
13	Environmental conditions					

B.14 All things considered, would you say that your neighbourhood/settlement is a good place to live in? 1. No. ☐ Yes ☐

B.15 (a) If 'No', please explain……………………………………………..

……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………………………………………………...
....

SECTION C

DIRECT OBSERVATION AND MEASUREMENT

FOR THE

C.1 House Type:

1				Rooming house (courtyard)
2				Rooming house (wagon type)
3				Single-family
4				Block of flats (multi-family)
5				Semi-detached
6				Storied building (single family)

C.2 Building Materials:

C.2 (a) Walling:

1				Corrugated iron sheets
2				Wood
3				Mud
4				Blocks
5				Burnt bricks
6				Cardboard/plywood sheets

C.2 (b) Roofing:

1				Corrugated iron sheets
2				Wood
3				Slate
4				Thatch
5				Decking
6				Cardboard/plywood sheets
7				Any other, specify: ____________________

C.3 Foundation:

1				Strip
2				Raft
3				Pile
4				None

C.4 House Condition:

1				Good (needs no repair)
2				Fairly Good (needs minor repair)
3				Bad (needs major repair)
4				Very bad (beyond repair)

C.5 Household Parking:

1				Private garage
2				Street side
3				Cartilage (premises)
4				Communal

C.6 Open Spaces:

1				Available within compound
2				Not available

C.7 Distance to nearest dwelling house from respondent:

1				Less than 5 metres
2				5 – 9
3				10 – 14
4				15 or more

C.8 Distance from Respondent's Dwelling to Basic Facilities:

S/No	Facility	1.more than 2 km	2.between 1 and 2 km	3.less than 1 km
(i)	Elementary School			
(ii)	Police Station			
(iii)	Hospital/Clinic/Maternity			
(iv)	Shopping area/local market			
(v)	Recreational Playground			
(vi)	Church			
(vii)	Mosque			
(viii)	Secondary School			

Thank you for your cooperation

EXACT TIME NOW.

COMMUNITY/SOCIO-ECONOMICS IMPACT ASSESSMENT STUDIES

SETTLEMENT HISTORY, SOCIAL ORGANISATIONS AND CULTURE QUESTIONNAIRE

1. Study No.--------------------------------
2. Interview No----------------------------
3. Interviewer's No.-----------------------
4. Ward ----------------------------------
5. Ward Code-------------------------------
6. Date of Interview: --
7. Settlement:…………………………………………………………
8. Informants' Name, Position/Organisation:

   (a) ____

   (b) ____

   (c) ____

   (d) ____

Exact time now: ____________________________________

SECTION A

FOR THE PARAMOUNT CHIEF

OR HIS APPOINTEES

A.1 Please give a brief account of the history of this settlement?

A.2 What is the name and rank of the paramount chief of this settlement? …………………………………………………………………………………………………… …………………………………………………………………………………………………… ………………………………

A.3 Please tell us briefly the administrative structure of this settlement, starting with the role of the paramount chief?

……………………………………………………………………………………………………
…………………………………………………………………………………………………

A.4 What are the criteria for appointing chiefs (traditional rulers) in this settlement (in descending order of importance)?

a) …………………………………………………………………………………………………… ……………

b) …………………………………………………………………………………………………… …………….

c) …………………………………………………………………………………………………… ….................

A.5 please list the criteria for appointing other chiefs (non-traditional rulers) in this settlement?

……………………………………………………………………………………………………
…………………………………………………………………………………………………

A.6 Are there any age groups in this settlement?

Yes ☐ No ☐

A.6(a) If "Yes", please state the traditional role(s) of these age-groups in the governance of this settlement.

………
……..

A6(b) please tell us how these groups are organised: ………………………………………………………..

………………………………………………………………………………………………

A.7 After the paramount chief, which persons or groups come next in the authority and power hierarchy of this settlement?

……

A.8 What traditional instruments of control are available in this settlement, with regards to rewards and punishment?

i) Rewards………………………………………………………………………………………
……

ii) Punishment: ………………………………………………………………………………….

………………………………………………………………………………………

A.9 Please tell us how the womenfolk are organised in your settlement.

………………………………………………………………………………………………
………………………………………………………………………………………

A.10 Do women have any defined role in the traditional governance of your settlement?

Yes ☐ No ☐

A.10(a) If "Yes", please explain

A.11 Please list t he types of festivals you have in this settlement?

S/No.	Festival	Period of Observation	Reason for Celebration

A.12 Please give us a short description of the three most important festivals observed in this community.

i) Festival

1: …………………………………………………………………………………………………

.ii) Festival

2:

…………………………………………………………………………………………………..

iii) Festival

3:

…………………………………………………………………………………………….…

…..

A13 Please describe the marriage practices of your people

…………………………………………………………………………………………………

……………………………………………………………………………………………

A.13 (a) Do you think that the marriage practices have been affected in any way by the presence of strangers/modernisation?

Yes ☐ No ☐

A.13 (b) If "Yes", please explain

SECTION B

NOW WE SHALL ASK YOU SOME QUESTIONS ABOUT THE LAND AND FARMING PRACTICES OF YOUR PEOPLE

B.1 Please tell us how farmland is owned in this settlement

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………..

…………………………………………………………………

B.2 Are individuals or groups permitted to sell farmland or lease it out?

☐ Yes ☐ No

B.3 Can non-indigenes among you acquire farmland whenever the land is ripe for farming?

☐ Yes ☐ No

B.4 Can strangers and non-indigenes acquire land for other development purposes (residential, commercial, industrial etc.) in this settlement?

☐ Yes ☐ No

B.4 (a) If "Yes", please tell us the modalities and security of such landed property.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………

B.5 What is the average cost of a plot of land (100ft x 50ft) in this settlement?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………..…

B.5 (a) Please recall the cost of the same size of residential land five years ago?

……………………………………………………………………………………………
……………………………………………………………………………………………
………………………………

B.6 What is the usual fallow period in this settlement? ……………………. (Years)

B.6 (a) Would you say that there have been an increase or decrease in the fallow period?

☐ Increase ☐ Decrease

B.6 (b) Please give reasons for your answers

……………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………..
....

SECTION C

PERCEPTION, ASSESSMENT AND EXPECTATIONS

1 Are you aware of the presence of Oil Company (ies) in your area?

YES ☐ NO ☐

2 If "YES", please state the name(s) of the company or companies as provided below:

S/No	Name of Oil Company	Date of Commencement of Operation in the Community
1		
2		
3		
4		

3 Please state the nature of SPDC's operations in your area?

-

C.3 (a) Does the company generate or discharges any waste material into the environment?

YES ☐ NO ☐

C.3 (b) If "YES', please tell us what you considered to be the most adverse aspect of its 0perations?

1.0 ☐ Air Pollution

1.1 ☐ Black Smoke (Gorgeous Succession)

1.2 ☐ Particulate Matters/Dusts

1.3 ☐ Chemical Substances

2.0 ☐ Water Pollution

2.1 ☐ Surface Water

2.2 ☐ Ground Water

3.0 ☐ Odour

4.0 ☐ Solid Wastes (waste Papers, Plastics Scraps, Wood Scraps, Metal Scraps etc.)

5.0 ☐ Others (please Specify) …………………………………………………………

3. (C) Please give reasons for your answer: …………………………………………………………..........

…………………………………………………………………………………………

4 Please indicate (in order of importance), what you consider the most beneficial aspects of SPDC's operations in your area?

☐ Increased employment opportunities for the local populace

☐ Scholarships for the training of the youth

☐ Opportunities to execute contract works

☐ Increased revenue in the form of taxes to the government

☐ Welfare programmes for the community (e.g. provision of social, economic, institutional, and physical infrastructure)

☐ Improvement of local agriculture

☐ Increased opportunity for small-scale business to spring up

☐ Company-induced influx of people with the attendant injection into the local environment of different value systems

Others, please specify:………………………………………………………………………………

Give reasons for your answer:…………………………………………………………………………

……………………………………………………………………………………………………

6 Please rate the performance of SPDC in the area of welfare improvements in your community with reference to the following aspects.

(TICK APPROPRIATE BOX)

i) Provision of scholarship for the training of the youth

☐	☐	☐	☐	☐
Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory

ii) Provision of infrastructure facilities

☐	☐	☐	☐	☐
Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory

iii) Provision of employment opportunities for the indigenes of host community

☐	☐	☐	☐	☐
Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory

iv) Provision of opportunities for contract works

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

v) Improvement of local agriculture

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vi) Aiding small-scale industry

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vii) Youth development programmes

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

vii) Prompt and satisfactory response to company-caused environmental problems.

Very Unsatisfactory	Unsatisfactory	DK/UC	Satisfactory	Very Satisfactory
☐	☐	☐	☐	☐

7 Are you aware of the proposed SPDC operation in your area?

YES ☐ NO ☐

7(a) if "Yes" how pleased or displeased are you with the proposed SPDC operations in the area?

(TICK APPROPRIATE BOX)

1. Very displeased ☐
2. Somewhat displeased ☐
3. Neither pleased nor displeased ☐
4. Somewhat pleased ☐
5. Very pleased ☐

8 If you are displeased, please tell us (in order of importance) three major reasons for your displeasure.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
....

9 If you are pleased, state (in order of importance) the three major reasons for your pleasure.

…………………………………………………………………………………………………
……………………………………………………………………………………………

10 Do you expect anything from SPDC as a company operating in your area?

(TICK APPROPRIATE BOX)

1 Yes ☐ 2. No ☐

C.10 (a). If "YES", state your three most urgent expectations (in order of urgency):

1. ____

2. ____

3. ____

10 (b). Please specify expectations from other companies operating in your area.

…………………………………………………………………………………………………
……

11 How would you describe the relationship between your settlement and SPDC?

1. Very strained ☐
2. Somewhat strained ☐
3. Don't know/uncertain (DK/UC) ☐
4. Somewhat cordial ☐
5. Very cordial ☐

11 (a) Please give reasons for your answer:

………………………………………………………………………………………………………
……..

12 Has your community ever had any conflict with SPDC?

☐ Yes ☐ No

a). If “Yes”, please indicate:

i) Number of Conflicts:
…………………………………………………………….............................

ii) Bases of the conflicts:

……………………………………………………………………………….......

………………………………………………………………………………………………

iii) Nature of the conflict:

……………………………………………………………………………..............

iv) Frequency of the conflicts:

……………………………………………………………………….................

v) Intensity (level of violence) of the conflict:

………………………………………………………...............

vi) Mode of conflict resolution:

……………………………………………………………………........

vi) Effects of the conflicts on the socio-economic well being of the community: ……………………..

………………………………………………………………………………………………

b). If “No”, please explain:

……………………………………………………………………………….......

………………………………………………………………………………………………

13 Please comment freely on SPDC as a company operating in your area.

……………………………………………………………………………………………………..

THANK YOU FOR YOUR COOPERATION.

EXACT TIME NOW: ________________________

HEALTH ASSESSMENT

This section presents the baseline health data of communities within the Iseni project area and is comprised mainly of information generated from sampled groups in the study communities. The data presented comprise of information generated through on the spot observations, informant interviews, self-reporting by respondents and hospital data where available. The questionnaires and checklist used for the Health Impact Assessment for the Environmental Impact Assessment studies is highlighted below:

QUESTIONNAIRE ON HEALTH IMPACT ASSESSMENT FOR EIA STUDIES

We are interested in studying the Health Impact for the proposed EIA project in your community. This questionnaire is designed to enable us to obtain related information. We need your assistance and cooperation in answering the questions asked below. Your answer will be treated as confidential.

Please fill in or tick as appropriate

A. SOCIO-DEMOGRAPHIC VARIABLES:

Name of town /village: ………………………………

(1) Name of head of household………………………...

(2).Age (last birthday)…………………

(3). Sex: Male ☐ Female ☐

(4) What is your marital status: Married ☐ Single ☐ Divorced ☐

Separated ☐ Widow ☐ Cohabit ☐

(5) Educational status:

a) No formal education

b) Primary School

c) Secondary School

d) Tertiary (NCE / OND / AL / HND / Degree)

e) Higher degree

(6) Occupation: (a) Farming ☐ (b) Fishing ☐ (c) Trading ☐

(d) Civil servant ☐ (e) Others (specify) ☐

(7) In your work place, what health problems are you exposed to:

……………………………………………………………………………………………

(8) Income per month (Adult only)…………………………………………………….

(9) How much does it cost you to take care of your family in a month?..................

(10) Religion……………

(11) Ethnic group…………………..

(12) How long have you lived in this community?

(13) Have you changed your residency in this community within the last five (5) years?

Yes ☐ No ☐

Reproductive Health Data:

How many children were born in your household between Jan. 1, 2007 and Nov. 1 2008 and what are the ages of their mothers?

Age of mother	**Total Number of children ever born by the same mother**		**Number of children born between Jan. 1, 2007 & Dec 31 2007**	
	Male	Female	Male	Female
(i)				
(ii)				
(iii)				
(iv)				
(v)				
(vi)				

(B) Life style / Habits

(1) Do you drink Alcohol? Yes ☐ No ☐

(2) If yes how often

- Every day

- At least once in a week
- Occasional

(3) Do you smoke? Yes / No

If yes, how many sticks/day……………

(4) Exercise: Yes / No

What type of exercise do you do?...

Knowledge, Attitude, Practice and Behavior on Sexually transmitted Infections

1. Do you have sexual partners not married to you Yes ☐ No ☐
2. How many are they? Yes ☐ No ☐
3. Have you heard of sexually Transmissible infections? Yes ☐ o ☐
4. Have you ever had any sexually Transmissible Infection? Yes ☐ No ☐
5. What symptoms (complaints) did you have then………………………………..
6. Were you treated by a doctor, a nurse or by yourself

- Treated by a doctor Yes ☐ No ☐
- By Nurse Yes ☐ No ☐
- By yourself Yes ☐ No ☐

7. How many times have you had STIs before?......................................
8. Have you heard of HIV/AIDS before? Yes ☐ No ☐
9. Do you know how HIV / AIDS can infect somebody? Yes ☐ No ☐
10. Name the method by which somebody can get HIV / AIDS………………….......................

………………………………………………………………………………...........................

11. Have you checked your status? Yes ☐ No ☐

12. Do you know anybody who has HIV/ AIDS Yes ☐ o ☐

13. How many do you? ……………………………………

14. Has member of your family, friends or community had or having tuberculosis?

Yes ☐ No ☐

Morbidity and Mortality

1. Please list persons (if any) who dies in your household between Jan.1 2007 and Dec. 31 2007.

Name (Optional)	Sex	Age	Cause of death (if known)
(i)			
(ii)			
(iii)			
(iv)			
(v)			
(vi)			
(vii)			

2. Please indicate number of members of your household that suffered from each of the different disease listed below between Jan. 1 2007 and Dec. 31, 2007 (if any)

Types of Disease	Male	Female	Total
(i)Diarrhoea			
(ii)Dysentery			
(iii)Measles			
(iv)Pneumonia			
(v)Typhoid fever			
(vi)Malaria			
(vii)Cholera			

Types of Disease	Male	Female	Total
(viii)Polio			
(ix)Yellow fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea worm			
(xvii) Sleeping sickness			
(xviii) River blindness			
(xix) Stroke			
(xx) Others(specify)			

3. Please indicate how many members of your family that are below 5 years who have suffered from the under-listed condition between Jan1, 2007 and Dec 31,2007.

Clinical Condition			
(i) Kwashiorkor			
(ii) Anaemia			
(iii) Rickets			
(iv) Goitre			
(v) Others(specify)			

4. How many members of your family have died from each of the diseases listed below between Jan.1, and 2007 and Dec 31, 2007 (lf any)

Type of Disease	Male	Female	Total
(i) Diarrhoea			
(ii) Dysentery			
(iii) Measles			
(iv) Pneumonia			

Type of Disease	Male	Female	Total
(v) Typhoid fever			
(vi) Malaria			
(vii) Cholera			
(viii) Polio			
(ix) Yellow Fever			
(x) Chicken pox			
(xi) Diphtheria			
(xii) Cancer			
(xiii) Tetanus			
(xiv) Tuberculosis			
(xv) AIDS			
(xvi) Guinea Worm			
(xvii) Sleeping sickness			
(xviii) River Blindness			
(xix) Stroke			
(x) Others (Specify)			

Types	Total Number	Total Number of Midwifes/ Nurses	Total Numbers of Doctors	Total Number of Medical staff
Hospital				
Maternity				
Dispensary				
Health Centre				
Private Clinic				
Patent Medicine Store				
Pharmacy Chemist				
Traditional Healing home				

Health Seeking Behaviour Data

1. Indicate types /number of health care institutions in your community
2. What treatment did/do you employ when sick?

i. Attended hospital / clinic

ii. Buys drugs from nearby chemist

iii. Consult native Doctors

iv. Self medication

3. Where did you go for child delivery(ies) ?

i. Attend hospital/health centres…….

ii. Maternity/private clinic…………..
iii. At home alone…………………...
iv. Native Doctors/traditional midwife
v. Any other (specify)………………..

Environmental Health Data

1. What is the major source of water available for your household? (tick the correct option)

I. Rivers / Stream
II. Well
III. Pond
IV. Rain Water
V. Public pipe-borne water
VI. Mono pump
VII. Borehole (commercial)
VIII. Borehole (private)
IX. Commercial Tankers

2. What type (s) of residential houses do you have in your community?

   (Tick the correct option)

Types of Houses (by Nature of Construction Materials	Total Number
(i) Wood (Batcher)	
(ii) Mud	
(iii) Corrugated iron sheets (zinc batcher)	
(iv) Cellophane (nylon)	
(v) Thatcher	
(vi) Block (Cement or brick)	
(vii) Others (specify)	

3. How many person live in a house?..

4. How many rooms are in your house / residence? ……………………………….

5. What type of toilet facility do you use? please tick from below.

1) Pit

2) Bush

3) Prier head

4) Bucket

5) Water Closet
6) Others (specify)…………………………………………………………………

6. How do you dispose of your household refuse? Please tick from the list below.

I. Private open dump
II. Public open dump
III. Organized collection (by Local Government, Community etc)
IV. Organized collection by (individual-commercial)
V. Burning
VI. Bush
VII. Burying
VIII. Rivers/stream

CHECK LIST FOR HEALTH ASSESSMENT

(A) ENVIRONMENTAL HEALTH CHECKLIST

(1) STATUS OF THE PHYSICAL ENVIRONMENT: CLEANLINESS STATUS OF THE PREMISES

S/NO	DESCRIPTION	GRADE	REMARK
1	Unswept + weed /bush uncleared	1	Poor
2	Swept / weed / bush not cleared to ground level or completely cleared to ground level but unswept	2	Fair
3	Cleared to ground level and swept	3	Good
4	3 + packed or burnt	4	V. Good

NOTE:

(2) REFUSE DISPOSAL (TYPE)

- Open dumping on land
- Thrown into the river
- Composting
- Incineration (or burning)
- Others P/S specify ………………………………………………………….

S/NO	DESCRIPTION	GRADE	REMARK
1	Full and over flowing / scattered around	1	Poor
2	Full and not over flowing or Incompletely packed	2	Fair
3	Completed packed, clean, empty or not full	3	Good

NOTE:

(3) SEWAGE

1) Defaecate into rivers / stream
2) Defaecate in the bush
3) Bucket
4) Pit toilet
5) Trench
6) VIP
7) Others (P/S specify)

(4) STATUS OF TOILET FACILITY

S/NO	DESCRIPTION	GRADE	REMARK
1	Sewage littering the whole place / unflushed /unwashed	1	Poor
2	Clean surrounding and Unwashed/unflushed	2	Fair
3	Clean / covered flushed and washed	3	Good

NOTE:

(5) WATER

- Sources of drinking water

- Tap
- Well
- Stream
- Rain

Indicator	Unity of Measurement	Community Performance
Quantity of water	No of litres per person per day	
Quantity of water (access)	No of users per point (of Tap or Well)	
% of households without safe drinking water supply		

(6) HOUSING

(a) Type:

- Mud with thatched roof
- Mud with zinc roof
- Blockhouse with zinc roof.

(b) Number of persons living in a room

(c) Ventilation

- Cross ventilation
- No-cross ventilation

(d) Distance from high-tension cable/wire (Minimum 30m)

(7) TRAFFIC

- Means of transport
- Use of seat belts, helmets
- Status of vehicle (good motoring condition)

- Traffic regulations/sign boards

(8) HEALTH RELATED SOCIAL AMENITIES

- Electricity
- Tarred Roads
- Education facilities
- Recreational

CHECKLIST FOR ASSESSING THE QUALITY OF AVAILABLE HEALTH FACILITY

A. Name of Community____

- Name of Health Institution____________________________________
- Outpatient and Inpatient (Delete not applicable)

B. Health professionals

S/N	Personnel	Number	Qualification	Years of Experience
1	Doctors			
2	Nurses			
3	Midwifes			
4	Lab Scientists			
5	Radiographers			
6	Anaesthetists			
7	Record Clerk			
8	Pharmacist			
9	Others			

C. Equipment

- Consulting table and chairs
- Examination couch
- Disposable needless and syringes
- Disposable suture kits
- Methods for sterilization
- Refrigerators
- Medical waste disposal methods
- X-ray facilities
- ECG
- Ultrasound
- Laboratory facilities
- Pharmacy (WHO Essential Drug List Available, List)
- No of beds
- Laundry facilities
- Catering facilities
- Operating theatre.

D. Hospital Building with the following features

FEATURES	YES	NO
• Clean consultation room		
• Clean waiting room		
• Treatment/minor procedures room		
• Privacy rooms		

FEATURES	YES	NO
• Clean running water/hand washing facilities		
• Toilet		
• Good light		
• Good ventilation (or AC)		
• Insect screens		

Remarks

E. Administration

FEATURES	YES	NO
• Appointment system		
• Health records		
• Security		
• Confidentiality		
• Scale of changes		
• Cleaning and maintenance routine		

Remarks

F. LOGISTICS

- Accessibility of the health Institution (average radial distance of the center from the members of the community) ______________________

- Communications Telephone/radio
- Hospital Ambulance

G.

- Average daily clinic attendance:
- Common diseases treated:

____

____

H MORBIDITY AND MORTALITY STATISTICS

H1 Table of distribution of common disease conditions last 12 months

Name of disease/Health condition	Frequency		TOTAL
	Males	Females	

H2: Table of distribution of common causes of death last 12 months

CAUSE OF DEATH	Frequency		TOTAL
	Males	Females	

Record of births last 12 months:

APPENDIX 5
ANALYTICAL RESULTS
Air quality and noise level in the project area (2013)

Sample Identity	SO_2 mg/m^3	No $_2$ mg/m$_3$	H_2S mg/m^3	HN_3 mg/m^3	CO mg/m^3	CO_2 mg/m^3	VOC mg/m^3	BTEX mg/m^3	SPM µg/m^3	Noise dB(A}
AQ01	0.02	<0.001	<0.001	<0.001	0.01	138	0.23	<0.001	3.01	48.9
AQ 02	0.02	<0.001	<0.001	0.001	0.00	140	0.21	<0.001	2.58	48.1
AQ 03	0.02	<0.001	<0.001	0.001	0.01	148	0.21	<0.001	3.04	47.1
AQ05	0.02	<0.001	<0.001	0.001	0.01	144	0.21	<0.001	3.25	52.6
AQ06	0.01	<0.001	<0.001	<0.001	0.00	135	0.18	<0.001	3.17	52.6
AQ 07	0.03	<0.001	0.001	<0.001	0.00	142	0.24	<0.001	2.94	48.3
AQ 09	0.01	<0.001	<0.001	<0.001	0.00	143	0.24	<0.001	3.07	48.3
AQ 10	0.03	<0.001	<0.001	<0.001	0.01	137	0.23	<0.001	2.98	51.7
AQ11	0.02	<0.001	<0.001	<0.001	0.03	143	0.17	<0.001	4.06	48.5
AQ 12	0.03	<0.001	<0.001	0.001	0.03	169	0.1	<0.001	4.85	57.8
AQ13	0.03	<0.001	<0.001	0.001	0.00	139	0.22	<0.001	3.02	45.6
Ofoni Comm.	0.03	<0.001	<0.001	<0.001	<0.001	141	0.23	<0.001	3.12	49.3
AQ Cont. 1	0.02	<0.001	0.001	0.001	0.02	145	0.25	<0.001	2.98	44.2
AQ Cont.2	0.02	<0.001	<0.001	<0.001	0.01	139	0.22	<0.001	2.89	48.6
AQ Cont.3	0.03	<0.001	0.001	<0.001	0.01	144	0.24	<0.001	2.67	49.3

FIELD MEASUREMENT FOR AIR QUALITY, NOISE AND METEOROLOGY OF ISENI FIELDS (2016)

S/N	Sample Identity	SO_2 mg/m^3	NO_2 mg/m^3	CH_4 mg/m^3	O_3 mg/m^3	CO mg/m^3	VOC mg/m^3	SPM mg/m^3	Noise db(A)	TEMP ^0C	Relative Humidity %	Wind Speed m/s	Wind Direction
1	AQ 1	<0.001	<0.001	<0.001	<0.001	0.00	2.10	8.00	41.70	28.20	84.00	0.30	SW
2	AQ 2	<0.001	<0.001	<0.001	<0.001	0.00	7.60	17.30	42.30	28.90	71.20	0.30	SW
3	AQ 3	<0.001	<0.001	<0.001	<0.001	0.00	8.80	18.00	46.20	29.70	73.80	0.10	SW
4	AQ 4	<0.001	<0.001	<0.001	<0.001	0.00	7.30	16.90	39.30	26.70	82.90	0.90	SW
Mean		<0.001	<0.001	<0.001	<0.001	0.00	6.45	15.05	42.38	28.38	77.98	0.40	SW
5	AQ Control 1	<0.001	<0.001	<0.001	<0.001	0.00	4.20	7.60	40.50	32.60	65.70	1.20	SW
6	AQ Control 2	<0.001	<0.001	<0.001	<0.001	0.00	3.90	6.80	42.10	30.90	74.80	0.70	SW

SOIL PHYSICO-CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS IN ISENI FIELD (2013)

Units		µS/cm	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	Colour	mg/kg	cmol/kg	cmol/kg	mg/kg
Parameters	**pH**	**EC**	**THC**	**TOC**	**NH4**	**NO2**	**NO3**	**AV.P**		**O&G**	**Ca**	**Na**	**phenol**
ISE SS1	4.68	189.0	<BDL	0.07	1.19	<BDL	0.12	4.96	BROWN	<BDL	0.27	0.58	<BDL
***ISE SS1**	4.27	213.0	<BDL	0.02	0.72	<BDL	0.09	3.77	BROWN	<BDL	0.22	0.43	<BDL
ISE SS2	4.92	125.0	<BDL	0.04	1.15	<BDL	0.17	5.12	BROWN	<BDL	0.19	0.41	<BDL
***ISE SS2**	4.65	98.0	<BDL	0.01	0.88	<BDL	0.12	4.44	BROWN	<BDL	0.16	0.39	<BDL
ISE SS3	5.13	117.0	<BDL	0.08	2.97	<BDL	0.23	3.98	BROWN	<BDL	0.21	0.48	<BDL
***ISE SS3**	4.98	123.0	<BDL	0.04	1.86	<BDL	0.15	3.31	BROWN	<BDL	0.17	0.42	<BDL
ISE SS4	4.67	98.0	<BDL	0.05	1.72	<BDL	0.22	5.29	BROWN	<BDL	0.15	0.44	<BDL
***ISE SS4**	4.41	82.0	<BDL	0.02	1.11	<BDL	0.13	4.41	BROWN	<BDL	0.18	0.39	<BDL
ISE SS5	4.39	126.0	<BDL	0.08	1.39	<BDL	0.45	3.28	BROWN	<BDL	0.15	0.38	<BDL
***ISE SS5**	4.11	135.0	<BDL	0.03	0.65	<BDL	0.21	2.76	BROWN	<BDL	0.11	0.31	<BDL
ISE SS6	5.26	99.0	<BDL	0.05	1.62	<BDL	0.19	3.33	BROWN	<BDL	0.23	0.58	<BDL
***ISE SS6**	5.17	84.0	<BDL	0.01	0.97	<BDL	0.11	2.51	BROWN	<BDL	0.22	0.42	<BDL
ISE SS7	4.90	213.0	<BDL	0.07	1.88	<BDL	0.22	6.79	BROWN	<BDL	0.31	0.76	<BDL
***ISE SS7**	4.76	147.0	<BDL	0.03	1.11	<BDL	0.14	4.17	BROWN	<BDL	0.28	0.61	<BDL
ISE SS8	4.45	145.0	<BDL	0.03	0.96	<BDL	0.27	3.57	BROWN	<BDL	0.24	0.54	<BDL
***ISE SS8**	4.28	119.0	<BDL	0.01	0.43	<BDL	0.15	3.11	BROWN	<BDL	0.27	0.52	<BDL
ISE SS9	5.19	176.0	<BDL	0.06	1.35	<BDL	0.09	4.98	BROWN	<BDL	0.28	0.49	<BDL
***ISE SS9**	4.87	132.0	<BDL	0.02	1.89	<BDL	0.05	4.02	BROWN	<BDL	0.22	0.43	<BDL
ISE SS10	4.79	138.0	<BDL	0.07	1.05	<BDL	0.14	2.45	BROWN	<BDL	0.31	0.62	<BDL
***ISE SS10**	4.42	122.0	<BDL	0.02	0.94	<BDL	0.09	1.77	BROWN	<BDL	0.29	0.57	<BDL
ISE SS11	4.83	167.0	<BDL	0.04	0.27	<BDL	0.27	2.38	BROWN	<BDL	0.18	0.44	<BDL
***ISE SS11**	4.46	119.0	<BDL	0.01	1.24	<BDL	0.18	2.22	BROWN	<BDL	0.19	0.37	<BDL
ISE SS12	5.26	179.0	<BDL	0.05	0.79	<BDL	0.22	2.45	BROWN	<BDL	0.35	0.72	<BDL
***ISE SS12**	4.84	202.0	<BDL	0.01	1.33	<BDL	0.15	1.98	BROWN	<BDL	0.28	0.59	<BDL
ISE SS13	5.51	123.0	<BDL	0.03	0.95	<BDL	0.27	4.62	BROWN	<BDL	0.25	0.63	<BDL

Units		μS/cm	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	Colour	mg/kg	cmol/kg	cmol/kg	mg/kg
Parameters	**pH**	**EC**	**THC**	**TOC**	**NH4**	**NO2**	**NO3**	**AV.P**		**O&G**	**Ca**	**Na**	**phenol**
***ISE SS13**	5.07	149.0	<BDL	0.01	0.47	<BDL	0.16	3.69	BROWN	<BDL	0.23	0.54	<BDL
ISE SS14	4.92	222.0	<BDL	0.09	0.18	<BDL	0.33	5.11	BROWN	<BDL	0.19	0.48	<BDL
***ISE SS14**	4.44	186.0	<BDL	0.03	2.15	<BDL	0.17	3.29	BROWN	<BDL	0.18	0.44	<BDL
ISE SS15	4.24	156.0	<BDL	0.06	1.76	<BDL	0.24	5.51	BROWN	<BDL	0.16	0.52	<BDL
***ISE SS15**	4.13	177.0	<BDL	0.02	1.43	<BDL	0.13	2.96	BROWN	<BDL	0.15	0.50	<BDL
ISE SS16	4.58	96.0	<BDL	0.05	1.19	<BDL	0.19	3.83	BROWN	<BDL	0.26	0.67	<BDL
***ISE SS16**	4.34	114.0	<BDL	0.01	0.62	<BDL	0.12	2.79	BROWN	<BDL	0.27	0.61	<BDL
ISE SS17	5.28	227.1	<BDL	0.03	0.76	<BDL	0.14	5.26	BROWN	<BDL	0.22	0.58	<BDL
***ISE SS17**	4.76	197.0	<BDL	0.01	0.33	<BDL	0.05	4.41	BROWN	<BDL	0.21	0.49	<BDL
ISE SS18	4.41	234.0	<BDL	0.05	0.92	<BDL	0.23	3.98	BROWN	<BDL	0.28	0.62	<BDL
***ISE SS18**	4.25	221.0	<BDL	0.02	0.78	<BDL	0.19	2.27	BROWN	<BDL	0.18	0.44	<BDL
ISE SS1 C	5.63	236.0	<BDL	0.05	0.37	<BDL	0.19	3.10	BROWN	<BDL	0.17	0.55	<BDL
***ISE SS1 C**	4.92	178.0	<BDL	0.01	0.11	<BDL	0.15	2.76	BROWN	<BDL	0.14	0.42	<BDL
ISE SS2 C	5.71	215.0	<BDL	0.03	0.26	<BDL	0.18	2.85	BROWN	<BDL	0.11	0.45	<BDL
***ISE SS2 C**	5.55	243.0	<BDL	0.01	0.18	<BDL	0.12	2.22	BROWN	<BDL	0.11	0.39	<BDL
ISE SS3 C	5.91	129.0	<BDL	0.06	0.23	<BDL	0.25	1.89	BROWN	<BDL	0.23	0.43	<BDL
***ISE SS3 C**	5.28	107.0	<BDL	0.02	0.15	<BDL	0.11	1.16	BROWN	<BDL	0.29	0.71	<BDL

ISE SS (SOIL SAMPLE) (TOP 0-15CM); *ISE SS (SOIL SAMPLE) (SUB 15-30CM)

SOIL CHARACTERISTICS (CONT'D)

Units	cmol/kg	cmol/kg	cmol/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	MV	%	%	%
Parameters	**K**	**EA**	**ECEC**	**TPH**	**PAH**	**Benzen**	**Toulene**	**Ethyl Benzen**	**Xylene**	**R.P**	**Clay**	**Silt**	**Sand**
ISE SS1	0.24	0.85	2.45	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	90.0	9.8	6.5	83.7
***ISE SS1**	0.19	0.72	2.04	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	110.0	11.6	4.9	83.5
ISE SS2	0.13	0.73	1.78	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	76.0	13.4	7.8	84.6
***ISE SS2**	0.11	1.16	2.10	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	95.0	12.8	5.9	81.3
ISE SS3	0.17	1.11	2.38	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	97.0	10.5	6.3	83.2
***ISE SS3**	0.14	0.81	1.92	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	124.0	15.2	4.3	80.5
ISE SS4	0.13	0.74	1.83	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	156.0	15.2	3.9	80.9
***ISE SS4**	0.16	0.92	2.00	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	98.0	16.9	5.8	77.3
ISE SS5	0.11	0.78	1.75	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	126.0	10.8	3.5	85.7
***ISE SS5**	0.08	1.05	1.84	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	88.0	12.7	4.6	82.7
ISE SS6	0.19	1.27	2.69	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	97.0	9.8	4.3	85.9
***ISE SS6**	0.17	0.94	2.11	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	128.0	14.2	3.7	82.1
ISE SS7	0.26	0.88	2.80	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	79.0	10.7	2.9	86.4
***ISE SS7**	0.21	0.75	2.40	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	86.0	13.7	3.3	83.0
ISE SS8	0.19	1.48	2.96	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	124.0	10.3	3.1	86.6
***ISE SS8**	0.21	1.19	2.67	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	86.0	12.7	3.9	83.4
ISE SS9	0.20	0.57	1.98	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	143.0	10.8	2.4	86.8
***ISE SS9**	0.18	0.44	1.68	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	110.0	12.7	3.7	83.6
ISE SS10	0.26	2.18	3.94	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	147.0	15.2	2.1	82.7
***ISE SS10**	0.24	1.29	2.94	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	58.0	17.1	3.7	79.2
ISE SS11	0.13	1.67	2.80	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	97.0	15.4	3.2	81.4
***ISE SS11**	0.15	1.04	2.08	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	76.0	13.8	5.7	80.5
ISE SS12	0.29	0.93	2.94	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	89.0	11.4	1.9	86.7
***ISE SS12**	0.22	0.78	2.45	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	125.0	12.9	4.6	82.5
ISE SS13	0.21	1.26	2.89	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	149.0	9.7	2.9	89.1

Units	cmol/kg	cmol/kg	cmol/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	MV	%	%	%
Parameters	**K**	**EA**	**ECEC**	**TPH**	**PAH**	**Benzen**	**Toulene**	**Ethyl Benzen**	**Xylene**	**R.P**	**Clay**	**Silt**	**Sand**
***ISE SS13**	0.19	1.11	2.58	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	121.0	10.5	3.6	85.9
ISE SS14	0.15	1.47	2.72	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	143.0	11.2	4.5	84.3
***ISE SS14**	0.13	1.15	2.31	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	97.0	14.8	3.8	81.4
ISE SS15	0.11	2.03	3.24	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	126.0	12.6	2.1	85.3
***ISE SS15**	0.13	1.36	2.53	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	75.0	15.2	4.1	80.7
ISE SS16	0.22	0.79	2.48	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	94.0	11.8	4.6	83.6
***ISE SS16**	0.23	0.55	2.17	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	82.0	15.2	5.9	78.9

ISE SS (SOIL SAMPLE) (TOP 0-15CM); *ISE SS (SOIL SAMPLE) (SUB 15-30CM)

SOIL CHARACTERISTICS (CONT'D)

Units		cm/s	%	g/cm3	%	cfu/g x 10^5	cfu/g x 10^3	cfu/g x 10^3	cfu/g x 10
Parameters	**Texture**	**Permaebility**	**Porosity**	**Bulk .D**	**Total .N**	**THB**	**THF**	**HUB**	**HUF**
ISE SS1	LS	0.13	52.0	1.10	0.29	1.52	0.61	1.23	0.17
***ISE SS1**	LS	0.11	48.0	0.94	0.27	1.78	0.82	1.43	0.23
ISE SS2	LS	0.17	58.0	1.19	0.25	1.62	0.52	1.29	0.19
***ISE SS2**	LS	0.16	55.0	1.25	0.19	1.97	0.77	1.76	0.21
ISE SS3	LS	0.11	60.0	1.29	0.14	1.53	0.39	1.42	0.17
***ISE SS3**	LS	0.08	55.0	0.84	0.26	2.13	1.11	1.86	0.52
ISE SS4	LS	0.06	64.0	1.14	0.21	1.78	0.76	1.53	0.31
***ISE SS4**	LS	0.02	60.0	0.95	0.17	1.52	0.88	1.29	0.38
ISE SS5	LS	0.09	55.0	1.38	0.12	1.17	0.61	1.03	0.29
***ISE SS5**	LS	0.08	50.0	1.11	0.19	1.94	1.23	1.75	0.79
ISE SS6	LS	0.14	49.0	1.42	0.12	1.58	0.95	1.29	0.42
***ISE SS6**	LS	0.10	45.0	1.33	0.23	1.76	0.84	1.58	0.37
ISE SS7	LS	0.05	60.0	1.29	0.21	1.45	0.65	1.21	0.28
***ISE SS7**	LS	0.03	58.0	1.22	0.54	1.29	0.39	1.15	0.17
ISE SS8	LS	0.07	62.0	1.16	0.39	1.18	0.17	0.94	0.09

Units		**cm/s**	%	**g/cm3**	**%**	**cfu/g x 10 ^{5}**	**cfu/g x 10 ^{3}**	**cfu/g x 10 ^{3}**	**cfu/g x 10**
Parameters	**Texture**	**Permaebility**	**Porosity**	**Bulk .D**	**Total .N**	**THB**	**THF**	**HUB**	**HUF**
***ISE SS8**	LS	0.02	53.0	1.23	0.33	1.48	0.19	1.09	0.12
ISE SS9	LS	0.13	49.0	1.98	0.29	1.23	0.12	0.77	0.11
***ISE SS9**	LS	0.08	43.0	1.47	0.25	2.14	1.31	1.97	0.24
ISE SS10	LS	0.15	55.0	1.26	0.22	1.76	1.04	1.43	0.29
***ISE SS10**	LS	0.09	52.0	1.22	0.18	1.35	0.81	1.27	0.15
ISE SS11	LS	0.08	57.0	1.76	0.11	1.08	0.57	0.94	0.12
***ISE SS11**	LS	0.04	55.0	1.39	0.34	1.75	1.25	1.63	0.81
ISE SS12	LS	0.13	62.0	1.22	0.27	1.39	0.92	1.27	0.39
***ISE SS12**	LS	0.11	58.0	1.15	0.21	1.79	0.84	1.25	0.41
ISE SS13	LS	0.09	60.0	1.43	0.15	1.38	0.59	1.22	0.23
***ISE SS13**	LS	0.07	58.0	1.27	0.27	2.46	1.87	2.13	0.29
ISE SS14	LS	0.15	47.0	0.89	0.22	2.21	1.42	1.84	0.33
***ISE SS14**	LS	0.12	43.0	1.15	0.14	1.95	1.06	1.53	0.21
ISE SS15	LS	0.09	56.0	1.38	0.11	1.72	0.79	1.44	0.18
***ISE SS15**	LS	0.07	52.0	1.27	0.28	2.27	1.27	1.97	0.72
ISE SS16	LS	0.13	60.0	1.42	0.23	1.98	0.93	1.62	0.34
***ISE SS16**	LS	0.09	55.0	1.29	0.19	1.43	0.91	1.29	0.42
ISE SS17	LS	0.09	63.0	0.83	0.23	3.81	1.78	2.24	0.39
***ISE SS17**	LS	0.06	58.0	0.97	0.15	2.76	0.96	2.13	0.13
ISE SS18	LS	0.11	52.0	1.11	0.28	2.19	0.34	1.73	0.11
***ISE SS18**	LS	0.09	61.0	1.04	0.26	1.31	0.08	1.11	0.07
ISE SS1 C	LS	0.16	52.0	0.72	0.27	1.88	0.68	1.27	0.41
***ISE SS1 C**	LS	0.14	50.0	0.66	0.23	1.27	0.52	0.89	0.28
ISE SS2 C	LS	0.11	62.0	0.93	0.14	1.56	0.74	1.07	0.47
***ISE SS2 C**	LS	0.09	55.0	0.85	0.11	1.24	0.46	1.11	0.33
ISE SS3 C	LS	0.16	58.0	0.94	0.15	1.73	0.82	1.39	0.36

Units		cm/s	%	g/cm3	%	cfu/g x 10^5	cfu/g x 10^3	cfu/g x 10^3	cfu/g x 10
Parameters	**Texture**	**Permaebility**	**Porosity**	**Bulk .D**	**Total .N**	**THB**	**THF**	**HUB**	**HUF**
***ISE SS3 C**	LS	0.12	52.0	0.87	0.18	1.78	0.76	1.53	0.31

ISE SS (SOIL SAMPLE) (TOP 0-15CM); *ISE SS (SOIL SAMPLE) (SUB 15-30CM)

HEAVY METALS IN ISENI SOIL

Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Parameters	**Fe**	**Cr**	**V**	**AS**	**Pb**	**Cu**	**Zn**	**Hg**	**Ba**	**Ni**	**Co**	**Cd**	**Al**	**Ag**
ISE SS1	310.68	1.987	<BDL	<BDL	1.775	0.024	7.921	<BDL	<BDL	4.987	<BDL	0.541	<BDL	<BDL
***ISE SS1**	297.65	1.117	<BDL	<BDL	0.904	0.310	6.080	<BDL	<BDL	3.761	<BDL	0.228	<BDL	<BDL
ISE SS2	426.43	2.081	<BDL	<BDL	1.382	0.037	8.298	<BDL	<BDL	2.651	<BDL	0.149	<BDL	<BDL
***ISE SS2**	397.64	1.765	<BDL	<BDL	0.896	0.038	7.194	<BDL	<BDL	2.228	<BDL	0.094	<BDL	<BDL
ISE SS3	513.23	1.457	<BDL	<BDL	2.183	0.015	5.552	<BDL	<BDL	5.491	<BDL	1.452	<BDL	<BDL
***ISE SS3**	428.70	0.882	<BDL	<BDL	1.902	0.013	7.610	<BDL	<BDL	3.475	<BDL	1.113	<BDL	<BDL
ISE SS4	398.78	1.237	<BDL	<BDL	1.254	0.019	5.443	<BDL	<BDL	2.987	<BDL	0.854	<BDL	<BDL
***ISE SS4**	330.27	1.119	<BDL	<BDL	1.006	0.028	8.294	<BDL	<BDL	1.765	<BDL	0.551	<BDL	<BDL
ISE SS5	541.99	2.108	<BDL	<BDL	1.652	0.180	5.493	<BDL	<BDL	3.892	<BDL	1.398	<BDL	<BDL
***ISE SS5**	420.68	1.765	<BDL	<BDL	1.171	0.015	6.662	<BDL	<BDL	2.979	<BDL	0.967	<BDL	<BDL
ISE SS6	629.76	0.945	<BDL	<BDL	0.897	0.073	7.091	<BDL	<BDL	4.045	<BDL	0.562	<BDL	<BDL
***ISE SS6**	441.21	0.771	<BDL	<BDL	0.554	0.049	8.953	<BDL	<BDL	3.287	<BDL	1.298	<BDL	<BDL
ISE SS7	392.31	1.654	<BDL	<BDL	1.208	0.031	10.872	<BDL	<BDL	2.176	<BDL	0.871	<BDL	<BDL
***ISE SS7**	351.91	1.292	<BDL	<BDL	1.529	0.029	6.629	<BDL	<BDL	2.007	<BDL	0.559	<BDL	<BDL
ISE SS8	329.88	1.021	<BDL	<BDL	0.924	0.025	7.215	<BDL	<BDL	3.145	<BDL	0.427	<BDL	<BDL
***ISE SS8**	257.69	0.875	<BDL	<BDL	0.662	0.031	8.882	<BDL	<BDL	2.764	<BDL	0.229	<BDL	<BDL
ISE SS9	359.81	2.451	<BDL	<BDL	0.829	0.170	6.062	<BDL	<BDL	1.118	<BDL	0.952	<BDL	<BDL
***ISE SS9**	297.62	1.987	<BDL	<BDL	0.523	0.053	5.598	<BDL	<BDL	1.083	<BDL	0.881	<BDL	<BDL
ISE SS10	310.23	1.303	<BDL	<BDL	1.423	0.020	8.291	<BDL	<BDL	2.387	<BDL	0.342	<BDL	<BDL
***ISE SS10**	300.89	1.111	<BDL	<BDL	1.018	0.024	6.724	<BDL	<BDL	3.245	<BDL	0.207	<BDL	<BDL

Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Parameters	**Fe**	**Cr**	**V**	**AS**	**Pb**	**Cu**	**Zn**	**Hg**	**Ba**	**Ni**	**Co**	**Cd**	**Al**	**Ag**
ISE SS11	398.77	0.925	<BDL	<BDL	2.171	0.055	6.204	<BDL	<BDL	4.980	<BDL	0.418	<BDL	<BDL
***ISE SS11**	315.73	0.827	<BDL	<BDL	1.795	0.039	5.558	<BDL	<BDL	3.269	<BDL	0.297	<BDL	<BDL
ISE SS12	342.55	1.382	<BDL	<BDL	0.727	0.015	6.287	<BDL	<BDL	3.106	<BDL	0.771	<BDL	<BDL
***ISE SS12**	339.78	1.227	<BDL	<BDL	0.534	0.150	7.210	<BDL	<BDL	2.784	<BDL	0.529	<BDL	<BDL
ISE SS13	415.64	0.965	<BDL	<BDL	1.628	0.063	8.882	<BDL	<BDL	3.208	<BDL	0.428	<BDL	<BDL
***ISE SS13**	398.78	0.761	<BDL	<BDL	1.985	0.045	5.498	<BDL	<BDL	2.765	<BDL	0.225	<BDL	<BDL
ISE SS14	536.73	0.815	<BDL	<BDL	1.542	0.045	11.092	<BDL	<BDL	2.208	<BDL	0.167	<BDL	<BDL
***ISE SS14**	298.76	0.629	<BDL	<BDL	1.227	0.007	7.129	<BDL	<BDL	1.765	<BDL	0.091	<BDL	<BDL
ISE SS15	322.17	1.442	<BDL	<BDL	0.867	0.010	9.823	<BDL	<BDL	3.287	<BDL	0.254	<BDL	<BDL
***ISE SS15**	297.65	0.978	<BDL	<BDL	0.329	0.016	5.557	<BDL	<BDL	2.226	<BDL	0.132	<BDL	<BDL
ISE SS16	396.55	1.528	<BDL	<BDL	0.663	0.024	6.712	<BDL	<BDL	3.076	<BDL	0.198	<BDL	<BDL
***ISE SS16**	321.29	1.229	<BDL	<BDL	0.517	0.330	4.520	<BDL	<BDL	1.527	<BDL	0.115	<BDL	<BDL
ISE SS17	625.89	1.987	<BDL	<BDL	2.564	0.180	6.593	<BDL	<BDL	1.807	<BDL	0.187	<BDL	<BDL
***ISE SS17**	337.99	1.117	<BDL	<BDL	1.298	0.250	7.012	<BDL	<BDL	0.887	<BDL	0.145	<BDL	<BDL
ISE SS18	613.99	2.081	<BDL	<BDL	1.652	0.200	11.865	<BDL	<BDL	1.453	<BDL	0.157	<BDL	<BDL
***ISE SS18**	441.91	1.765	<BDL	<BDL	0.776	0.072	9.835	<BDL	<BDL	1.115	<BDL	0.111	<BDL	<BDL
ISE SS1 C	590.83	0.815	<BDL	<BDL	0.817	0.019	8.672	<BDL	<BDL	1.343	<BDL	0.476	<BDL	<BDL
***ISE SS1 C**	300.15	0.629	<BDL	<BDL	0.542	0.020	6.534	<BDL	<BDL	1.007	<BDL	0.398	<BDL	<BDL
ISE SS2 C	326.71	1.442	<BDL	<BDL	0.439	0.020	5.439	<BDL	<BDL	1.254	<BDL	0.256	<BDL	<BDL
***ISE SS2 C**	279.87	0.978	<BDL	<BDL	0.227	0.032	3.308	<BDL	<BDL	0.984	<BDL	0.141	<BDL	<BDL
ISE SS3 C	335.42	1.528	<BDL	<BDL	0.186	0.025	4.441	<BDL	<BDL	1.140	<BDL	0.079	<BDL	<BDL
***ISE SS3 C**	276.54	1.229	<BDL	<BDL	0.072	0.021	3.682	<BDL	<BDL	0.786	<BDL	0.054	<BDL	<BDL

ISE SS (SOIL SAMPLE) (TOP 0-15CM); *ISE SS (SOIL SAMPLE) (SUB 15-30CM)

SOIL PHYSICOCHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS (2016)

Units		µS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	%	mg/kg	mg/kg	mg/kg	cmol/kg
Parameters	**pH**	**EC**	**THC**	**PAH**	**TPH**	**PHENOL**	**TOC**	**AV.P**	**T.N**	**NH4+**	**NO3-**	**NO2-**	**Na+**
ISE SS1	3.37	54.43	<0.001	<0.001	<0.001	<0.001	0.72	2.96	0.04	2.18	0.19	<0.001	0.04
***ISE SS1**	3.66	30.27	<0.001	<0.001	<0.001	<0.001	0.59	1.32	0.01	1.43	0.15	<0.001	0.01
ISE SS2	4.13	50.93	<0.001	<0.001	<0.001	<0.001	0.78	3.57	0.07	3.37	0.23	<0.001	0.06
***ISE SS2**	4.44	61.02	<0.001	<0.001	<0.001	<0.001	0.50	2.86	0.02	1.42	0.14	<0.001	0.03
ISE SS3	3.61	36.94	<0.001	<0.001	<0.001	<0.001	0.54	4.02	0.04	2.54	0.11	<0.001	0.07
***ISE SS3**	3.75	41.38	<0.001	<0.001	<0.001	<0.001	0.33	3.53	0.01	0.87	0.08	<0.001	0.05
ISE SS4	4.28	57.86	<0.001	<0.001	<0.001	<0.001	0.82	2.86	0.03	2.43	0.21	<0.001	0.08
***ISE SS4**	4.18	61.34	<0.001	<0.001	<0.001	<0.001	0.64	1.77	0.02	1.19	0.19	<0.001	0.05
ISE SS5	3.32	57.86	<0.001	<0.001	<0.001	<0.001	0.71	2.42	0.08	4.32	0.32	<0.001	0.06
***ISE SS5**	3.44	53.92	<0.001	<0.001	<0.001	<0.001	0.55	1.74	0.02	2.17	0.17	<0.001	0.04
ISE SS6	3.38	38.72	<0.001	<0.001	<0.001	<0.001	0.53	3.39	0.05	3.22	0.26	<0.001	0.06
***ISE SS6**	3.25	40.33	<0.001	<0.001	<0.001	<0.001	0.19	1.85	0.02	1.56	0.15	<0.001	0.05
ISE SS7	3.69	58.47	<0.001	<0.001	<0.001	<0.001	0.62	2.48	0.04	2.78	0.13	<0.001	0.03
***ISE SS7**	3.39	24.76	<0.001	<0.001	<0.001	<0.001	0.41	1.29	0.01	1.25	0.07	<0.001	0.01
ISE SSC1	4.07	53.14	<0.001	<0.001	<0.001	<0.001	0.52	2.22	0.03	1.76	0.24	<0.001	0.05
***ISE SSC1**	4.10	63.16	<0.001	<0.001	<0.001	<0.001	0.39	1.34	0.01	1.11	0.16	<0.001	0.02
ISE SSC2	3.45	47.60	<0.001	<0.001	<0.001	<0.001	0.27	1.98	0.02	2.13	0.19	<0.001	0.07
***ISE SSC2**	3.78	27.30	<0.001	<0.001	<0.001	<0.001	0.14	1.15	0.01	1.45	0.13	<0.001	0.05
ISE SSC3	5.22	88.92	<0.001	<0.001	<0.001	<0.001	0.46	2.08	0.02	1.78	0.22	<0.001	0.05
***ISE SSC3**	3.92	42.50	<0.001	<0.001	<0.001	<0.001	0.15	1.52	0.01	1.32	0.14	<0.001	0.03

CATIONS AND HEAVY METALS RESULTS

Units	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Parameters	**K+**	**Ca2+**	**Mg2+**	**EA**	**ECEC**	**O&G**	**Fe**	**Cd**	**Cr**	**Pb**	**Cu**	**Hg**	**Ar**
ISE SS1	0.11	0.39	0.87	1.76	3.17	<0.001	1877.783	9.156	13.765	<0.001	2.754	<0.001	<0.001
***ISE SS1**	0.09	0.27	0.75	1.30	2.42	<0.001	1656.541	7.876	10.774	<0.001	2.101	<0.001	<0.001
ISE SS2	0.16	0.45	0.68	1.85	3.20	<0.001	1905.170	7.198	11.352	<0.001	4.163	<0.001	<0.001
***ISE SS2**	0.14	0.39	0.52	1.37	2.45	<0.001	1638.320	4.086	10.142	<0.001	3.643	<0.001	<0.001
ISE SS3	0.12	0.52	0.81	2.16	3.68	<0.001	1546.470	2.764	14.987	<0.001	3.081	<0.001	<0.001
***ISE SS3**	0.08	0.47	0.77	1.53	2.90	<0.001	1332.890	1.181	9.853	<0.001	1.762	<0.001	<0.001
ISE SS4	0.15	0.41	0.68	1.42	2.74	<0.001	1746.234	9.762	15.287	<0.001	2.129	<0.001	<0.001
***ISE SS4**	0.11	0.33	0.52	1.18	2.19	<0.001	1552.870	2.876	6.071	<0.001	1.745	<0.001	<0.001
ISE SS5	0.09	0.28	0.94	2.35	3.72	<0.001	1798.523	5.209	17.845	<0.001	4.189	<0.001	<0.001

Units	cmol/kg	cmol/kg	cmol/kg	cmol/kg	cmol/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Parameters	**K+**	**Ca2+**	**Mg2+**	**EA**	**ECEC**	**O&G**	**Fe**	**Cd**	**Cr**	**Pb**	**Cu**	**Hg**	**Ar**
***ISE SS5**	0.05	0.25	0.75	1.82	2.91	<0.001	1197.089	4.101	11.093	<0.001	1.663	<0.001	<0.001
ISE SS6	0.13	0.37	0.72	1.97	3.25	<0.001	1594.270	8.765	12.086	<0.001	3.251	<0.001	<0.001
***ISE SS6**	0.08	0.31	0.63	1.35	2.42	<0.001	1172.953	4.097	7.726	<0.001	1.743	<0.001	<0.001
ISE SS7	0.06	0.42	0.67	1.72	2.90	<0.001	1679.332	6.543	14.329	<0.001	5.102	<0.001	<0.001
***ISE SS7**	0.02	0.33	0.54	1.39	2.29	<0.001	1279.853	5.807	13.771	<0.001	2.764	<0.001	<0.001
ISE SSC1	0.13	0.52	0.78	2.21	3.69	<0.001	1489.234	1.175	8.675	<0.001	4.442	<0.001	<0.001
***ISE SSC1**	0.08	0.27	0.52	1.76	2.65	<0.001	1307.542	0.782	5.206	<0.001	1.897	<0.001	<0.001
ISE SSC2	0.10	0.38	0.82	1.94	3.31	<0.001	1697.223	3.024	5.423	<0.001	1.203	<0.001	<0.001
***ISE SSC2**	0.07	0.31	0.75	1.33	2.51	<0.001	1278.831	1.172	2.207	<0.001	1.015	<0.001	<0.001
ISE SSC3	0.11	0.42	0.79	1.65	3.02	<0.001	1554.117	2.172	4.671	<0.001	2.102	<0.001	<0.001
***ISE SSC3**	0.08	0.35	0.64	1.29	2.39	<0.001	1208.513	0.775	3.337	<0.001	1.856	<0.001	<0.001

HEAVY METALS AND SOIL CHARACTERISATION

Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	%		%	cm/s	g/cm3
Parameters	**Ni**	**V**	**Zn**	**Ba**	**As**	**Clay**	**Silt**	**Sand**	**Texture**	**Porosity**	**P.M**	**B.D**
ISE SS1	8.575	<0.001	95.432	<0.001	<0.001	76.5	19.9	3.6	C	53.0	0.06	1.27
***ISE SS1**	6.704	<0.001	88.907	<0.001	<0.001	81.4	16.9	1.7	C	62.0	0.04	1.31
ISE SS2	5.352	<0.001	112.725	<0.001	<0.001	84.3	11.7	4.0	C	55.0	0.07	1.24
***ISE SS2**	4.113	<0.001	89.254	<0.001	<0.001	87.6	11.3	1.1	C	57.0	0.05	1.29
ISE SS3	7.685	<0.001	97.132	<0.001	<0.001	76.4	14.8	8.8	C	60.0	0.08	1.25
***ISE SS3**	4.796	<0.001	85.432	<0.001	<0.001	80.1	13.5	6.4	C	65.0	0.06	1.31
ISE SS4	9.107	<0.001	104.321	<0.001	<0.001	57.8	23.8	18.4	C	51.0	0.05	1.24
***ISE SS4**	6.432	<0.001	80.543	<0.001	<0.001	60.7	17.5	21.8	C	55.0	0.04	1.29
ISE SS5	5.498	<0.001	77.131	<0.001	<0.001	61.4	23.7	14.9	C	48.0	0.08	1.27
***ISE SS5**	2.276	<0.001	69.843	<0.001	<0.001	70.8	20.5	8.7	C	51.0	0.07	1.31
ISE SS6	7.146	<0.001	91.182	<0.001	<0.001	66.4	18.7	14.9	C	52.0	0.07	1.23
***ISE SS6**	6.623	<0.001	67.453	<0.001	<0.001	72.7	15.4	11.9	C	57.0	0.06	1.29
ISE SS7	4.976	<0.001	59.102	<0.001	<0.001	3.1	12.6	84.3	S	29.0	0.14	1.46
***ISE SS7**	2.874	<0.001	44.372	<0.001	<0.001	5.7	13.7	80.6	S	32.0	0.11	1.48
ISE SSC1	5.609	<0.001	80.182	<0.001	<0.001	79.6	16.5	3.9	C	61.0	0.05	1.25
***ISE SSC1**	3.332	<0.001	72.345	<0.001	<0.001	82.5	14.8	2.7	C	64.0	0.03	1.30
ISE SSC2	6.765	<0.001	50.125	<0.001	<0.001	72.4	23.5	4.1	C	59.0	0.07	1.22
***ISE SSC2**	5.098	<0.001	37.791	<0.001	<0.001	79.5	19.2	1.3	C	63.0	0.05	1.28
ISE SSC3	4.772	<0.001	62.093	<0.001	<0.001	85.4	11.6	3.0	C	52.0	0.07	1.25
***ISE SSC3**	1.986	<0.001	54.318	<0.001	<0.001	89.4	8.8	1.8	C	55.0	0.06	1.29

GROUNDWATER PHYSICOCHEMICAL CHARACTERISTICS (2013)

Parameters	**Unit**	**BH1**	**BH2**	**BH3**	**BH4**	**BH5**	**BH6**	**BH7**	**BH C1**	**BH C2**	**BH C3**	**OFONI CW**
pH		6.98	6.06	6.25	5.40	6.06	5.80	6.37	6.37	6.55	6.10	7.24
Temp	**^oC**	29.4	28.9	28.7	29.6	29.5	29.2	29.3	29.3	29.5	29.3	28.7
TDS	**mg/L**	46.50	47.10	44.90	26.90	49.10	29.40	50.11	47.61	49.20	47.10	26.91
COND	**µS/cm**	83.70	84.92	80.23	42.19	88.10	52.87	90.15	85.67	88.21	82.15	48.41
DO	**mg/L**	3.80	4.10	4.30	4.60	3.90	4.10	4.30	5.20	4.80	5.10	5.50
Colour	**Pt/Co**	8.00	10.00	13.00	5.00	8.00	9.00	11.00	5.00	3.00	7.00	2.00
T.Alkalinity	**mg/L$CaCO_3$**	16.94	18.31	16.17	9.33	20.19	10.97	20.28	19.82	19.66	18.30	7.95
R.P	**Mv**	93.00	87.00	84.00	90.00	81.00	77.00	79.00	72.00	66.00	69.00	48.00
BOD5	**mg/L**	0.86	0.93	0.88	0.76	0.85	0.94	0.79	0.87	0.92	0.85	0.71
Salinity	**mg/L**	7.20	9.60	7.03	6.27	10.01	6.42	10.90	9.28	9.12	9.12	5.51
COD	**mg/L**	2.22	2.47	2.34	1.66	1.87	2.11	1.96	2.29	2.45	2.13	1.59
Turbidity	**NTU**	100.14	98.71	93.88	3.51	47.32	26.81	50.92	54.21	100.60	75.92	0.46
CO3	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
CN	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
H2S	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
THC	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
TSS	**mg/L**	13.42	10.11	8.97	11.25	10.96	12.11	10.26	8.15	8.77	8.65	7.11
NH4	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
NO2	**mg/L**	<BDL	<BDL	<BDL	<BDL	0.002	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
NO3	**mg/L**	0.009	0.011	0.016	0.005	0.013	0.006	0.009	0.007	0.005	0.008	0.0
PO4	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
SO4	**mg/L**	1.238	1.213	1.025	0.629	1.131	0.438	0.879	1.225	0.927	1.396	0.484
Silicon	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Hardness	**mg/L$CaCO_3$**	5.29	4.76	3.84	2.80	6.14	3.32	3.89	6.66	4.15	4.29	3.68
Ca	**mg/L**	1.160	1.092	0.913	0.857	1.113	0.745	0.991	1.242	0.985	0.881	0.849
Na	**mg/L**	2.170	1.987	1.853	1.117	2.138	1.202	1.683	2.095	1.229	1.379	1.662

Parameters	Unit	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH C1	BH C2	BH C3	OFONI CW
K	mg/L	0.829	0.732	0.619	0.555	0.852	0.331	0.684	0.925	0.764	0.549	0.438
Mg	mg/L	2.861	2.536	2.228	1.453	3.117	1.976	2.505	3.141	2.786	2.563	1.997
O&G	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Phenol	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
THC	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
TSS	mg/L	13.42	10.11	8.97	11.25	10.96	12.11	10.26	8.15	8.77	8.65	7.11
NH4	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
NO2	mg/L	<BDL	<BDL	<BDL	<BDL	0.002	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
NO3	mg/L	0.009	0.011	0.016	0.005	0.013	0.006	0.009	0.007	0.005	0.008	0.0
PO4	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
SO4	mg/L	1.238	1.213	1.025	0.629	1.131	0.438	0.879	1.225	0.927	1.396	0.484
Silicon	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Hardness	mg/L	5.29	4.76	3.84	2.80	6.14	3.32	3.89	6.66	4.15	4.29	3.68
Ca	mg/L	1.160	1.092	0.913	0.857	1.113	0.745	0.991	1.242	0.985	0.881	0.849
Na	mg/L	2.170	1.987	1.853	1.117	2.138	1.202	1.683	2.095	1.229	1.379	1.662
K	mg/L	0.829	0.732	0.619	0.555	0.852	0.331	0.684	0.925	0.764	0.549	0.438
Mg	mg/L	2.861	2.536	2.228	1.453	3.117	1.976	2.505	3.141	2.786	2.563	1.997
O&G	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Phenol	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
As	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Ag	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Co	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Mn	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cu	mg/L	0.001	0.001	<BDL	<BDL	<BDL	0.003	0.001	<BDL	<BDL	<BDL	<BDL
Fe	mg/L	0.027	0.032	0.019	0.037	0.022	0.015	0.019	0.009	0.011	0.007	0.004
Cr	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cd	mg/L	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL

Parameters	Unit	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH C1	BH C2	BH C3	OFONI CW
Ni	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Pb	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Hg	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
V	**mg/L**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Zn	**mg/L**	0.319	0.228	0.416	0.298	0.331	0.278	0.304	0.275	0.192	0.284	0.304
Al	**mg/l**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Ba	**mg/l**	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL

GROUNDWATER PHYSICOCHEMICAL CHARACTERISTICS (2016)

Units		**oC**	**mg/l**	**µS/cm**	**mg/l**	**MV**	**N.T.U**	**mg/l**	**mg/l**	**mg/l**	**Pt-Co**		**mg/l**	**mg/l**
Parameters	**pH**	**Temp**	**TDS**	**EC**	**DO**	**R.P**	**Turbidity**	**T.H**	**O&G**	**COD**	**Colour**	**Odour**	**PO43-**	**TA**
BH1	6.80	27.5	94.05	188.10	2.10	35.00	1.70	68.00	<0.001	1.75	5.00	UN OBJ.	0.52	0.22
BH2	5.40	26.8	93.35	186.70	1.90	30.00	1.39	66.00	<0.001	2.25	2.00	UN OBJ.	0.71	0.14
BH3	6.20	27.8	151.00	302.00	2.70	55.00	1.50	98.00	<0.001	1.37	3.00	UN OBJ.	1.16	0.20
BHC1	5.10	27.1	86.25	172.50	2.00	40.00	1.62	57.00	<0.001	1.50	3.00	UN OBJ.	0.37	0.14
BHC2	6.20	27.3	147.50	295.00	2.50	50.00	1.84	101.00	<0.001	1.00	4.00	UN OBJ.	0.98	0.18

GROUNDWATER PHYSICOCHEMICAL CHARACTERISTICS (2016) CONT'D

Units	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Parameters	**BOD5**	**Salinity**	**Ca2+**	**Mg2+**	**Na+**	**K+**	**CO32-**	**SO42-**	**NO3-**	**Cl-**	**PHENOL**	**MAH**	**TPH**	**PAH**
BH1	0.70	26.50	11.52	5.17	3.24	1.17	ND	1.27	0.11	14.67	<0.001	<0.001	<0.001	<0.001
BH2	0.90	35.23	9.31	3.76	4.28	1.23	ND	1.16	0.08	19.50	<0.001	<0.001	<0.001	<0.001

Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Parameters	**BOD5**	**Salinity**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**CO_3^{2-}**	**SO_4^{2-}**	**NO_3^-**	**Cl^-**	**PHENOL**	**MAH**	**TPH**	**PAH**
BH3	0.55	40.01	14.05	7.12	5.37	0.95	ND	2.35	0.27	25.47	<0.001	<0.001	<0.001	<0.001
BHC1	0.60	21.30	7.95	3.82	1.96	0.72	ND	1.96	0.09	11.79	<0.001	<0.001	<0.001	<0.001
BHC2	0.40	58.05	19.43	7.95	5.41	1.85	ND	3.02	0.13	32.13	<0.001	<0.001	<0.001	<0.001

GROUNDWATER PHYSICOCHEMICAL CHARACTERISTICS (2016) CONT'D

Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Parameters	**THC**	**BTEX**	**Co**	**Ba**	**Hg**	**As**	**Fe**	**Cd**	**Cr**	**Pb**	**Cu**	**Ni**	**V**	**Zn**
BH1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007
BH2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.033	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
BH3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
BHC1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006
BHC2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

SEDIMENT QUALITY CHARACTERISTICS (2013)

Parameters	Unit	BS1	BS2	BS3	BS4	BS5	BS6	BS C1	BS C2	BS C3
pH		4.85	4.90	4.92	5.27	4.95	5.29	5.95	5.72	4.59
EC	**µS/cm**	61.42	43.40	40.61	39.76	33.29	55.27	39.76	17.85	63.40
THC	**mg/kg**	0.27	0.19	0.33	0.26	0.54	0.18	0.11	0.17	0.12
TOC	**%**	0.35	0.59	0.42	0.51	0.47	0.38	0.29	0.38	0.27
NH_4	**mg/kg**	1.29	0.88	0.67	0.45	0.73	0.59	0.83	0.77	0.34
NO_2	**mg/kg**	0.07	0.05	0.09	0.03	0.05	0.08	0.06	0.04	0.06
NO_3	**mg/kg**	1.24	1.76	1.33	1.15	0.97	1.32	1.57	1.21	1.36
AV.P	**mg/kg**	0.95	0.76	0.81	0.77	0.82	0.93	0.85	0.72	0.63
Colour		DARK B	DARK B	DARK B	DARK B	DARK B	DARK B	DARK B	DARK B	DARK B
O&G	**mg/kg**	0.39	0.25	0.45	0.36	0.68	0.27	0.22	0.29	0.35
Na	**cmol/kg**	0.32	0.26	0.13	0.24	0.21	0.28	0.37	0.45	0.38
K	**cmol/kg**	0.44	0.37	0.17	0.37	0.47	0.43	0.64	0.57	0.62
Ca	**cmol/kg**	1.17	0.99	0.48	0.64	0.73	0.92	1.29	1.45	0.96
Ca	**cmol/kg**	1.17	0.95	0.48	0.64	0.73	0.92	1.29	1.45	0.96
Phenol	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mg	**cmol/kg**	2.25	1.94	1.37	1.29	1.32	0.58	0.55	1.78	1.10
EA	**cmol/kg**	2.28	1.64	1.32	1.36	2.29	2.57	1.74	1.31	1.22
ECEC	**cmol/kg**	6.46	5.16	3.47	3.90	5.02	4.78	4.59	5.56	4.28
TPH	**mg/kg**	0.08	0.06	0.09	0.06	0.13	0.08	0.06	0.05	0.03
PAH	**mg/kg**	0.01	0.01	0.02	BDL	0.02	0.01	BDL	BDL	BDL
R.P	**MV**	119	126	118	134	115	132	127	98	100
Clay	**%**	71.9	69.5	74.7	66.8	77.6	69.4	73.9	70.5	64.8
Silt	**%**	19.8	21.1	17.6	20.6	15.2	18.2	16.6	18.7	22.8
Sand	**%**	8.3	9.4	7.7	12.6	7.2	12.4	9.5	10.8	12.4
Texture		LS	LS	LS	LS	LS	LS	LS	LS	LS

Parameters	Unit	BS1	BS2	BS3	BS4	BS5	BS6	BS C1	BS C2	BS C3
Permaebility	**cm/s**	0.11	0.07	0.08	0.09	0.05	0.13	0.12	0.10	0.09
Porosity	%	55.0	49.0	51.0	53.0	44.0	59.0	57.0	50.0	52.0
Bulk .D	**g/cm3**	1.18	1.10	1.13	1.14	0.98	1.20	1.19	1.14	1.16
Total .N	**%**	0.27	0.19	0.11	0.13	0.24	0.17	0.22	0.18	0.25
Al	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Fe	**mg/kg**	128.5	111.9	97.6	156.3	126.5	133.0	77.8	93.3	86.9
Cr	**mg/kg**	2.254	1.178	2.108	2.765	1.349	1.108	0.762	0.594	0.919
Cd	**mg/kg**	0.617	0.418	0.519	0.882	0.227	0.079	0.039	0.075	0.067
Ni	**mg/kg**	1.297	1.225	0.972	1.542	0.794	1.101	0.921	0.873	0.929
Pb	**mg/kg**	2.108	1.763	1.776	2.381	1.982	2.131	1.498	1.276	1.597
Zn	**mg/kg**	37.610	27.453	19.956	30.171	27.765	36.291	5.492	7.771	6.261
Hg	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
V	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Co	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
As	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cu	**mg/kg**	0.172	0.196	0.254	0.114	0.176	0.096	0.054	0.072	0.043
Ba	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mn	**mg/kg**	1.276	0.795	1.118	2.076	1.563	0.982	0.498	0.663	0.621
Benzen	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Toulene	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ethyl Benzen	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Xylene	**mg/kg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
THB	**cfu/g**	3.24	4.16	3.97	5.53	4.74	3.97	4.02	3.87	3.53
THF	**cfu/g**	1.28	1.98	1.68	2.21	1.98	1.82	1.25	1.63	1.27
HUB	**cfu/g**	1.47	2.03	1.82	2.35	2.12	1.97	1.39	1.76	1.33
HUF	**cfu/g**	0.29	0.68	0.33	0.87	0.76	0.59	0.31	0.46	0.25

SEDIMENT QUALITY CHARACTERISTICS (2016)

Units		**mg/kg**	**mg/kg**	**mg/kg**	**%**	**mg/kg**	**MV**	**%**	**%**	**%**	**%**	**mg/kg**	**mg/kg**	**mg/kg**
Parameters	**pH**	**THC**	**PAH**	**BTEX**	**TOC**	**PHENOL**	**R.P**	**CLAY**	**SILT**	**SAND**	**O.M**	**Ca2+**	**Mg2+**	**Na+**
BS 1	5.70	<0.001	<0.001	<0.001	0.11	<0.001	96.00	3.4	0.8	95.8	0.19	19.756	37.490	21.365
BS 2	5.41	<0.001	<0.001	<0.001	1.31	<0.001	102.00	75.2	19.4	5.4	2.26	21.342	62.101	97.652
BS 3	5.45	<0.001	<0.001	<0.001	1.54	<0.001	87.00	79.6	16.8	3.6	2.66	17.675	58.321	88.404
BS C1	5.70	<0.001	<0.001	<0.001	0.98	<0.001	94.00	71.8	18.4	9.8	1.70	32.409	77.082	90.152
BS C2	6.00	<0.001	<0.001	<0.001	1.22	<0.001	85.00	80.5	16.3	3.2	2.11	29.205	60.453	79.38

Units	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**%**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Parameters	**k+**	**Cl-**	**NO3-**	**SO42-**	**CO32-**	**Fe**	**Zn**	**Ba**	**Cr**	**Pb**	**Cu**	**Cd**	**Hg**	**V**
BS 1	5.310	95.82	0.85	1.28	0.36	1683.250	13.281	<0.001	0.351	<0.001	8.525	4.324	<0.001	<0.001
BS 2	11.183	101.27	1.13	3.76	0.46	1439.760	89.711	<0.001	7.625	<0.001	11.776	5.129	<0.001	<0.001
BS 3	9.804	97.61	1.25	3.19	0.49	1774.540	74.803	0.002	11.193	<0.001	9.753	7.142	<0.001	<0.001
BS C1	13.241	84.35	1.33	2.78	0.44	1021.870	84.172	<0.001	5.634	<0.001	10.543	2.192	<0.001	<0.001
BS C2	18.084	90.46	0.91	2.52	0.42	1355.440	69.253	<0.001	7.032	<0.001	7.654	3.609	<0.001	<0.001

Units	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Parameters	**Co**	**As**	**Ni**	**PAH**	**MAH**	**BTEX**	**O&G**	**THC**	**TPH**
BS 1	<0.001	<0.001	2.225	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BS 2	<0.001	<0.001	5.613	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BS 3	<0.001	<0.001	3.794	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BS C1	<0.001	<0.001	4.054	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BS C2	<0.001	<0.001	3.117	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

SURFACE WATER QUALITY CHARACTERISTICS (2013)

Parameters	Unit	SW1	SW2	SW3	SW4	SW5	SW6	SW C1	SW C2	SW C3
pH		6.20	5.84	6.25	6.49	6.53	6.63	6.74	6.77	5.60
Temp	**Oc**	29.2	28.7	28.4	29.8	30.2	29.3	28.7	27.9	29.3
TDS	**mg/L**	48.90	31.80	48.30	48.28	48.31	48.50	48.80	49.30	24.40
COND	**µS/cm**	83.11	54.09	82.11	82.05	82.13	82.45	82.96	83.81	41.44
DO	**mg/L**	5.20	4.90	4.70	5.10	5.50	5.70	5.80	5.70	6.20
Colour	**Pt/Co**	4.00	6.00	5.00	5.00	7.00	4.00	6.00	4.00	5.00
T.Alkalinity	**mg/L CaCO3**	13.41	10.11	15.16	16.03	22.54	17.97	13.31	13.69	7.11
R.P	**mV**	81.00	66.00	109.00	65.00	74.00	69.00	60.00	64.00	86.00
BOD5	**mg/L**	0.79	0.88	0.72	0.93	0.85	0.74	0.81	0.77	0.74
Salinity	**mg/L**	8.50	7.29	9.66	9.85	12.28	8.85	7.36	8.70	5.10
COD	**mg/L**	1.98	2.20	1.80	2.32	2.13	1.85	2.03	1.93	1.85
Turbidity	**mg/L**	6.51	7.70	59.44	60.18	100.54	56.88	43.21	52.91	2.57
O&G	**mg/L**	0.152	0.098	0.271	BDL	0.013	0.328	0.198	0.314	0.208
CO3	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CN	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
H2S	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
THC	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TSS	**mg/L**	9.11	8.42	9.25	8.82	8.65	9.11	7.94	7.21	8.04
NH4	**mg/L**	0.53	0.29	0.21	0.14	0.11	0.18	0.15	0.11	0.09
NO2	**mg/L**	0.013	0.008	0.005	BDL	BDL	0.004	0.002	BDL	BDL
NO3	**mg/L**	0.97	1.03	0.88	0.61	0.54	0.92	0.87	0.69	0.71
PO4	**mg/L**	0.03	0.06	0.03	0.02	0.02	0.03	0.02	<BDL	0.03
SO4	**mg/L**	1.98	3.78	1.87	1.92	1.45	2.27	2.65	2.09	1.86
Silicon	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hardness	**mg/L CaCO3**	5.43	7.29	5.17	4.97	4.41	5.62	5.38	4.57	3.39

Parameters	**Unit**	**SW1**	**SW2**	**SW3**	**SW4**	**SW5**	**SW6**	**SW C1**	**SW C2**	**SW C3**
Ca	**mg/L**	1.54	2.39	1.08	1.15	1.02	1.45	1.72	1.16	0.94
Na	**mg/L**	2.76	6.54	3.32	2.75	2.46	3.21	4.52	3.79	3.38
K	**mg/L**	1.91	2.83	1.54	1.67	1.55	1.79	2.18	1.65	1.29
Mg	**mg/L**	3.59	8.5	4.32	3.58	3.17	3.89	5.12	4.11	3.98
Mg	**mg/L**	2.12	4.81	2.98	2.28	1.97	2.54	3.32	2.49	2.25
O&G	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Phenol	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Al	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ba	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Co	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Mn	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cu	**mg/L**	0.005	BDL	0.002	0.004	0.001	0.003	0.002	BDL	BDL
Fe	**mg/L**	0.016	0.007	0.015	0.013	0.009	0.011	0.007	0.006	0.011
Cr	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cd	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ni	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pb	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hg	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
V	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zn	**mg/L**	0.171	0.098	0.123	0.119	0.115	0.119	0.071	0.097	0.112
Ag	**mg/L**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL = BELOW DETECTION LIMIT (i.e <0.001)

SURFACE WATER QUALITY CHARACTERISTICS (2016)

Units		**oC**	**mg/l**	**µS/cm**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**Pt-Co**	**Odour**	**N.T.U**	**mg/l**
Parameters	**pH**	**Temp**	**TDS**	**E.C**	**DO**	**T.H**	**TSS**	**BOD5**	**Salinity**	**COD**	**Colour**		**Turbidity**	**PO_4^{3-}**
SW1	7.80	27.7	19.25	38.50	3.50	10.00	7.00	1.40	7.95	3.50	4.00	UN OBJ.	3.10	0.08
SW2	8.20	28.1	20.25	40.50	4.90	8.00	5.00	1.60	12.38	4.00	2.00	UN OBJ.	2.70	0.11
SW3	8.00	27.6	19.40	38.80	4.60	10.00	5.00	1.25	11.51	3.13	2.00	UN OBJ.	2.40	0.07
SW C1	7.80	27.6	18.85	37.70	3.60	12.00	8.00	1.10	11.26	2.75	3.00	UN OBJ.	3.45	0.05
SW C2	7.80	27.4	19.50	39.00	4.80	16.00	9.00	1.00	10.79	2.50	1.00	UN OBJ.	3.70	0.07

Units	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Parameters	**CO_3^{2-}**	**TA**	**Ca^{2+}**	**Mg^{2+}**	**K^+**	**Na^+**	**Cl^-**	**SO_4^{2-}**	**NO_3^-**	**PHENOL**	**TPH**	**THC**	**BTEX**	**PAH**
SW1	ND	0.30	2.80	0.73	0.54	1.06	4.40	0.97	0.02	<0.001	<0.001	<0.001	<0.001	<0.001
SW2	ND	0.38	2.40	0.49	0.68	1.77	6.85	1.32	0.07	<0.001	<0.001	<0.001	<0.001	<0.001
SW3	ND	0.34	2.53	0.61	0.82	1.54	6.37	1.29	0.05	<0.001	<0.001	<0.001	<0.001	<0.001
SW C1	ND	0.28	3.11	0.87	0.55	1.19	6.23	1.23	0.09	<0.001	<0.001	<0.001	<0.001	<0.001
SW C2	ND	0.30	4.09	1.18	0.39	1.12	5.97	1.16	0.04	<0.001	<0.001	<0.001	<0.001	<0.001

Units	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Parameters	**MAH**	**O&G**	**As**	**Fe**	**Zn**	**Cr**	**Pb**	**Cu**	**Cd**	**Hg**	**V**	**Ni**	**Ba**	**Co**
SW1	<0.001	<0.001	<0.001	0.007	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SW2	<0.001	<0.001	<0.001	0.009	0.002	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SW3	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SW C1	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SW C2	<0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

MICROBIOLOGY RESULTS (2016)

Microbial Count and Isolation of Diversity Species of Iseni Soil

Parameters	THB		THF		HUB		HUF	
	cfu/g x10^7	Isolates	cfu/g x10^5	Isolates	cfu/g x10^2	Isolates	cfu/g x10^1	Isolates
SS1a	1.84	*Micrococcus sp, Deinococcus sp, Pseudomonas sp.*	0.75	*Candida, Penicillium, Geotrichum sp.*	1.35	*Micrococcus, Pseudomonas sp.*	0.54	*Candida, Penicillium sp.*
SS1b	1.56		0.49		1.28		0.38	
SS2a	1.91	*Bacillus, Pseudomonas, Acinetobacter sp.*	0.81	*Aspergilus sp, Mucor sp, Sporobolomyces*	1.52	*Bacillus, Pseudomonas sp.*	0.73	*Sporobolomycesp.*
SS2b	1.77		0.67		1.47		0.56	
SS3a	1.68	*Staphylococcus, Micrococcus, Bacillium sp.*	0.51	*Candida, Cladosporium sp.*	1.33	*Bacillus, Staphylococcus sp.*	0.45	*Candida sp.*
SS3B	1.25		0.36		1.26		0.21	
SS4a	2.04	*Nocardia, Bacillus, Enterobacter sp.*	0.97	*Geotrichum, fusarium, Penicillium sp.*	1.86	*Nocardia, Bacillus sp.*	0.78	*Penicillium, Geotrichum sp.*
SS4b	1.86		0.78		1.63		0.62	
SS5a	1.79	*Proteus, Nocardia, Micrococcus sp.*	0.63	*Rhizopus, Candida sp.*	1.39	*Micrococcus, Proteus sp.*	0.49	*Candida sp.*
SS5b	1.52		0.47		1.32		0.32	

Parameters	THB		THF		HUB		HUF	
	cfu/g x10^7	Isolates	cfu/g x10^5	Isolates	cfu/g x10^2	Isolates	cfu/g x10^1	Isolates
SS6a	1.36	*Pseudomonas, Micrococcus, Bascillus sp.*	0.32	*Penicillium sp.*	1.08	*Bacillus, Pseudomonas sp.*	0.27	*Penicillium sp.*
SS6b	1.07		0.18		0.87		0.16	
SS7a	1.58	*Staphylococcus, Flovobacteria, Proteus sp*	0.47	*Aspergillus, Candida sp.*	1.25	*Staphylococcus sp.*	0.42	*Candida sp.*
SS7b	1.23		0.35		1.17		0.22	
Control 1a	1.72	*Saricina, Bacillus, Nocardia sp.*	1.40	*Bacillus, Nocardia sp.*	1.40	*Bacillum, Nocardia sp.*	0.61	Candida sp.
Control 1b	1.44		1.35		1.35		0.40	
Control 2a	1.57	*Pseudomonas, Proteus, Bacillus sp.*	0.57	*Aspergillus sp. Saccharomyces sp.*	1.20	*Bacillus, Pseudomonas sp.*	0.44	Saccharomyces sp.
Control 2b	1.26		0.40		1.16		0.35	
Control 3a	1.28	*Vibrio, Micrococcus, Bacillus sp.*	0.36	*Penicillium, Candida sp.*	1.02	*Bacillus sp.*	0.23	Penicillium sp.
Control 3b	1.03		0.21		0.74		0.14	

Note: 'a' denotes Top
'b' denotes Bottom

Microbial Count & Isolation of Diversity Species of Iseni Surface Water

Parameter	THB		TF		HUB		HUF		TCC	E.coli
	Isolates	cfu/ml x10^7	Isolates	cfu/ml x10^5	Isolates	cfu/ml x10^2	Isolates	cfu/ml x10^1	MPN/ 100ml	MPN/ 100ml
Sw 1	*Pseudomonas, Bacillus,*	3.11	*Candida, Penicillium,*	1.04	*Pseudomonas, Bacillus.*	2.09	*Candida sp.*	0.90	140	70

Parameter	THB		TF		HUB		HUF		TCC	E.coli
	Isolates	cfu/ml x10^7	Isolates	cfu/ml x10^5	Isolates	cfu/ml x10^2	Isolates	cfu/ml x10^1	MPN/ 100ml	MPN/ 100ml
	Enterococuss sp.		*Aspergillus sp.*				*Aspergillus sp.*			
Sw 2	*Salmouilla sp, Bacillus sp, Escherichia sp.*	3.09	*Rhizopus, Penicillum, Candida.*	0.78	*Bacillus sp.*	1.90	*Candidas sp.*	0.48	170	70
Sw 3	*Enterococcus, Micrococus sp, Pseudomonas,*	3.20	*Mucor sp, Candida sp.*	0.85	*Enterococus Pseudomonas sp.*	2.01	*Candida sp.*	0.62	90	40
Control 1	*Bacillus sp, Klebsiella sp.*	3.04	*Aspergillus, Candida sp.*	0.70	*Bacillus sp.*	1.86	*Nill*	0.30	60	40
Control 2	*Pseudomonas sp, Bacillus sp.*	2.93	*Candida sp.*	0.61	*Bacillus sp.*	1.82	*Candida sp.*	0.58	40	20

Microbial Count & Isolation of Diversity Species of Iseni Ground Water

Parameter	THB		TF		HUB		HUF		TCC	E.coli
	Isolates	cfu/ml x10^7	Isolates	cfu/ml x10^2	Isolates	cfu/ml x10^5	Isolates	cfu/ml x10^1	MPN/ 100ml	MPN/ 100ml
BH 1	*Pseudomonas sp, Micrococcus sp.*	3.07	*Candida, Fusarium.*	0.73	*Micrococcus sp .*	2.00	*Candida sp.*	0.64	90	20
BH 2	*Antinonyes sp, Pseudomonas sp.*	2.95	*Mucor, Candida sp.*	0.48	*Pseudomonas sp.*	1.84	*Candida sp.*	0.60	70	20
BH 3	*Pseudomonas sp, Micrococcus sp.*	2.88	*Mucor sp, Candida sp.*	0.59	*Pseudomonas sp.*	1.79	*Mucor sp.*	0.45	40	ND

Control 1	*Micrococci, Arthrobacter, Bacilli sp.*	3.45	*Nill.*	0.28	*Nill*	1.53	Nill.	0.24	20	ND
Control 2	*Micrococcus sp, Antinonyes sp.*	2.85	*Candida sp.*	0.46	*Micrococcus sp.*	1.77	Nill.	0.16	40	10

Microbial Count & Isolation of Diversity Species of Iseni Sediments

Parameters (Units)	**THB**		**TF**		**HUB**		**HUF**		**SRB**	
	Isolates	**cfu/g x10^7**	**Isolates**	**cfu/g x10^5**	**Isolates**	**cfu/g x10^2**	**Isolates**	**cfu/g x10^1**	**Isolates**	**cfu/g x10^4**
Sed. 1	*Pseudomonas sp, Bacillus sp, Enterococuss sp, Micrococcus sp.*	3.79	*Candida, Sailharonyus, Aspergillus sp.*	1.88	*Pseudomonas, Bacillus sp, Micrococcus sp.*	2.26	*Candida sp. Aspergillus sp.*	1.04	*Desulfovibrio sp.*	2.75
Sed. 2	*Bacillus sp, Vibrio sp, Micrococcus sp, Norcadia sp.*	3.52	*Rhizopus, Candida.*	1.48	*Bacillus sp, Norcadia sp.*	1.95	*Candidas sp.*	0.70	*Desulfovibrio sp.*	2.08
Sed. 3	*Enterococus, Micrococus, Pseudomonas, Bacillus.*	3.67	*Mucor sp, Candida sp, Penicillium sp.*	1.73	*Micrococcus sp, Pseudomonas sp, Bacillus sp.*	2.18	*Caudida sp, Penicillium sp.*	0.85	*Desulfovibrio sp.*	2.32
Control 1	*Bacillus sp, Pseudomonas*	3.32	*Aspergillus, Candida sp.*	1.35	*Bacillus sp, Klebsiella sp.*	1.91	*Nill*	0.44	*Desulfovibrio sp.*	2.00

	sp, Klebsiella sp.									
Control 2	*Pseudomonas sp, Antinonyies sp, Bacillus sp.*	3.06	*Candida sp, Aspergillus sp..*	1.18	*Bacillus sp, Pseudomonas sp.*	1.88	*Candida sp.*	0.62	*Desulfovibrio sp.*	1.93

APPENDIX 6
GEOTECHNICAL REPORTS OF THE ACCESS ROAS AND WELLS

Iseni Well 001 Location and Access Road Project

This report includes our findings on the geotechnical investigation program carried out at the SPDC operated Iseni Well 001 location and along the proposed access road from Ofoni community to the well location. Investigation data were based on cone penetration tests, boreholes, hand auger as well as laboratory tests. From these, two geological layers were generalized. The Iseni Well 001 location consists of thick deposit of soft to firm silty Clay soil from ground surface to an average depth of 26.25m with slightly sandy sand occurring between depths of 23.25m and 26.25m. Encountered directly beneath the Clay layer are fine to coarse well graded sand deposits that extended to the termination depth of 45.0m below ground surface. Within the explored depth of 5m for the proposed access road which stretches from Ofoni community to Well 001 location consist of 4m to 5m depth silty clay from the ground surface with thin sand deposits (about 0.5 - 1.0m) lying underneath and occurring in places. Ground water level was measured between 1.0m and 3.25m at the Well location while along the road alignment its average depth was 1.9m. Aside the ground water, surface water was also noticed within the adjoining streams areas along the proposed road and inside the previously excavated ditches at the Well 001 location.

Foundation stability analysis was evaluated through ultimate and serviceability limit states, which were carried out employing Eurocode 7 design methods. For the proposed Rig load of 15610KN over the 20m x 45m concrete slab, stability can be achieved at founding depths of 0.5m and 1.0m. However, for depth of 0.5m to be adopted, grading and adequate stabilization needs to be carried out to guarantee uniform bearing resistance across the site owing to ongoing farming activities, the presence of ditches (varies between 0.3 and 0.7m deep) and thick vegetation roots particularly at the areas farther away the existing slab. Wherever proper compaction cannot be performed or is undesirable, the slab depth may be extended to 1.0m or the Rig may be supported on pile assisted raft foundation. In the latter case, the platform can be supported on ground beams arranged in a grid over the foundation piles. Plotted bearing resistance curves for 406mm diameter circular pile are given in Figure 7.1.

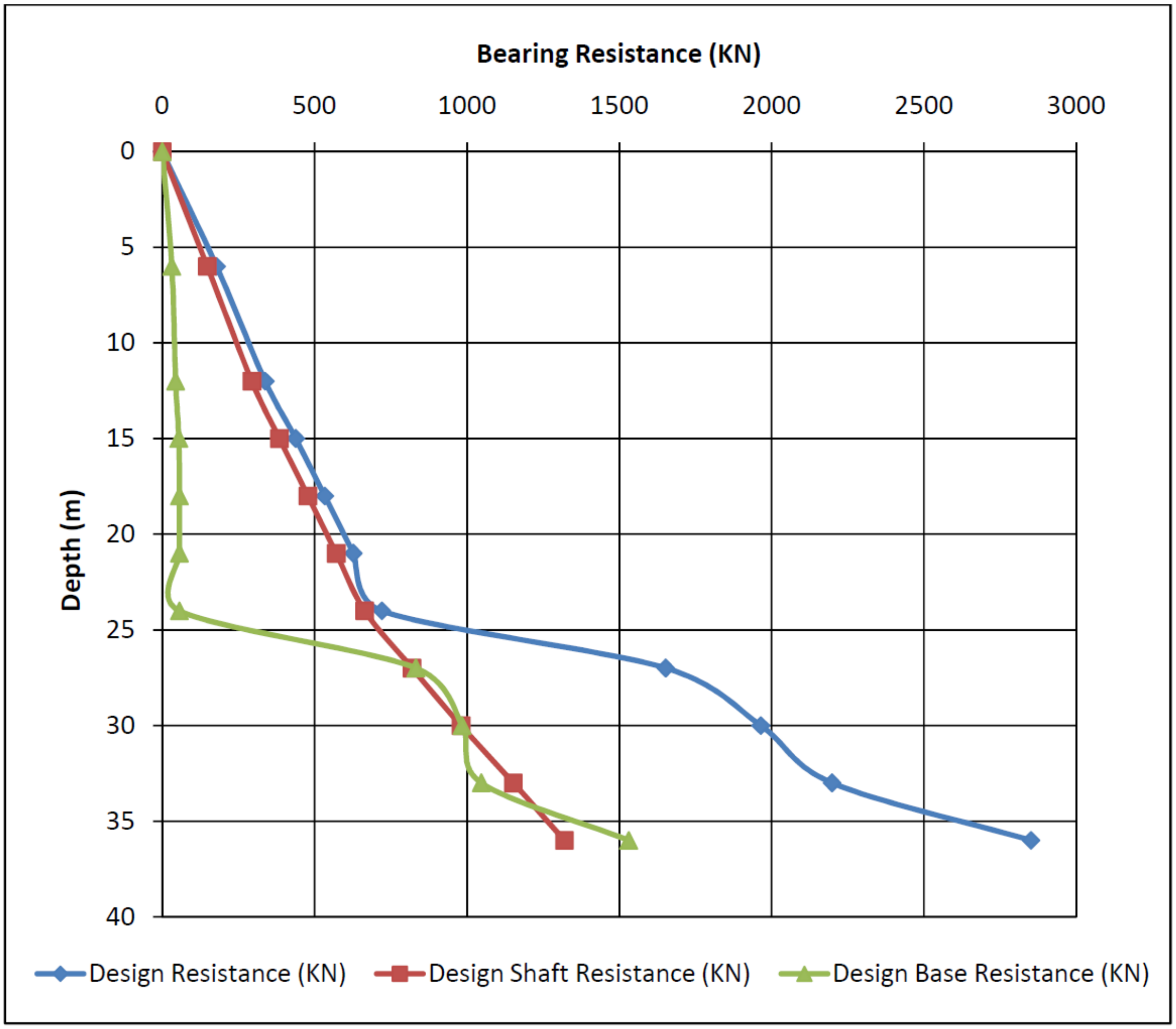


Figure 7.1: Bearing resistance for single 406mm diameter circular steel pile

The total number of piles required is a function of the adopted spacing between the piles and the depth of embedment. To avoid difficulty with "tightening up" during driving of the piles, it will be proper to begin the driving process from the centre piles and then advance outwards in both directions. For the proposed point load of 915KN over 300mm x 300mm concrete pile, 3Nos piles spaced at 3 x pile diameter and driven to depth between 18m and 21m below ground surface are adjudged to be only marginally okay for the load. To take advantage of the adequate resistance offered by the sand deposits, the piles may be as well be extended to 30m which in this case will only require 2 numbers of piles to support the design load. For purposes of foundation design, recommended design value for poisson's ratio, soil elastic modulus, shear modulus and modulus of subgrade reaction are 0.5, 11MPa, 4MPa and 372991kN/m3 respectively for depth of 1.0m. Proposed flexural rigidity value at depth of 1.0m is 3 x 109 N-m, assuming concrete strength of 30MPa. Design stiffness values for other depths can be obtained from Table 5.3.

Table 5.3: Characteristic value of Stiffness properties

Depth (m)	Soil Type	Characteristic value of Undrained Shear Strength, Cu (kPa)	Characteristic Standard Penetration Test, SPT (N- Value)	Poisson's ratio	Soil Elastic Modulus (Mpa)	Shear Modulus (Mpa)	Modulus of Subgrade Reaction (kN/m^3)
1	Clay	22		0.5	11	4	372991
1.5	Clay	24		0.5	12	4	402622
3	Clay	25		0.5	12	4	420108
6	Clay	31		0.5	15	5	521574
9	Clay	44		0.5	22	7	733921
12	Clay	44		0.5	22	7	738994
15	Clay	54		0.5	27	9	908936
18	Clay	56		0.5	28	9	949087
21	Clay	56		0.5	28	9	950399
24	Clay	56		0.3	28	11	779021
27	Sand		31	0.4	23	8	696255
30	Sand		34	0.4	24	9	730741
36	Sand		43	0.4	29	10	878940
42	Sand		49	0.4	32	11	962574

Depending on the kind of road that is intended, the recommended strength value for the access road formation specified as a percentage California Bearing Ratio (CBR) is 3.5 while the coefficient of sub-grade reaction is 70749kN/m3. Generally, owing to the existing terrain of the proposed access road, a significant quantity of earthwork has to be planned for. This will include bush clearing and carting away, cuts and fill as well as replacement of localized soft pots with approved materials. For the areas close to the stream, the final grading for the road should be decided with reference to maximum possible level of the streams. The construction of a culvert at this point is strongly recommended to direct the flow of the stream. For purposes of compaction control, Optimum Moisture Content of 11.83% and a Minimum Dry Density of 1.62Mg/m3 which corresponds to 95% of the Standard Proctor Density can be adopted. To verify the adequacy of the compaction during construction, it is advisable to carry out in-situ field density measurement and compare same with the specified soil density.

Iseni Well 004 Location and Access Road Project

This report includes our findings on the geotechnical investigation program carried out at the SPDC operated Iseni Well 004 location and along the proposed access road which starts from Iseni Well 001 and ends at the well 004 location. Investigation data were based on cone penetration tests, boreholes, hand auger as well as laboratory tests. From these, two geological layers were generalized. The Iseni Well 004 location consists of thin deposit of silty Clay soil from ground surface to an average depth of 3.0m. Encountered directly beneath the Clay layer are fine to coarse well graded sand deposits that extended to the termination depth of 45.0m below ground surface. Within the explored depth of 5m for the proposed access road consists mainly of silty clay. Ground water level was measured at an average depth of 2.7m at the Well location while along the road alignment its average depth was 1.5m. Aside the ground water, surface water was also noticed within the adjoining streams areas along the proposed road and inside the previously excavated ditches at the Well 004 location.

Foundation stability analysis was evaluated through ultimate and serviceability limit states, which were carried employing Eurocode 7 design methods. For the proposed Rig load of 15610KN over the 20m x 45m concrete slab, stability can be achieved at founding depths of 0.5m and 1.0m. However, for depth of 0.5m to be adopted, grading and adequate stabilization needs to be carried out to guarantee uniform bearing resistance across the site owing to the presence of ditches (varies between 0.2 and 0.5m deep) and thick vegetation roots particularly at the areas farther away the existing slab. Wherever proper compaction cannot be performed or is undesirable, the slab depth may be extended to 1.0m or the Rig may be supported on pile assisted raft foundation. In the latter case, the platform can be supported on ground beams arranged in a grid over the foundation piles. Plotted bearing resistance curves for 406mm diameter circular pile are given in Figure 7.1.

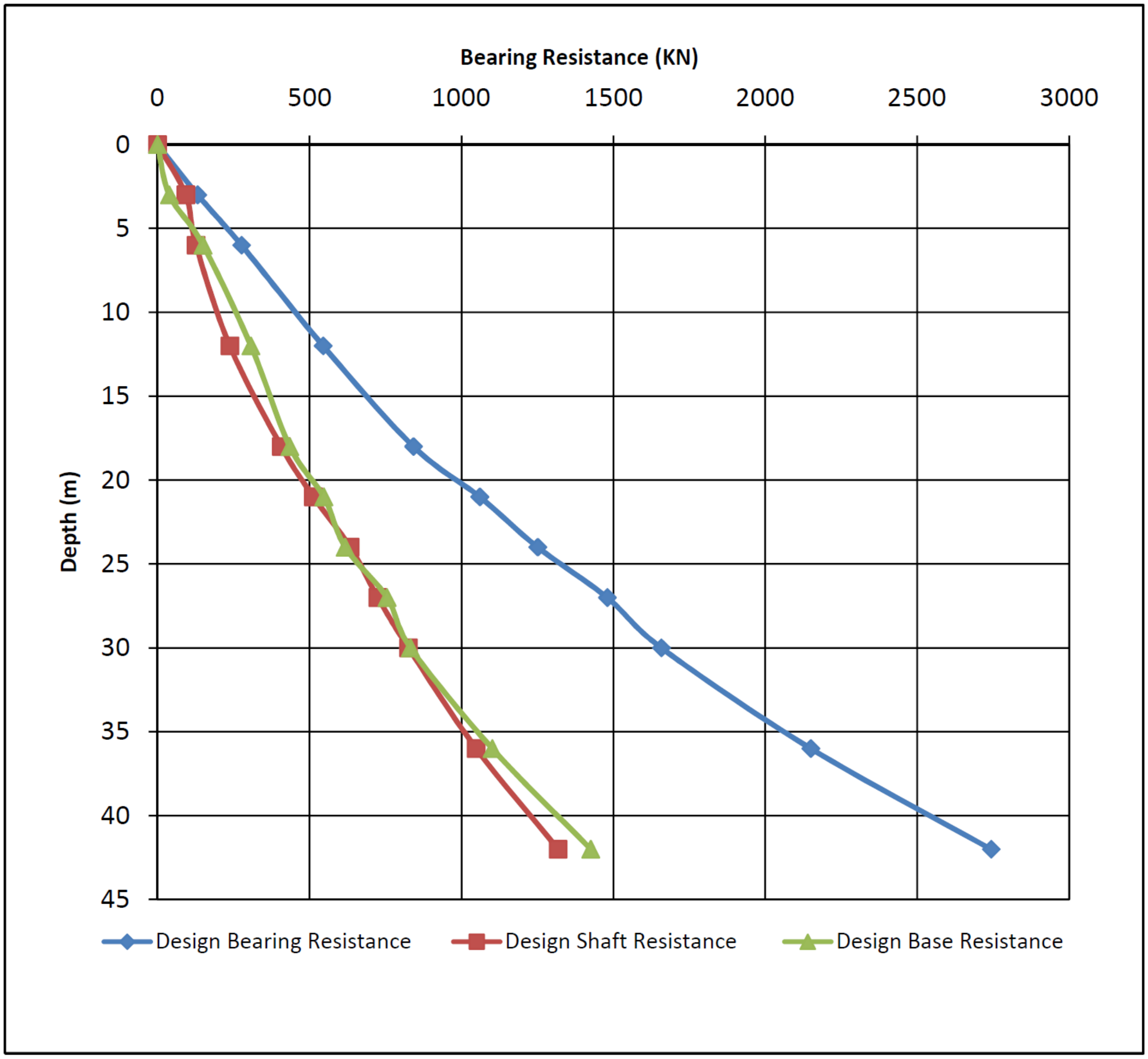


Figure 7.1: Bearing resistance for single 406mm diameter circular steel pile

The total number of piles required is a function of the adopted spacing between the piles and the depth of embedment. To avoid difficulty with "tightening up" during driving of the piles, it will be proper to begin the driving process from the centre piles and then advance outwards in both directions. For the proposed point load of 915KN over 300mm x 300mm concrete pile, at depth of 12m, it will require 4 numbers of piles to endure the overall load. The numbers of piles is reduced to 3 at depth of 18m. Beyond this depth only 2 numbers of piles will be needed. For purposes of foundation design, recommended design value for poisson's ratio, soil elastic modulus, shear modulus and modulus of subgrade reaction are 0.5, 13MPa, 4MPa and 451073kN/m^3 respectively for depth of 1.0m. Proposed flexural rigidity value at depth of 1.0m is 3 x 109 N-m, assuming concrete strength of 30MPa. Design stiffness values for other depths can be obtained from Table 5.3.

Table 5.3: Characteristic value of Stiffness properties

Depth (m)	Soil Type	Characteristic value of Undrained Shear Strength, Cu (kPa)	Characteristic Standard Penetration Test, SPT (N- Value)	Poisson's ratio	Soil Elastic Modulus (Mpa)	Shear Modulus (Mpa)	Modulus of Subgrade Reaction (kN/m3)
0.5	Clay	22		0.5	11	4	365912
1	Clay	27		0.5	13	4	451073
1.5	Clay	31		0.5	16	5	525031
3	Clay	39		0.5	19	6	649540
4.5	Sand		32	0.4	24	8	712051
6	Sand		39	0.4	27	10	810725
9	Sand		44	0.4	30	11	891778
12	Sand		46	0.4	30	11	913426
15	Sand		46	0.4	30	11	913426
18	Sand		42	0.4	28	10	853265
21	Sand		49	0.4	32	11	962574
24	Sand		41	0.4	28	10	842252
27	Sand		38	0.4	26	9	793482
30	Sand		41	0.4	28	10	842630
36	Sand		44	0.4	30	11	887373
42	Sand		48	0.4	32	11	951939

Depending on the kind of road that is intended, the recommended strength value for the access road formation specified as a percentage California Bearing Ratio (CBR) is 4.0 while the coefficient of sub-grade reaction is 74118kN/m^3. Generally, owing to the existing terrain of the proposed access road, a significant quantity of earthwork has to be planned for. This will include bush clearing and carting away, cuts and fill as well as replacement of localized soft pots with approved materials. For the areas close to the stream, the final grading for the road should be decided with reference to the maximum level of the streams. The construction of a culvert at this point is strongly recommended to direct the flow of the stream. For purposes of compaction control, Optimum Moisture Content of 11.9% and a Minimum Dry Density of 1.60Mg/m^3 which corresponds to 95% of the Standard Proctor Density can be adopted. To verify the adequacy of the compaction during construction, it is advisable to carry out in-situ field density measurement and compare same with the specified soil density.

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