The Shell Petroleum Development Company of Nigeria Limited

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT REVALIDATION OF FORCADOS-YOKRI INTEGRATED PROJECT (NON-ASSOCIATED GAS WELL)

AUGUST 2018

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ACKNOWLEDGEMENT

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EXECUTIVE SUMMARY

ES1 INTRODUCTION

ES1.1 BACKGROUND

Forcados-Yokri field is situated in OML 43 and 45, in Burutu Local Government Area of Delta State. Forcados-Yokri field is one of SPDC's largest oil fields. The Forcados section of the field was discovered in 1968 and the Yokri extension in 1971.

A redevelopment strategy for the Forcados Yokri Integrated Project (FYIP) started in the late 1990's. The scope of work covered by the Final Investment Decision (FID) obtained in 1999 included development of total expectation reserves of 292MMstb (proved reserves of 201 MMstb) of oil and 92 bscf (proved reserves of 52 bscf) of gas. Unfortunately, the Niger Delta security crisis escalated in 2006 stalling the project close to the commissioning phase of some of the new facilities. The installed facilities were abandoned in a hurry without any preservation. At the time of leaving site, the overall percentage completion for the works was estimated at 88%.

The project was resuscitated and reframed in 2010 with initial plans to export gas to NLNG via OGGS. Due to Federal government's drive to increase domestic gas production, the project is now being completed as domestic gas hub supply. On this premise, the FYNAG project was initiated to supplement gas volumes going to Domestic gas and to improve the utilization of existing gas treatment and gas export infrastructure. The Forcados-Yokri field has an expectation STOIIP and GIIP (AG + NAG) of 2878 MMstb and 2298.7 Bscf respectively (1.1.2018 ARPR).

ES 1.2 VALUE OF THE PROJECT

The project is expected to significantly improve the economic base of the country and be a catalyst to further promote foreign participation in the country's industrialization efforts. Furthermore, the project activities will lead to a creation of many businesses and employment opportunities through direct and indirect involvement of consultants, community contractors, suppliers and other professionals at different stages of the project.

ES1.3 OBJECTIVES OF THE STUDY

The objectives are to:

- Obtain previous ecological, social and health baseline studies from existing EIA reports from the area and juxtapose it with the new baseline data;
- Acquire new ecological baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Identify the environmental sensitivities of the project area using previous and current baseline data;
- Determine and evaluate the existing impacts of the SPDC facilities on the environment
- 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 for both existing and envisaged sensitivities; and

- Develop an Environmental Management Plan (EMP).

ES1.4 PROJECT OBJECTIVES

The main project objectives are:

- Support Federal Government domestic gas supply aspirations.
- Comply with the flares down policy;
- Improve SPDC Reputation;
- Provision of employment opportunities;
- Promotion of human capital development;
- Promotion of good relationship between SPDC and the host communities.

ES1.5 LEGAL AND ADMINISTRATIVE FRAMEWORK

This study was carried out in accordance with the Mineral Oil (Safety) Regulations, 1963, Oil Pipelines Ordinances (CAP) 145, 1956 and Oil Pipelines Act, 1965, Petroleum (Drilling and Production) Regulations (1969), Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988, FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995), S.I. 15 - National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv), Environmental Impact Assessment Act No. 86, 1992 (FMEnv), FEPA (Now FMEnv) National Guidelines for Spilled Oil Fingerprinting (Act 14 of 1999), FEPA (Now FMEnv) National Guidelines on Waste Disposal through Underground Injection (1999), FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999), FEPA (Now FMEnv) National Policy on the Environment (1989), National Oil Spill Detection and Response Agency (NOSDRA), 2006 and National Environmental Standards Regulatory and Enforcement Agency (NESREA), 30th July, 2007.

Other regulations include Forestry Law CAP 51, 1994, Land Use Act of 1978, The Bendel State Town and Country Planning Laws Cap 165 (as applicable to Delta State) of 1975, Delta State Environmental Protection Agency Edict No 5 of 1997, Delta State Ecology Law, 2006, Bendel State Forestry Law Cap 59, 1976 (now applicable to Delta State), Delta State Revenue Edict, 1997, Delta State Waste Management Law, 2004 and Delta State Internal Revenue Consolidation Law, 2009.

Other regulations are the National Inland Waterways Authority Act No 13 of 1997, International Laws and Regulations (World Bank Guidelines on Environmental Assessment {EA} (1991), International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, Convention on the Migratory Species of Wild Animals (Bonn Convention), Convention of Biological Diversity, Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention), Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and United Nations Framework Convention on Climate Change (1992)), Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26), Nigerian Ports Authority Act No 38 of 1999, Endangered Species (Control of International Trade and Traffic) Act 11 of 1985, and the Environmental Impact Assessment (EIA) Process – A Manual for EIA Execution in SPDC, SPDC 99-201, 2000. This document sets down the guidelines for an enhanced, cost effective and improved EIA process in SPDC, which fully incorporates

Social Impact Assessment (SIA), Health Impact Assessment (HIA) and effective consultation with all the Stakeholders in the EIA.

ES2 NEED FOR THE PROJECT

The objective is to support Federal Government's aspiration to increase domestic gas supply.

ES 2.1 ENVISAGED SUBSTAINABILITY

The envisaged sustainability is categorized as follows:

Economic sustainability

The Forcados-Yokri fields have proven reserves of gas that can economically and commercially support the project. There is high demand for natural gas in the international market and the Federal Government of Nigeria has need to increase domestic gas. The project will therefore contribute substantially to the revenue accruing to Nigeria.

Technical sustainability

The Project shall be undertaken with strict adherence to internationally and nationally acceptable engineering design and construction standards. Technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project. Consideration shall be given to local content in relation to some components of the equipment. SPDC shall leverage on its experience globally in this regard.

Environmental sustainability

Construction techniques vary according to the environment and will be guided by regulatory and engineering design standards. The incorporation of the recommendations from this study at the various stages of the project development and strict adherence to the Environmental Management Plan (EMP) will ensure environmental sustainability.

Social Sustainability

The Project will offer gainful employment to the host communities in addition to putting in place scholarship schemes and manpower skill development to enterprising members of the host communities. Continuous consultation with stakeholder communities will further promote social sustainability of the project.

ES 2.2 PROJECT ALTERNATIVES

The project alternatives/options considered were:

- Do Nothing,
- Complete all works to NLNG as initially planned pre- abandonment.
- Complete and modify for domestic gas supply

Option 3 with the following advantages was chosen:

- Employment opportunities.
- Contract opportunities.
- The aspiration of the Federal Government of Nigeria to stop flaring gas and increase oil production would be realized.
- The Federal Government of Nigeria aspiration to increase supply of domestic gas will be achieved.
- Increased revenue gain from sales of gas.
- Reduction of pressure on vegetation, as an alternative source of fuel
- Reduction of Nigeria's contribution to greenhouse gas emissions

ES 2.3 PROJECT LOCATION

Forcados Yokri field is in OMLs 43 and 45 in Burutu Local Government Area of Delta State. It is bounded approximately by the co-ordinates 319435mE - 335238mE and 158355mN - 141626mN with area coverage of 244.64sqKm (24464.0 hectares).

ES 3.0 PROJECT DESCRIPTION

SPDC plans to drill one NAG (1) well off shore around cluster 11 platform. This scope was captured in the previous FYIP EE based EIA but was not executed before the expiry of the permit

ES 4.0 DESCRIPTION OF ENVIRONMENTAL CONDITION

The purpose of the data acquisition was to establish the status of the environmental. The environmental components evaluated comprised of biophysical, social and health.
This section compares current data obtained in 2018 with previous data obtained in 2012, This comparison provides us information on impacts of existing facilities such as flow stations, clusters, pipelines and manifolds on the environment in addition to determining the impact of proposed project activities on the environment.

Climate and meteorology

The FYIP project environment lies within tropical swamp belt of southern Nigeria characterized by heavy rains, frequent thunder storms, high relative humidity and relatively moderate temperatures. The rains occur mostly during the wet season from March to November of each year, with a monthly average of 199.58 mm reported for the area. Wind are dominated by SW winds with speeds of 3.1-4.6 m/s measured during the present study.

Air quality and Noise

There were no significant differences between proposed project area and control locations in noise and air quality conditions. Maximum noise levels at the project area was 69.2dB (A) which is within national regulatory limits. However, an increasing trend in noise was observed when compared with previous data from the field. The increasing trend is attributed to increasing oil and gas operations as well as ship traffic in the area. Other air quality indicators including Sulphur dioxide, nitrogen dioxide, volatile organic compounds and suspended particulate matter were low and within national regulatory limits. The particulate fractions, PM2.5 and PM10 were also within stipulated limits of US EPA of 35 µg/m3 and 150 µg/m3 for PM2.5 and PM10 respectively. An increasing trend was observed in SPM which was attributed to the current particulate matter (black smoke) pollution in the Niger Delta. In contrast to noise and SPM, VOC showed an apparent decreasing trend which was attributed to improved management of associated gas in line with government's flare down policy.

Surface water

The pH of surface water (7.5-7.9) are within normal range for marine waters which is usually between 7.5 and 8.4. Electrical conductivity was significantly higher around the proposed project location than control indicating possible localized saline intrusion from effluents or sea water. Dissolved oxygen levels were normal (5.38-5.43 mg/l) and well above 2 mg/l below which most fish are endangered. Levels of BOD and COD were within normal values for unpolluted water.

Turbidity and total suspended sediments levels were high but within normal levels for estuarine environments where tide-induced resuspension of sediments usually leads to elevated values. Observed values were within historical levels of TSS reported for the Niger Delta.

Nitrate levels (0.5-0.6 mg/l) were low compared to normal values in unpolluted waters. Nitrite levels (0.1-0.3 mg/l) were slightly elevated compared to guideline of 0.15 mg/l recommended for marine fish. Presence of nitrite is usually associated with recent input of organic wastes.

Organic matter sources in the area include tidal export of organics from swamp forests and maritime activities. Phosphate (0.013-0.09 mg/l) were within historical values for the Niger Delta and normal range in most natural waters.

Major cations and anions including chloride and sodium were within normal values for coastal waters, but their concentrations were significantly higher around the proposed project location compared to control indicating possible localized saline intrusion from sea tides or effluent discharges.

Heavy metals were largely undetected in surface waters. Trace levels were measured in zinc, iron, copper and cobalt. The level of zinc was within those of historical measurements in the Niger Delta. All measured heavy metal levels were below concentrations harmful to aquatic biota.

Levels of Oil and grease (0.11-0.27 mg/l), Total Hydrocarbons (0.006-0.361mg/l) and Total Petroleum Hydrocarbons (0.118-0.61 mg/l) at the project location were not significantly different from those of the control. Polycyclic Aromatic Hydrocarbons and BTEX were generally below detection limits. Although petroleum hydrocarbon level of 0.3 mg/l or more can cause toxic effects fish (Alken Muray, 2006), NNPC/RPI (1985) reported average value of 70.7 mg/l for oil and grease in Niger Delta indicating that the observed concentrations are within background levels for the study area. Microbial counts were generally low compared to natural counts in unpolluted waters and hydrocarbon utilizing microbes were absent in the surface waters indicating absence of petroleum pollution.

Trending of surface water parameters showed increase in pH and conductivity possibly pointing to increasing saline intrusion; decrease in DO and increase in BOD indicating deteriorating conditions with regard to organic wastes and effluents. Heavy metals such as zinc, copper, iron, showed increasing trends and for zinc and iron the levels at the proposed project location were significantly higher than control indicating possible local contamination. Bacterial counts showed increasing trend particularly around the proposed project location possibly associated with local organic enrichment around the project site.

Sediments

Sediments varied from sandy to sand-clay texture indicating a low affinity for micro-pollutants including heavy metals and petroleum hydrocarbons. Sediment pH was mildly acidic which is related to that of overlying surface waters. Total organic carbon level was <1% signifying absence of organic pollution. Redox conditions were generally positive, a conducive environment for microbial degradation of organic matter. Nitrate levels were low particularly around the proposed project area, indicating active microbial assimilation associated with organic matter degradation.

Levels of heavy metals in sediments were low and within recommended sediment quality guidelines. Cadmium concentration (0.97-1.85 mg/kg) was, however, higher than sediment guideline of 0.99 mg/kg but within historical levels of BDL to 8 mg/kg for the Niger Delta.

The highest cadmium level of 1.85 mg/kg was obtained at the control indicating the widespread problem of cadmium pollution in the area.

BTEX were not detected in the sediments indicating absence of recent petroleum pollution. PAH was also not detected in the sediments. TPH (5.03-44.03 mg/kg) was significantly higher around the proposed project area than control indicating low level contamination around the area, but all levels were below sediment guideline of 50 mg/kg indicating absence of petroleum pollution.

Microbial counts were generally low compared with normal counts in unpolluted sediments. Total fungi was marginally higher around the project area while hydrocarbon utilizing fungi was only found in the project area indicating greater microbial activity around the project area capable of degrading organic matter including oil.

Trending of sediment parameters showed decrease in pH possibly linked to discharge of acidic sediments from mangrove swamp forests into the coastal waters. Similarly, TOC showed decreasing trend possibly linked to erosion of organic matter deficient sediments from coastal areas into the water. Exchangeable cations showed increasing trends which may be attributed to variations in tidal conditions during sampling.

Heavy metals showed increasing trends. Although the levels of heavy metals were within recommended sediment guidelines (except cadmium), increasing trends in heavy metal is a course for concern because of their persistence and toxicity and adequate attention should be paid to pollution control measures particularly during the proposed NAG well drilling.

Total petroleum hydrocarbons showed increasing trend with significantly higher levels around the project area compared to control indicating local sources of contamination. Although the present levels of TPH were within sediment quality guidelines, the increasing trend calls for close attention to pollution control measures in the area particularly with during the proposed NAG well drilling.

Hydrobiology

Phytoplankton: Phytoplankton diversity and density were generally high. The phytoplankton followed the order of dominance: Bacillariophyceae > Cyanophyceae > Euglenophyceae > Dynophyceae > Chlorophyceae in the project area. The dominance of the phytoplankton by bacillariophytes (diatoms) is usually considered an indicator of unpolluted environment. There were no significant differences between the project location and control in phytoplankton diversity indices including the Shannon index. Shannon index was generally above 3 indicating unpolluted water.

Zooplankton: The zooplankton belonged to six taxa including copepods, hyrozoa, molluscs, decapods, rotifers and chaetognths. Zooplankton was dominated by rotifers followed by copepods in the project area and control with no significant difference between project area and control in the diversity indices. Dominance of rotifers and copepods is usually associated with unpolluted environments. Shannon index ranged from 2.7 to 3.1 in the project area and above 3 in the control indicating moderately polluted conditions in the project area.

Macrobenthos: The benthos was composed of polychaetes, crustaceans, gastropods and molluscs with polychaetes dominating the project area while crustaceans dominated the control. Dominance of polychaetes is usually an indicator of organically enriched and polluted environment. Shannon index ranged from 2.4 to 2.6 in the project area and from 2.13 to 2.15 in the control with no significant difference between the project area and control. The range of Shannon indices obtained is indicative of moderate sediment pollution.

Fisheries: Fishes of the study area include both fin and shell fishes. The shellfishes include the crustaceans namely, blue swimming crab (Callinectes spp.), the mangrove swamp crabs (Cardiosoma sp and Sesarma sp), the shrimps (Penaeus notialis, Parapaeneopsis atlantica and Palaemonetes africanus) and prawns (Macrobrachium spp. and Nematopalaemon hastatus). The molluscs include cockles (Senilia senilis), whelks (Thais sp.), oysters (Crassostrea gasar) and the periwinkles (Tympanotonus fuscatus and Pachymelania aurita). The fin fishes include bonga fish, croakers, gobies, groupers, grunts, snappers, sole, shad, mullets and tilapias. Fishes such as the bonga-Ethmalosa fimbriata migrate along the nearshore-inshore axis in relation to changes in salinity, food availability and age.

Fishing gears of the area are many and varied, but commonly include gillnets, tow nets, cast nets, beach seines, lift nets, traps, hooks and lines, fences and stakes. Fishes are processed for preservation by gutting or merely washed in water for smoke-drying.

Vegetation

Vegetation characteristics reflect a typical fresh water and mangrove swamp forests that extends from Yakri to Sikebolon, Ogbotobo and Forcados. The physiognomy of the fresh water swamp is at different stages of re-growth with vegetation cover of 75 – 85% with an average ranged between 20 – 26m. The mean tree density was 900 trees/ha. A total of 33 plant species belonging to 23 families was recorded in the study area, common tree species

in the swamp forest include Elaeis guineensis, Alstonia boonei, Ceiba pentandra, lophira alata, Pycnanthus angolensis among others. Microphanerophyes and Nanophanerophytes constituted 70 and 80% of the vegetation respectively.
Common plant diseases in the study area include leaf spot and mosaic virus caused mostly by Aspergillus, Fusarium spp and Curalaria spp. The plant tissues analysis indicated that the mean concentration of Fe, Zn, Cu and Mn, Cd, Ni, and Pb were 110.34, 44.82, 4.4 and 90.19, <0.01, 0.06 and 0.14 mg/kg respectively. The results indicate that there was no toxicity in the plant tissues in the study area.

Wildlife

A total of 15 mammals species representing 10 families were recorded in the study area including Bovidae, Swidae and Artiodactyla. While the wildlife species include Cercopithecus mona, Manis tetradactyla, Potamochoerus porcus, Tragelaphus scirptus, Viverra civetta, Philantomba maxwelli and Protexerus stranger among others. Also, a total of 23 bird families representing 39 species were recorded in the study area, while reptiles and amphibians were represented by 16 and 6 species respectively in the study area.

Social Status

Age and sex are important demographic variables in the study of demographic classification, mortality, fertility, and nuptiality. Majority of respondents (68.9%) were adults aged between 30-59 years, about one fifth (18.9 %) are youngsters (20-29 years) while those aged 60 years and above constitute only 12.2 %. The household age structure and composition of the population in the coastal community conform to the overall Niger Delta and indeed Nigeria's pyramidal structure. Population is rather overwhelmingly loaded from the lower age-cohorts. About 39.2% of the household population comprise persons aged less than 15 years with persons in the productive age bracket of 15-59 years constituting is 55.4%. Those respondents aged 60 years and above were the fewest(4.3%) in the population pyramidal structure. A further analysis of the age and sex composition indicates that the female gender were mainly of lower age bracket comprising newly married women and adolescent girls The overall implication of the age profile is that the population is young and growing and places a heavy burden on the adult population.

Gender distribution of the population in Ogulagha reveals a male dominated structure. This data generally agrees with the earlier results of 49% and 51 % females in Boruta LGA in 1991 and 2006 respectively (FGN, 2007). It was observed that over 90% of the community members live in their own houses while less than11% live in rented accommodations.

Analysis of data collected indicates 80.50% of the respondents have primary school education, 38% (secondary school education), 28.25% (tertiary education) while less than 20.0% of the respondents are without any form of formal education. Only an insignificant 15.0% of respondents have some form of informal technical education in the areas of welding,

electrical/electronic engineering, drilling, pilling, carpentry, auto repairs and body works. The level of educational attainment was found to be significantly higher among the male population (65.0% with secondary education leaving certificate) compared to the modal literacy level of 50.0% but lower among married women (33.5%). These data sharply contrast with the 2012 findings of 22.4%(tertiary education), 24.1% (secondary education), 6.50%(vocational education) and 32.70% (no formal education), which shows that literacy level amongst the population is improving particularly in the areas of secondary and technical education. These improvements may be adduced to the high premium given to education as evidenced from the physical and environmental quality of existing public primary and secondary educational institutions visited in the area.

The marital status and household size of respondents derived from this study showed statistical difference from the 2012 study findings. In the 2012 EES, 39.8 % of the respondents were married while 20.4 % were of the single status as compared with 52.50%(married) and 48.0%(single) in 2018. The proportion of respondents divorced/separated from their spouses or widowed constituted 3.0% and or 5.3% in 2012 compared with those divorced (5.0%) or widowed (8.25%) in 2018. Average household size was 8 persons.

Christianity is the dominant religion in the project environment. Traditional worship hitherto rooted in the culture of the people is fast disappearing though its relic is still retained in existing festivals and ceremonial dances, even acclaimed Christians participate in the community festivals at different levels of commitment

The traditional leadership and governing system in Ogulagha Kingdom is structured into hierarchies with about five functional organs; the paramount chief/king (the clan head), the traditional council (a cabinet of council of chiefs, community EXCO, youth EXCO, and women leaders), Ogulagha Development Organization (ODO), a Representative Council, an Advisory Council, Youth Body and the Women Group respectively. The paramount ruler and his 18-man Ogulagha Kingdom Traditional Council of Chiefs wields much influence in the traditional governance of the Ogulagha Kingdom and must be consulted for any successful project implementation in the area.

The livelihood of the people in the project area is largely based on the primary natural resources available in the area. Fishing and trading were observed to be the major occupations of respondents in Ogulagha. Aside from the traditional occupations, other income generating activities identified include contracting, transportation (boat driving), and technical and artisanal works like tailoring, welding, engine boats repairs/maintenance, electrical works, carpentry and oil and gas jobs.

Ogulagha community has a number of public and private schools. Some of the schools in the project community were constructed while those in deplorable conditions have been renovated and equipped through the intervention efforts of SPDC. Staff accommodation facilities are provided as component part of existing public educational institutions in the form of principal, headmaster and teachers' quarters in Ogulagha. There is also a vocational training center (Youth Development Scheme) established by SPDC to train youths from Ogulagha and a number of neighboring communities (SPDC.2004). Ogulagha community has regular and reliable energy supply courtesy of the SPDC. The SPDC had installed water treatment facilities in the project community in an attempt to improve the portability of borehole water though some of them have become Non-functional with time. The population now relies on water from SPDC's Terminal water scheme supplied through mono-pumps.

The water bodies and satellite communities within them are all accessible by water using hand-dug canoes and outboard engine boats. There are tarred and concrete paved roads in Ogulagha

GSM communication is available in the study area. Ogulagha also hosts at least two (2) base stations/masts of the GSM providers. The resident populations have access to either Glo and Airtel networks. Ogulagha community has a modern well-equipped and furnished cottage hospital courtesy of the community developmental efforts of SPDC and NDDC.

Health Status

Data collection during the Community survey was carried out using both quantitative and qualitative methods. Emphasis was however given to participatory rapid appraisal methods because they are encouraged by the relevant Nigerian environmental legislations, to ensure the inputs of members of the impacted Communities.

The following rapid appraisal methods were used during the Community survey:

- Focal Group Discussion, with adult and youth members of the Communities of both sexes.
- Key informant interviews, especially with health workers in the Communities and Community leaders; and
- On-the-spot observations.

The Communities are rural and populated predominantly by people of the Ijaw ethnic group, who are mainly farmers, fisher folks, traders and marine transporters. Members of the Communities are subsistent farmers of cassava, sweet potato, maize and vegetable. The production of palm oil, from wild oil palm trees, was also noticed in the Communities.

Fishing is the main occupation of most members of the Communities, carried out in the sea, the estuaries and the several impounded water bodies in the Communities. Respondents in the Communities, however, complained during the field study of dwindling catches in recent years which they blamed on incessant crude oil spills.

Members of the Communities meet their drinking water needs from a variety of sources that include: sachet/bottled water, Community water borehole, and rain. Most of the sachet water consumed in the Communities is produced by a factory in Ogulagha that gets it water supply from the Forcados Terminal.

Open defecation is common in the Communities, at the beach in Ogulagha Community. The use of jetty-type (over-hung) is also common in the Communities, especially by residents of the Communities residing close to the bank.

Vectors found in the communities include Anopheles mosquito, Culex mosquito, Aedes mosquitoes, Tsetse fly, Sand flies and Housefly.

The use of firewood and other biomass fuel as domestic fuel is a major cause of indoor air pollution, with wide-ranging health implications (WHO, 2003), one of which is an acute respiratory infection in under-five children.

The wastes generated in the Communities are mainly garbage, and they were mostly dumped close to their houses, or at the bank of the river.

Alcohol is commonly taken in the Communities, like most other Communities in South-south Nigeria. The prevalence of cigarette smoking is still about 20% amongst the youths of the Communities, with the average smoker smoking at most three sticks of cigarette a day.

Ogulagha Community is served by the Ogulagha Cottage Hospital. The Ogulagha Cottage Hospital is a secondary health care facility built and equipped by SPDC, but currently being managed by the Delta State government. It offers good quality primary and secondary health care services, made possible by the specialized equipment provided by SPDC that exceed the equipment required for a secondary healthcare facility.

ES 5.0 Existing and Potential Environmental Impacts

The assessment of the degree of alteration to natural conditions of the environment viz-a-viz the project activities. However, the overall potential negative impacts of the project activities on the environment was generally minimal. The project activities which showed potential negative impacts include but not limited to the following:

- Movement of equipment and personnel, Rig movement
- Route & location clearing Dredging & Sand filling, Pilling, Concrete and asphalt works,
- Excavation, Backfilling, Pipeline coating, Stringing & welding; NDT and cathodic
- protection and Base camp activities.
- Drilling and well hook-up.
- Well & pipeline testing
- Commissioning & Handover
- Well work-over, Gas production
- Removal of surface installations, Plugging of wells (Decommissioning phase)

The negative impacts will be generally minimal, localized and short-term, particularly given the fact that the adverse impacts will be properly mitigated with the strict implementation of the Environmental Management Plan developed for the proposed project. Significant negative impacts of the proposed project include but not limited to the following:

- Third party agitation
- Increase in road traffic, potential for accidents and injuries
- Loss of livelihood
- Influx of people causing Pressure on health and other Infrastructure
- Reduction in air quality
- Loss of aquatic species (Fisheries, Planktons and benthic fauna)
- Increase in noise and vibration
- Increase in crime rate
- Potential for skills acquisition
- Opportunity for direct and indirect Employment
- Opportunity for wealth creation
- Potential for development of infrastructures and economic enhancement.

E.S 6.0 Mitigation Measures

To ensure that all negative impacts are reduced to the barest minimum in the execution of the project the following mitigation measures shall be applied:
SPDC shall,

- use only pre-mobbed regularly maintenance of vehicles, vessels, generators and other machines.
- use of wet scrubbers for all emission sources
- use of mufflers for vehicle exhaust.
- ensure pre-employment and regular medical check-up for project work force
- access control into the camp is ensured
- ensure health awareness is conducted for workers on the mode of transmission of STIs (including HIV/AIDS
- ensure that the cluster is located outside the border of the navigation fairway in keeping with government regulations requiring the fairway to be kept free and open to water transport traffic
- ensure that Vessel/boat operators observe recommended speed limits
- ensure that only certified vessel/boat operators shall be employed.
- enhance the local communities by supporting entrepreneurial skill development through training and empowerment schemes.
- ensure effective consultation with stakeholders
- ensure commitment and transparent adherence to P-GMoU programmes.
- identify and address legacy issues promptly
- support skills acquisition and empowerment schemes to facilitate occupational proficiency, productivity, and sustainability

E.S 7 Environmental Management Plan

The Environmental Management Plan provides guideline and procedures for managing the significant impacts of the project. It ensures that potential adverse effects are reduced to As Low As Reasonably Practicable (ALARP). The EMP also checks the effectiveness of the proposed mitigation and enhancement measures. An Environmental Monitoring plan was also developed to ensure adequate monitoring of the key environmental receptors.

E.S 8 Conclusion

The Project 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.

CHAPTER ONE
INTRODUCTION

1.1 Background

Forcados-Yokri field is situated in OML 43 and 45, in Burutu Local Government Area of Delta State. Forcados-Yokri field is one of SPDC's largest oil fields. The Forcados section of the field was discovered in 1968 and the Yokri extension in 1971. Till date, a total of 152 wells have been drilled in the field to date.

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The FYNAG project part of the broad FYIP project is on a critical schedule with plans to start drilling in October 2018. Following engagements with DPR, an agreement was made to allow limited sampling around the area to ascertain baseline and possible impacts of existing facilities in the area around the proposed NAG well. The Minute of meeting to this regard can be seen in Appendix 1.

1.2 Project Location

Forcados-Yokri field is a brown field situated in the coastal swamp area straddling the mouth of the Forcados River in Burutu Local Government Area, Delta State (Figures 1.1). The location of the Forcados-Yokri project in OMLs in the Western Division is shown in Figure 1.2.

Fig 1.1: Map of Nigeria showing Delta state where the Forcados-Yokri field is located

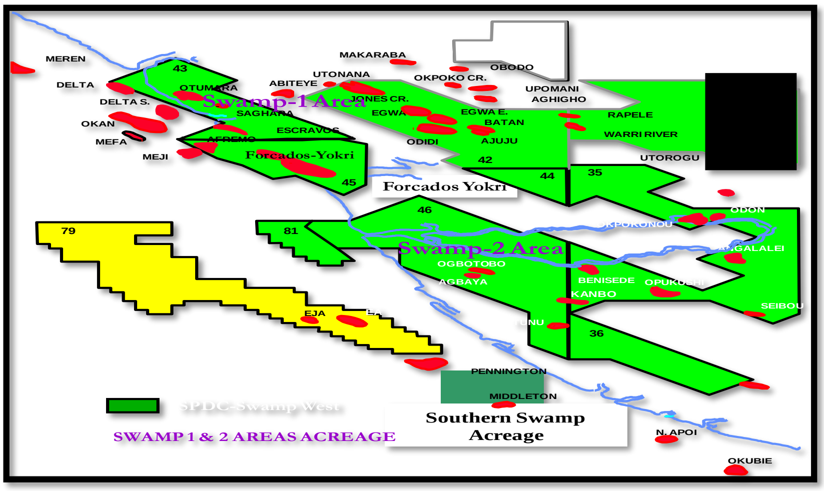


Figure 1.2: Map showing location of the Forcados-Yokri project in OMLs in the Western Division

The objectives of this study are to:

- Obtain previous ecological, social and health baseline studies from existing EIA reports from the area and juxtapose it with the new baseline data;
- Acquire new baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the existing, potential and cumulative 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) to manage impacts during the project phases.

1.3 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:

1.3.1 The Mineral Oil (Safety) Regulations, 1963

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

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

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

1.3.3 Petroleum (Drilling and Production) Regulations (1969)

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

1.3.4 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.

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

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

1.3.6 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.

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

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

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

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

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

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

1.3.10 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.

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

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

1.3.12 Forestry Law CAP 51, 1994

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

1.3.13 Land Use Act of 1978

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

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

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

1.3.15 Delta State Environmental Protection Agency Edict No 5 of 1997

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

1.3.16 Delta State Ecology Law, 2006

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

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

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

1.3.18 Delta State Revenue Edict, 1997

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

1.3.19 Delta State Waste Management Law, 2004

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

1.3.20 Delta State Internal Revenue Consolidation Law, 2009

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

1.3.21 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.

1.3.22 Nigerian Ports Authority Act No 38 of 1999

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

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

1.3.23 International Laws and Regulations

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

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

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

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

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

- International waterways.

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

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).
The Bonn Convention concerns the promotion of measures for the conservation and management of migratory species.

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

Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention)
The convention sets aside areas of cultural and natural heritage for protection. The latter is defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal
The convention focuses attention on the hazards of the generation and disposal of hazardous wastes. The convention defines the wastes to be regulated and control their trans-boundary movement to protect human and environmental health against their adverse effects.

United Nations Framework Convention on Climate Change (1992)
In order to achieve sustainable social and economic development, energy consumption for developing countries needs to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general. This also includes the application of new technologies on terms which make such an application economically and socially beneficial, determined to protect the climate system for present and future generations.

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

National Environmental Standards Regulatory and Enforcement Agency (NESREA), 2007
The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established as a parastatal of the Federal Ministry of Environment. NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria.

Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26)
An Act to compel every company producing oil and gas in 1979 No. 99. Nigeria to submit preliminary programmes for gas reinjection and detailed plans for implementation of gas re-injection.

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

1.3.24 SPDC Policies and Principles

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

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

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

(c) HSE Policy
It is SPDC's Policy that all activities shall be planned and executed in a manner that:

- Preserves the health, safety and security of all Company and contractor personnel and members of the public;
- Preserves the integrity and security of Company assets;
- Minimises the impact of operations on the environment; and
- Is sensitive to the needs and concerns of the Host Communities.
- Implications of implementing this policy are that:
- All activities shall be analysed to systematically identify related hazards, risks and sensitivities;
- Arrangements shall be put in place to control the hazards, risks and sensitivities and to deal with consequences should they arise;
- Any activity which is unhealthy, unsafe, environmentally unsound or may adversely impact relations with the community, shall be suspended until an acceptable solution is found;
- All personnel, including those of contractors, shall be trained and made fully aware of the hazards, risks, sensitivities and controls in place; and
- Plans and procedures shall be in place to respond to any emergency or loss of control.

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

(d) Environmental Assessment Policy (1998)
It is SPDC's policy that all activities shall be planned and executed in such a manner so as to minimize the impact of its operations on the environment i.e.:

- Carry out Environmental Impact Assessments and Evaluation in relation to all aspects of the natural and social environment that may affect or be affected by its activities;
- Identify any such interface for the complete life cycle of both new and existing facilities and operations;
- Enhance positive effects, prevent intolerable impacts from occurring;
- Limit the nature and extent of any residual negative impacts, however caused, such that they are as low as practicable;
- Consult relevant stakeholders;
- Leave the environment at the end of the useful life of any operation in a condition suitable for future use;
- Routinely monitor the environmental status of each operation and take corrective action as necessary.
- The implications of implementing the policy are:
- The environmental impact of all new activities or developments shall be thoroughly evaluated and the necessary preventive measures implemented,
- An Environmental Impact Assessment (EIA) shall be carried out for each new project or activity,

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

(e) SCiN Biodiversity Policy

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

Therefore, we are committed to:

- Work with others to maintain Ecosystems

- Respect the basic concept of Protected Areas
- Partner with others to make positive contributions towards the conservation of biodiversity in our areas of operations
- Conduct Environmental Assessments with increased focus
- on impacts on biodiversity and
- 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 of wastes in an environmentally responsible manner;
- Track and maintain records of waste streams and provide an auditable trail as to their management and disposal.

Other considerations, including:

- Societal Expectations;
- Government Relations;
- Joint-Venture Partner Relations;
- Sustainable Community Development;
- Land Acquisition and Compensation;
- Media Relations (based on SPDC Corporate Policies – 2000).

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

1.4 Declaration

Shell Petroleum Development Company (SPDC) in its capacity as the operator of the NNPC/Shell/Total/NAOC Joint Venture, and on behalf of her partners, hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the facility upgrade of the Forcados Yokri Integrated Oil and Gas Project. SPDC management is committed to the implementation of the Environmental Management Plan (EMP) proposed in this EIA report. SPDC hereby declares that it has prepared this EIA report using the best available expertise in personnel, equipment, and internationally acceptable methods.

1.5 Structure of this EIA Report

Chapter One - Introduction presents the background information, administrative and legal framework, terms of reference;

Chapter Two - Project Justification, discusses the project background, project objectives, rationale for the project, envisaged sustainability, and development options considered;

Chapter Three - Project Description, describes the type of project, scope, location, material input/output and by-products, waste generation, technical layout and process, operation and maintenance, schedule;

Chapter Four - Description of Existing Environment - provides information on the baseline environmental conditions of the project area describing the physical, chemical, biological social, and health environment; Consultation and Stakeholder engagements;

Chapter Five - Impact of the existing flowstations and associated and Potential Environmental Impacts - highlights the Potential Environmental Impacts of the proposed project activities;

Chapter Six – Mitigation Measures/Alternatives – describes the mitigation options of impacts;

Chapter Seven - Environmental Management Plan - provides the proposed plans for environmental management; and

Chapter Eight - Conclusion and Recommendations – provides remediation plans after decommissioning/abandonment.

1.6 Reporting Exercise

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

1.7 Quantification and evaluation of impacts

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

1.8 Determination of appropriate remedial measures

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

1.9 Monitoring Plan

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

1.10 Report Writing

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

CHAPTER TWO
PROJECT JUSTIFICATION

2.1 Need for the Project

The initial objectives of the Forcados-Yokri Integrated Project were changed to support the Federal Governments aspiration to increase domestic gas supply. The current scope is to drill one (1) NAG well, treat, compress at CCP/CPF and export to domestic gas.

2.1.1 Value of Project

The project is expected to significantly improve the economic base of the country and be a catalyst to further promote foreign participation in the country's industrialization efforts. Furthermore, the project activities will lead to a creation of many businesses and employment opportunities through direct and indirect involvement of consultants, community contractors, suppliers and other professionals at different stages of the project.

2.1.2 Project Objectives

The project objectives are to:

- Support Federal Government domestic gas supply aspirations.
- Comply with the flares down policy;
- Secure our licence (OML);
- Improve SPDC Reputation;
- NAG, treat, compress at CCP/CPF and export to domestic gas.
- Enhance field wide technical Integrity, Safety and Environmental standards;
- Provide benefits to the host community through power and water supply.
- Provision of employment opportunities;
- Promotion of human capital development;
- Provision of basic social amenities to the host communities;
- Promotion of good relationship between SPDC and the host communities.

2.2 Benefits of The Project to The Communities

SPDC is committed to improving the quality of life in communities in its operating area and as a result, the FYIP is designed to benefit the host communities in the following ways:

- provision of employment opportunities;
- promotion of human capital development;
- provision of basic social amenities to the host communities;
- promotion of good relationship between SPDC and the host communities.

2.3 Project Alternatives

2.3.1 Project Options

The project alternatives considered were;

- Do Nothing,
- Complete all works to NLNG as initially planned pre- abandonment.
- Complete and modify for domestic gas supply

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

Table 2.1: Project Alternatives / Options Considered

S/N	Options	Advantages	Disadvantages
1	Do nothing	No additional capital Expenditure	The aspiration of the Federal Government of Nigeria to stop flaring gas and increase oil production may not be realized. There will be loss of revenue, as SPDC gas supply commitment to the Bonny NLNG plant for processing and export cannot be met. No employment & contract opportunities to the communities
2.	Complete the project to supply gas to Nigerian Liquefied Natural Gas (NLNG) as initially proposed pre-abandonment.	Employment opportunities Contract opportunities The aspiration of the Federal Government of Nigeria, to stop flaring gas and increase in oil production would be realized. There will be revenue gain, as SPDC gas supply commitment to the Bonny NLNG plant for processing and export would be met.	Increased pressure on existing infrastructure Increased environmental footprint in the area. Domestic gas supply obligations to government will not be realized.
3	Complete and modify facilities for domestic gas supply.	Employment opportunities. Contract opportunities. The aspiration of the Federal Government of Nigeria to stop flaring gas and increase oil production would be realized. The Federal Government of Nigeria aspiration to increase supply of domestic gas will be achieved. There will be revenue gain from sales of gas. Pressure on vegetation, as an alternative source of fuel, will be reduced. Reduce Nigeria's contribution to greenhouse gas emissions.	Increased environmental foot print in the area.

Alternative 3 was chosen as it aligns with aspirations of the Federal Government to increase the supply of domestic gas to the domestic gas grid for power generation and utilization for industrial/domestic purposes.

2.3.2 Drilling Location alternatives

The drilling location alternatives for the FYI NAG Well is presented in Table 2.2.

Table 2.2: Drilling alternatives - Surface locations

Drilling alternatives	Advantages	Disadvantages	Remarks
Drill from new surface location outside the FYIP area	Drilling from new location is less complicated Possible gas supply sources to feed into Bonny Gas facility fast decline profile; Supports the current SPDC gas strategy Increase revenue to the government and SPDC Strong developmental pull to the Forcados field; Explore the identified Deep HC opportunities beneath the Forcados field Boost NLNG's commitment on gas (train 6) (increasing the volume of export gas to the NLNG)	Additional land take required Increase in the Environmental footprint in the Forcados field. Delay in project execution High Capital Expenditure Increased pressure on existing socio-economic facilities Construction of a new boat landing	Not recommended
Drill from surface locations within the existing FYIP area	No new land acquisition required Close to existing facility (Forcados Terminal, NorthBank FS, CCP/CLP); No entry into new Environment (Reduce Environmental footprint) Possible gas supply sources to feed into the CCP/CLP Supports the current SPDC gas strategy	Drilling from existing location may be challenging Increased pressure on existing facilities within the	Recommended

Drilling alternatives	Advantages	Disadvantages	Remarks
	Increase revenue to the government and SPDC Strong developmental pull to the Forcados field; Explore the identified Deep HC opportunities beneath Forcados field Existing boat landing and anchor points.		

2.4 Envisaged Sustainability

The envisaged sustainability is categorized as follows:

2.4.1 Economic sustainability

The Forcados Yokri field, making up Forcados Yokri Integrated Project (FYIP), namely Forcados, Southbank, Estuary, North bank and Yokri have large reserves of natural gas. There are, therefore, proven reserves of gas that can economically and commercially support the project. There is high demand for natural gas in the international market and the Federal Government of Nigeria has needs to increase domestic gas. Part of this demand will be met from some of the fields in Forcados Yokri. The project will therefore contribute substantially to the revenue accruing to Nigeria.

2.4.2 Technical sustainability

The Project shall be undertaken with strict adherence to internationally and nationally acceptable engineering design and construction standards. Technologies that are economically viable and having minimal environmental, social and health impacts shall be utilised in the execution of the proposed project. Consideration shall be given to local content in relation to some components of the equipment. Shell shall leverage on its experience globally in this regard.

2.4.3 Environmental sustainability

Construction techniques vary according to the environment and will be guided by regulatory and engineering design standards. The incorporation of the 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.

2.4.4 Social Sustainability

The Project will offer gainful employment to the host communities in addition to putting in place scholarship schemes and manpower skill development to enterprising members of the host communities. Continuous consultation with stakeholder communities will further promote social sustainability of the project.

CHAPTER THREE
PROJECT DESCRIPTION

3.1 Location

Forcados Yokri field is bounded approximately by the co-ordinates 319435mE - 335238mE and 158355mN - 141626mN with area coverage of 244.64sqKm (24464.0 hectares). The area is composed of meandering creeks and mangrove swamps with dredge slots leading to well heads distributed over the area. The land terrain of the project area is covered by fresh water swamp forest in the North Bank - Yokri axis and mangrove swamp forest in South Bank.

There are four flowstations in the Forcados-Yokri field. These include the Estuary flowstation, Yokri flowstation, North Bank flowstation and South Bank flowstation. Estuary and South bank flowstations were commissioned in 1970 while North Bank and Yokri were commissioned in 1972 and 1973 respectively. The co-ordinates of the four flowstations in the Forcados-Yokri Field are;

- Yokri: 315800 mE and 158300 mN
- North Bank: 322000 mE and 155800 mN
- South Bank: 322100 mE and 150600 mN
- Estuary 320000 mE and 152400 mN (offshore)

The location of the facilities in the Forcados node is presented in Figure 3.1.

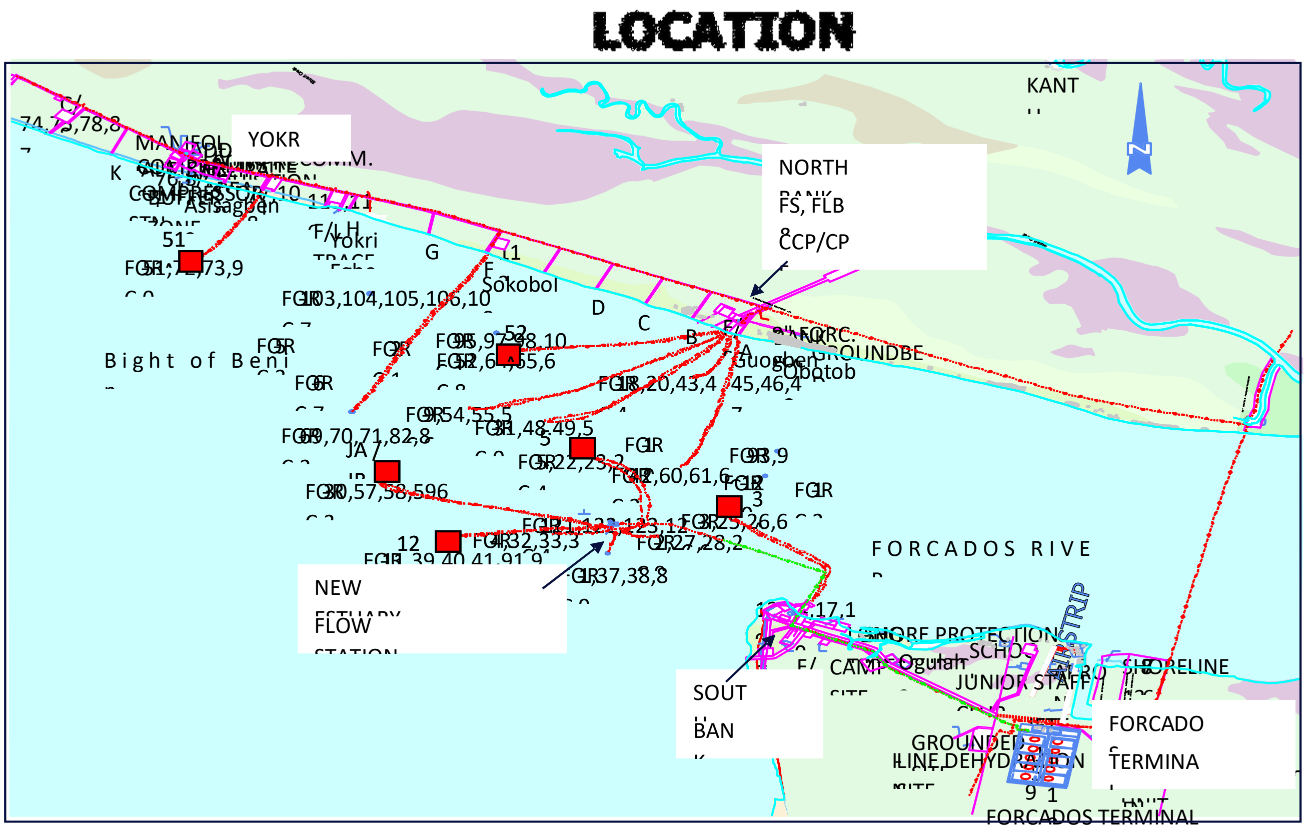


Fig. 3.1: Location of facilities in the Forcados node

3.2 Project Premises.

The well objective is to provide an optimum drainage point in the crest of H3.000/ H3.500 reservoirs for supply of gas to DOMGAS and initially develop about 109.1 Bscf and later 51 Bscf of gas in the H3.500R and H3.000R reservoir blocks respectively with an average initial potential of 40MMscf/d of gas.

The NAG well is planned to strategically address gas supply shortfall in Forcados Yokri and enable start-up of FYIP gas compressor for export to DOMGAS. This will deliver between 30-50 MMscf/day of gas to the DOMGAS network by developing the Forcados Yokri H3.000 and H3.500 reservoirs. It will also act as an enabler for the provision of AG solution, facilitate flares down in Forcados Yokri assets, deliver HCM (PRA) and protect license. The well is to be drilled from surface location Cluster JA. Site visits and re-evaluation of Cluster JA were carried out and the suitability was finally established with the technical endorsement of the well proposal based on the cluster JA in February 2015 and the well completion design change in February 2016. T

The well objective is to develop a total of 160Bscf of Gas and 3.8MMbbls of Condensate from the H3000 & H35000 reservoirs and produce at an average rate of 40MMscf/d to the CPF, complementing the in-field AG production to meet the promised domestic supply from Forcados Node.

3.3 FYIP Scope of Work

Completed Scope of Work

Onshore

Southbank Flowstation Completion Works

- Inspection of installed facilities – mechanical, electrical, instrument, telecoms
- Removal and replacement of internal lagging of the enclosed flare.
- Reinstatement of damaged or missing items – involving hot work, excavation, electrical & instrumentation works.
- Installation of outstanding items, e.g. water hydrants, pig launcher, piping works.
- Pipelines pressure testing and tie-in works.
- Deep water borehole drilling and associated installation works.
- Pre-commissioning and commissioning activities.

Offshore

- Procurement and installation of vandalized 33kV and 3.3kV composite Power/Fibre optics (FO) Subsea cable
- Inspect installed new Estuary flow station facilities
- Install 5 No. Cluster Jackets
- Construct 18" x 5.5km Oil Pipeline (New Estuary FS – South Bank)
- Construct 12" x6.4km Gas Pipeline (New Estuary FS -South Bank)
- Install 33KV Power Cable Back-up (Forcados Terminal - CPF Ring).
- Construct 8" Gaslift line (North Bank Gas Plant - Yokri Flowstation)

Ongoing Scope of Work
Onshore
Yokri Flowstation completion works:
- Inspection of installed facilities – mechanical, electrical, instrument, telecoms.
- Completion of enclosed Flare works.
- Reinstatement of damaged or missing items – involving hot work, excavation, electrical & instrumentation works.
- Completion of piping and pressure testing works.
- Completion of outstanding installations, electrical substation, vessels, instrumentation, etc.
- Completion of drainage/gutter system.
- Deep water borehole drilling and associated installations.
- Pre-commissioning and commissioning activities.

Estuary Flowstation completion works:
- Rehabilitate and complete the new Estuary flow station.
- Construct 24" x 4km Gas Pipeline (New Estuary FS - CPF)

North Bank flow station completion works:
- Inspection of installed facilities – mechanical, electrical, instrument, telecoms.
- Completion of enclosed Flare works.
- Reinstatement of damaged or missing items – involving hot work, excavation, electrical & instrumentation works. Completion of piping and pressure testing works.
- Completion of outstanding installations, electrical substation, vessels, instrumentation, etc.
- Completion of drainage/gutter system.
- Deep water borehole drilling and associated installations.
- Pre-commissioning and commissioning activities.
- Integrate a Hydrocarbon dew point facility using a JT / LTS vessel system with the current TEG dehydration facility providing water dew pointing.
- Modify operation of the North Bank Export compressor due to changes to export gas flow rates and composition, and inclusion of the hydrocarbon dew pointing unit.
- Modify the 16-inch FY – Odidi pipeline and associated manifolds to reflect the reversed flow direction.

Gas Plant (CPF/CCP) Completion works:
- Inspection of installed facilities – mechanical, electrical, instrument, telecoms.
- Reinstatement of damaged or missing items – involving hot work, excavation, electrical & instrumentation works. Completion of piping and pressure testing works.
- Completion of piping and pressure testing works.
- Completion of outstanding installations, electrical substation, vessels, instrumentation, etc.
- Completion of drainage/gutter system.
- Reinstatement of roads.
- Deep water borehole drilling and associated installations.

- Pre-commissioning and commissioning activities.

Outstanding Scope of Work

- Construct and install new cluster jackets to replace 18 existing Clusters. (Moved to Phase 2)
- Overhead 33kV Cable from North Bank Manifold – CPF
- Install 700V Power Control Cable Ring Main
- Pipeline Phase 1:
    - Construct Gas lifting Facilities (8" Ring Main and 4" Spurlines to 24 Clusters
    - Replace 6" Existing Oil Bulk lines from 18 Clusters to the respective Flowstations
    - Construct 6" SouthBank to Forcados Terminal fuel gas back-up Line.
    - Lay 1No. 8 km and 6 " flow line to a slug catcher at North Bank Gas Processing Facilities and integrating with the existing AG facilities at the CPF
- Pipeline Phase 2:
    - Construct new gas flowline from NAG Well to CPF.
    - Construct 16'' Export Gas pipeline-34km
    - 6'' Bulkline replacement-105km
    - Afremo pipeline repair works 8'' X 12.2km
    - Gas lift pipeline 8" x 20km
    - Gas lift spur-line 4"x 20km
    - Old Estuary flow station(OEFS) pig launcher replacement and inter-connecting piping works
- Non-Associated Gas (1 NAG) Well and 4 Oil Development

Non-Associated gas (NAG) well scope

The Wells work scope in 2018 is as follows: Drill and Complete Forcados TXZK-8 NAG Well. The NAG well will be drilled from Cluster JA. Preliminary Surface coordinate of well are 318860.65 mE and 152858 mN.

3.4 Project Activities

The project activities include the following:

3.4.1 Mobilisation of personnel and equipment

Pre-Construction works including:

- Facilities Site completion.

Drilling activities:

- Well Site Preparation
- Rig Move and Positioning
- Spudding and drilling of well
- Wells completion
- Wells hook up

- Drilling Waste Management
- Transport of completed modules (Booster compressors, Gas generators, fan coolers, utility packages, etc) to site.
- Steel Structural / Mechanical Piping Fabrication Works in the Yard and transport to site.
- Installation of Pre-commissioned modules and Skids
- Hook up of all Piping Works and tie-in
- Systems pre-commissioning/commissioning works
- 72hrs Reliability Run
- 90 days performance test

3.4.2 Equipment to be deployed for the Work

The following equipment will be deployed for the work:

- Pipeline Lay Barges
- Drilling Rigs
- Piling Rigs
- Shuttle boat
- Tugboats, Work barges
- Welding Machines
- Generator Barges
- Small equipment and tools

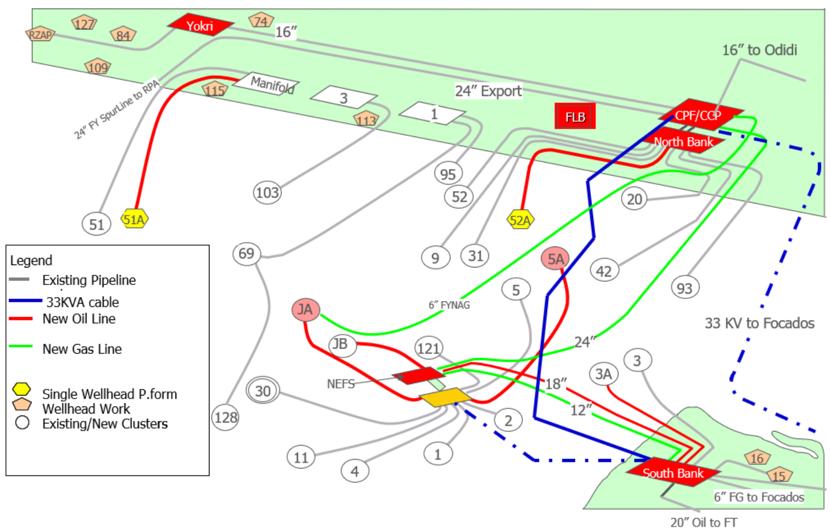


Fig 3.2: Schematics showing the relation between the FYIP NAG wells and the FYIP project (NAG well at JA cluster)

3.5 Pre-Commissioning and Commissioning Activities

Pre-commissioning of all fabricated units shall be completed at the fabrication yard before deployment to site. Pre-commissioning of pre-defined systems shall then progress using well defined pre-commissioning loop diagrams. Pre-commissioning activities shall include cleaning, visual inspections, hydrotests, loop tests, functional testing, gauging, baseline inspections, drying and preservation where required. Prior to commissioning of pre-defined systems, relevant approvals shall be secured from DPR and EPIC contractors shall ensure availability of all relevant vendor supports.

Where it is not practicable to find abundant source of suitable water (i.e. from borehole), standard procedures require that the pressure testing water treated with appropriate corrosion inhibitors, biocides and oxygen scavengers with proven minimal adverse environmental effects shall be used. Standard toxicity tests will be carried out in DPR approved laboratories if chemicals are to be used. The pipelines shall be de-watered and dried using nitrogen or vacuum drying. Used hydrotest water shall be discharged in an environmentally responsible manner (i.e. evacuated to Forcados Terminal via the Trans Ramos Pipeline). All pre-commissioning activities (especially those involving the use of Hydrotest water) shall be witnessed by the Department of Petroleum Resources (DPR). The commissioning activities before the introduction of hydrocarbon will include:

- Checking vendor data
- Preparing commissioning procedures;
- Preparing test equipment/procedures;

- Checking project documentation;
- Assembling relevant project reference data;
- Checking individual systems.

3.6 Utilities, Infrastructure and Logistics during Construction Activities

Items of utilities, infrastructure and logistics, as applicable to the Project, are described below:

- Accommodation/Labour Camp: Prior to the commencement of construction activities, temporary, fully serviced accommodation shall be provided by the contractor on site, within the SPDC acquired area. This will limit human traffic significantly, thus minimizing accident potential.
- Power Generation and Distribution: Diesel generating set(s) of adequate capacity shall be installed, to provide required electrical power during construction. Noise and emissions shall be managed to stay within the allowable limits and SPDC shall ensure contractor's compliance, through effective supervision and audits.
- Supplies to the Construction Site: Supplies of food, materials, consumables, fuel, water etc shall be by barge through the inland waterways. Associated environmental impacts from water transportation (erosion of river banks, disruption of fishing activities, etc.) will be managed. The intention is to minimize disruption and nuisance to social life in the project area.

3.7 Expected Wastes

Drilling Discharges

Water based mud (bentonite) and pseudo oil-based mud (POBM) will be used for the upper and lower sections of the holes respectively. Spent muds and drilling fluids will also be generated during drilling. The POBM drill cuttings will be transported to onshore and treated at the Thermal Desorption Unit (TDU) at Forcados Terminal

The TDU referred to above shall be used to separate oil from the drilling cuttings, mud and sand (solids). The TDU employs heat to strip the volatile fluid content off the solids (e.g. drill cuttings) and the vaporised fluid later recovered by condensation. The unit eventually produces solids that are free of Pseudo Oil Based Mud (POBM). The treated solid is usually about 99.97% pure solid which is within regulatory limits. The water-based mud shall be shipped to deep offshore (depth of water greater than 200ft and distance greater than 12 nautical miles) and dumped. Drilling fluids and chemicals will be continuously recycled/reused.

Sewage Discharges

Sewage discharges include all sanitary waste or black-water (water from convenience facilities containing faecal matter) and grey-water (water from convenience facilities but not containing faecal matter). The working assumption is that an individual generates 0.1m3 per day of black-water and 0.2 m3 per day of grey-water. Thus, the volume of sewage per day expected from the drilling rig (with a workforce of 100 - 150 persons) would range between 30 - 45m3 per day while the volume expected from CPF (with an operations workforce of about 80 persons) would be

24m3. In line with DPR guidelines and standards all sewage generated at any phase of the FYIP shall be treated with biological treatment unit such that it meets the underlisted conditions before discharge.

Residual Chlorine	=	0.8 – 2.0 mg/l
BOD5	=	10 mg/l (inland) and 30 mg/l (offshore)
Total Feacal Coliform	=	2000 feacal coliforms/ml
TSS	=	No floating or settleable solids that form deposits
DO	=	4.0 – 5.0mg/l

Drainage Discharges

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

- clean area floor drains,
- deluge drains,
- machine area floor drains, bunded areas beneath fuel or chemical storage areas, and
- overflow drains on diesel/fuel tank systems.

Solid Wastes

Several operational solid wastes will be generated throughout drilling operations. These will be collected, appropriately segregated/sorted and managed in compliance with approved/ recommended waste management guidelines. The rig has a garbage compactor and scrap food macerator that will aid in the effective handling of some wastes. In accordance with Annex V of MARPOL 73/78, macerated food waste shall be discharged to sea without any floating substances.

Scrapped pipes, vessels and other materials from existing facilities will be cleaned by flushing and salvaged. The salvaged steel materials will be disposed of by transporting to a steel plant for re-cycling or to SPDC scrap-yard for possible re-use. Where salvaging of pipes and other steel materials (eg, estuary bulk-line flowlines) is not feasible during the construction phase of the FYIP, the pipes, flowlines etc will be flushed in-situ and left in their present position until final abandonment of the facilities when safe salvaging and disposal can be executed by SPDC.

3.8 Drilling

Table 3.1 Potential waste expected from the Proposed project

Waste Type	Control /Management Measures
Mud	- Used pseudo oil-based mud (POBM) will be re-used in the drilling of other wells. (Standard toxicity will be conducted in DPR approved laboratories on the POBM before they are used) -Spent water-based mud shall be shipped to deeper water (greater than 200ft and distance from shore greater than 12 nautical miles) for disposal.
Cuttings	- Cuttings drilled with POBM and contaminated with POBM will be sent to TDU for treatment. The top-hole cuttings drilled with water based mud shall be shall shipped to deep water (depth greater than 200ft and distance from shore greater than 12nautical miles) for discharge. -
Cement	- Cement residues and returns generated during the top-hole cementation stage will be collected and incinerated
Brine (NaCl) Discharge	- Solids free, lightweight, non-toxic completion brine will be used. - Excess brines shall be diluted and discharged
Sand Consolidation Fluid	-Used sand consolidation fluids (well fix etc.) will be collected in drums and sent for incineration
Sewage	-It is envisaged that the maximum number of personnel at drilling site at any one time will be about 150 persons. Sanitary sewage produced at site will be treated on the rig sewage biological treatment plant as per DPR standard. The water can be re-used for flushing the system or disposed in rivers. Regular monitoring will be carried out.
Industrial and domestic wastes	-Industrial and domestic wastes will be segregated according to the currently operated segregation scheme which distinguishes between food waste, paper waste, scrap metals, chemical waste, medical waste etc. These will be sent to SPDC respective waste disposal facilities.
Rig bilge	-Oily water discharges shall be controlled to less than 20ppm oil in water by the rig oil/water separation system.

Spudding and drilling of wells, well completion and hook up is one of the major activities in addition to site preparation/dredging and flow lines and bulk lines installation.

The drilling and completion operations shall be managed at the project sites. Drilling operation requires the use of special drilling fluid (mud).

Drainage Discharges

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

- Clean area floor drains;
- Deluge drains;
- Machine area floor drains;
- Bunded areas beneath fuel or chemical storage areas;
- Overflow drains on diesel fuel tank system.

The first two sources contain non-oily water and are therefore discharged overboard without any treatment. The other discharges may contain oil or chemicals and would be routed to the oilywater drainage and treatment system. The expected waste from the drilling activities and their management strategies are tabulated in Table 3.2

Table 3.2: Estimated Waste Volume Forecast

Activity	Waste	Amount
Drilling	WBM Cuttings	266.7 m3/well
	SBM Cuttings	114.3 m3/well
	Plastic drums	<1T
	Metal drums	<1T
	Sewage	11 m3/month
	Grey water	50 litres/person/day
	Spent Water Based Mud	101.6 m3/well
	Spent Synthetic Based Mud	154.41 m3/well
Others	Office waste	1.0 kg/day
	Medical waste	1.5 kg/day
	Kitchen waste (food waste)	10 kg/day

3.9 Operation and Maintenance Activities

3.9.1 General

The wellhead shall be operated in accordance with operational procedures developed through SPDC extensive experience. The project will be managed by fully trained andqualified personnel who are conversant with SPDC's HSE policy guidelines.

3.9.2 Operations

Facilities Safeguarding Philosophy

Wellhead:

- The wellhead will be maintained and safeguarded in accordance with SPDC's HSE policy and guidelines.

3.10 Decommissioning/Abandonment Plan

All the facilities are designed for a minimum of 25-year life. The operation and maintenance procedure provide for monitoring the performance and the integrity of the system components.

When facilities perform at diminishing returns and field is completely exploited SPDC standard procedure for decommissioning/abandonment shall be invoked. A decommissioning team shall be set up to plan and implement the guidelines for decommissioning.

The following activities are involved in decommissioning/abandonment:

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

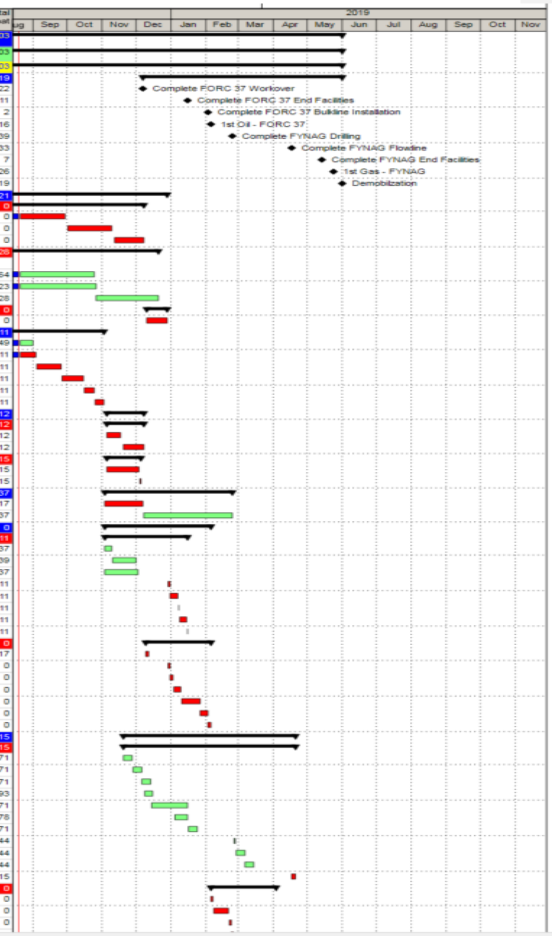
3.10.1 Demolition and Site Clean-up

Demolition of structures, at the end of the field's life shall be carefully planned and carried out to minimize environmental impact. The flowlines shall remain intact as they will be buried in the riverbed and thus shall not impose any environmental risk. At the end of demolition, various solid wastes shall be sorted according to their types and then disposed of according to FME waste disposal guidelines.

3.10.2 Site Remediation and Monitoring

All impacted sites will be remediated and re-instated to a safe and environmentally acceptable condition in which it can be returned to its owner. All contractors' remediation plans must be approved by SPDC prior to implementation.

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)



Activity ID	Activity Name	Remaining Duration	Phys. % Complete	Start	Finish	Total Float
FYIP Step 1 Offshore Schedule 19 Aug 2018 - Work in progress		245		10-Apr-17 A	31-May-19	103
Offshore Step 1		245		10-Apr-17 A	31-May-19	103
FYNAG and FORC 37		245		10-Apr-17 A	31-May-19	103
Milestone		176		06-Dec-18	31-May-19	119
PH2-4550	Complete FORC 37 Workover	0	0%		06-Dec-18	22
PH2-4590	Complete FORC 37 End Facilities	0	0%		15-Jan-19	11
PH2-4640	Complete FORC 37 Bulkline Installation	0	0%		02-Feb-19	2
PH2-4580	1st Oil - FORC 37	0	0%		04-Feb-19	16
PH2-4560	Complete FYNAG Drilling	0	0%		23-Feb-19	39
PH2-4570	Complete FYNAG Flowline	0	0%		17-Apr-19	33
PH2-4540	Complete FYNAG End Facilities	0	0%		13-May-19	7
PH2-4630	1st Gas - FYNAG	0	0%		24-May-19	126
PH2-4510	Demobilization	0	0%		31-May-19	119
Procurement		113		10-Apr-17 A	28-Dec-18	21
FYNAG Pipeline		80		26-Mar-18 A	07-Dec-18	0
PH2-4410	Payment of Line Pipe Mill by Vendor	30	90%	26-Mar-18 A	28-Sep-18	0
PH2-4420	Shipping of Pipes	30	0%	01-Oct-18	09-Nov-18	0
PH2-4430	Custom Clearance and Delivery to Warehouse	20	0%	12-Nov-18	07-Dec-18	0
FYNAG End Facilities		106		10-Apr-17 A	20-Dec-18	28
PH2-4440	Issue PO for Metering	0	100%	26-Mar-18 A	28-May-18 A	
PH2-4380	Procurement of Valves, Instrumentation, and Piping Materials (Risers & I J etc)	48	25%	10-Apr-17 A	24-Oct-18	64
PH2-4450	Procurement of Metering	50	35%	23-May-18 A	26-Oct-18	23
PH2-4520	Shipment and delivery to site	47	0%	26-Oct-18	20-Dec-18	28
FORC 37		15		10-Dec-18	28-Dec-18	0
PH2-4340	Free issue FORC 37 Materieals (Pipes and End facilities)	15	0%	10-Dec-18	28-Dec-18	0
Contracting		55		08-Jan-18 A	02-Nov-18	11
A1180	Contracting Strategy Engagement with NAPIMS	10	10%	30-Mar-18 A	31-Aug-18	49
A1150	Issue Updated RFQ to Sub-contractor	11	10%	08-Jan-18 A	03-Sep-18	11
A1160	Return of Technical and Commercial Proposal	16	0%	04-Sep-18	25-Sep-18	11
A1170	Evaluation of Technical and Commercial Proposal	14	0%	26-Sep-18	15-Oct-18	11
A1190	Negotiate of Commercial Proposal	7	0%	16-Oct-18	24-Oct-18	11
A1200	Part C MTB Approval	7	0%	25-Oct-18	02-Nov-18	11
Pre-mobilization		25		05-Nov-18	07-Dec-18	12
Engineering		25		05-Nov-18	07-Dec-18	12
A1520	Setup Engineering Team & Office	10	0%	05-Nov-18	16-Nov-18	12
A1460	Installation/Construction Engineering	15	0%	19-Nov-18	07-Dec-18	12
Pre-mobilization of Work Spread		22		05-Nov-18	04-Dec-18	15
PH2-4470	Pre-mob of work Spread Including Lay Barge and all other supply/security/emergency respons	21	0%	05-Nov-18	03-Dec-18	15
A1530	Issue HSE Certificate	1	0%	04-Dec-18	04-Dec-18	15
Well Driling and Work-over		113		03-Nov-18	23-Feb-19	37
A1490	FORC 37 Workover	34	0%	03-Nov-18*	06-Dec-18	17
PH2-4460	Well Drilling (FORC TXZK 8)	79	0%	07-Dec-18	23-Feb-19	37
FORC 37		80		03-Nov-18	04-Feb-19	0
FORC 37 End Facilities Installation		74		03-Nov-18	15-Jan-19	11
A3610	Site verification and Follow-on engineering	7	0%	03-Nov-18	09-Nov-18	37
A3630	Bulk Procurement	21	0%	10-Nov-18	30-Nov-18	39
A3620	Pre-mobilisation of Jack-up barge and all other supply/security/emergency response vessels	30	0%	03-Nov-18	02-Dec-18	37
A3640	Mobilisation to Cluster 1	2	0%	29-Dec-18	30-Dec-18	11
A3670	Installation of End Facilities at Cluster 1	7	0%	31-Dec-18	06-Jan-19	11
A3650	Pre-commissioning (Leak test) of the End Facilities at Cluster 1	1	0%	07-Jan-19	07-Jan-19	11
PH2-4480	Installation of Hookup Pipings at OEFS	7	0%	08-Jan-19	14-Jan-19	11
PH2-4490	Pre-commissioning (Leak test) of the End Facilities at OEFS	1	0%	15-Jan-19	15-Jan-19	11
FORC 37 Dual Bulkline Installation		49		09-Dec-18	04-Feb-19	0
A3560	Offshore pre-installation survey	3	0%	09-Dec-18	11-Dec-18	17
A3570	Barge move to location	2	0%	29-Dec-18	30-Dec-18	0
A3580	Install Matteresses	3	0%	31-Dec-18	02-Jan-19	0
A3590	Dual Bulkline Installation	7	0%	03-Jan-19	09-Jan-19	0
A3600	Riser Installation (4 nos)	17	0%	10-Jan-19	26-Jan-19	0
A3660	Hydrotest	7	0%	26-Jan-19	02-Feb-19	0
PH2-4500	Hookup and Commission Riser at OEFS	2	0%	02-Feb-19	04-Feb-19	0
FYNAG 6" Flowline Construction		132		19-Nov-18	20-Apr-19	15
Onshore		132		19-Nov-18	20-Apr-19	15
A1360	Onshore pre-installation survey	8	0%	19-Nov-18	27-Nov-18	71
A2900	RoW Preparation	7	0%	28-Nov-18	05-Dec-18	71
A2910	Linepipe Stringing	7	0%	06-Dec-18	13-Dec-18	71
A1390	Mobilization for Onshore Pipe Installation	7	0%	08-Dec-18	15-Dec-18	93
A2940	Weld/NDT/FJC/Crossings	28	0%	14-Dec-18	15-Jan-19	71
A2950	Trenching	10	0%	04-Jan-19	15-Jan-19	78
A2960	Lowering	7	0%	16-Jan-19	23-Jan-19	71
A2920	Beach tie-in set-up	2	0%	25-Feb-19	26-Feb-19	44
A2930	Beach tie-in	7	0%	27-Feb-19	06-Mar-19	44
A3060	Installation of CP	7	0%	07-Mar-19	14-Mar-19	44
A2890	Backfilling	3	0%	17-Apr-19	20-Apr-19	15
Offshore		58		05-Feb-19	03-Apr-19	0
A2780	Barge move to location	2	0%	05-Feb-19	06-Feb-19	0
A2790	Install Matteresses	14	0%	07-Feb-19	20-Feb-19	0
A2800	Set-up at NB	2	0%	21-Feb-19	22-Feb-19	0

Figure 3.3: Project Schedule for FYIP NAG Project

CHAPTER FOUR
DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 General Study Approach

This chapter presents the result of the EIA revalidation study for the Forcados Yokri Integrated Project (FYIP). The purpose of this 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 status of the environmental components that are affected by existing facilities such as flowstations, and the status of the environmental components that are affected by the cumulative impact. The environmental components evaluated comprised biophysical, social and health.

The chapter compares existing data obtained in 2018 with previous data obtained in 2001 and 2012/2013.This comparison provides us information on impacts of existing facilities such as flowstations, clusters, pipelines and manifolds (at Yokri, North Bank, South Bank, Estuary and Forcados estuary) etc on the environment in addition to determining the impact of proposed project activities (drilling of NAG well) on the environment.

The status and sensitivities of the various ecological components of the Forcados Yokri Integrated Project (FYIP) study area were assessed from review of existing reports on Environmental studies, conducted in recent times by Shell Petroleum Development Company (SPDC) in the area (EIA of Forcados Yokri Integrated Project 2001, EE based EIA of Forcados Yokri Project 2012/2013), published literature, detailed questionnaires, interviews, maps, field sampling surveys, laboratory and data analyses.

4.1.1 Statistical Analysis

A number of statistical tools were employed; the student t-Test Paired Two Samples for means, and the single-factor (one-way) Analyses of Variance (ANOVA). The t-Test Paired Two Samples for Means was employed to compare two sets of data (study area and control) while the single factor ANOVA was used to compare three sets of data (2001, 2012/13 and 2018). The objective was to determine statistically significant impacts of existing facilities (e.g flowstations, manifolds, pipelines and other associated facilities) on the environment, social and health components of the area with time. $P < 0.05$ indicated 95 % confidence levels while $p > 0.05$ indicated no significant differences between pairs of values being compared at 95% confidence level. The Mean and standard deviations were also applied to data to even-out potential errors from field data including those resulting from the instrument and those introduced by the observer.

4.1.2 Description of Sampling Locations

The 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). Purposive sampling was applied in the selection of study stations, taking into account tidal influence and regime. Control stations were located outside the spatial boundary.

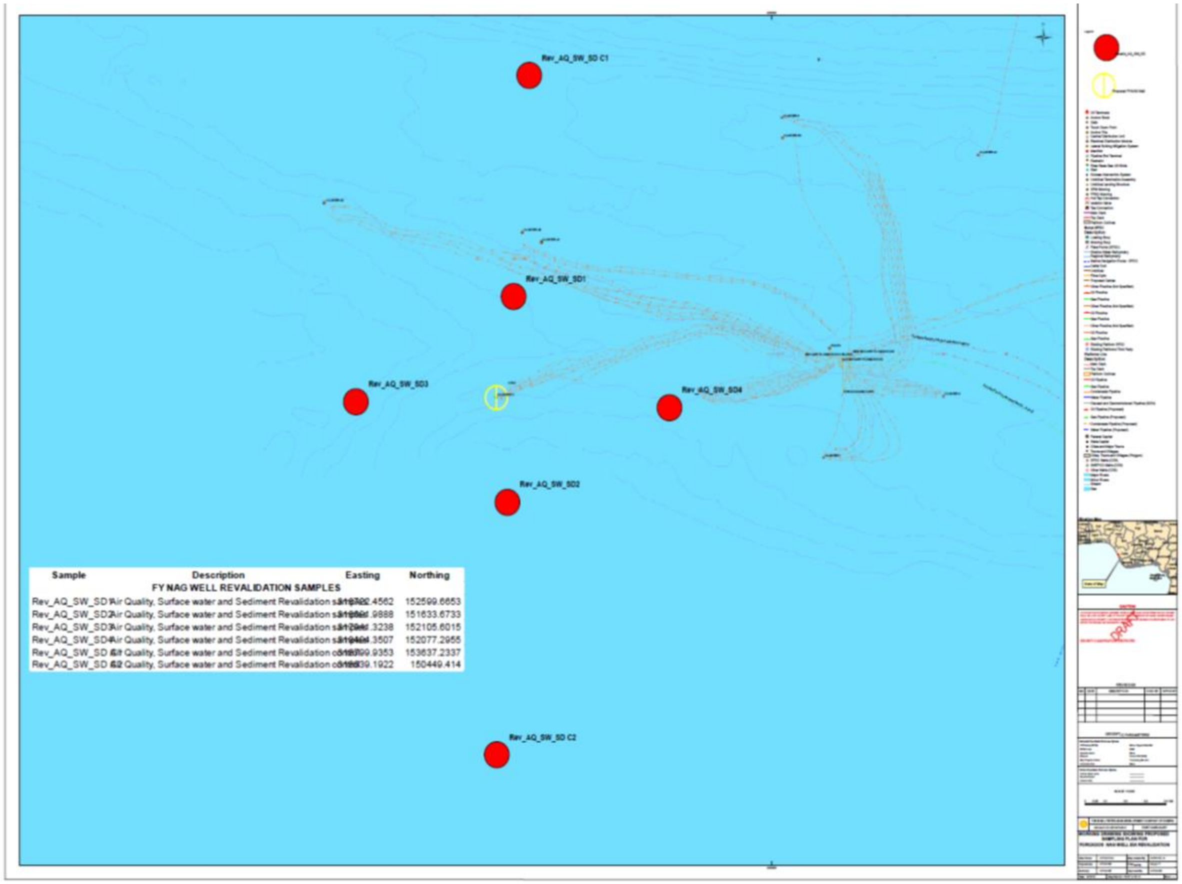


Fig. 4.1: Map showing the study area with the sampling stations

4.1.3 Literature Review

The baseline data used for the description of the environment in this report were obtained from the following documents:

- Environmental Impact Assessment of Forcados Yokri Integrated Project 2001;
- EE based EIA of Forcados Yokri Project 2012/2013

4.2 Baseline Data Acquisition Methods

The fieldwork was undertaken 22nd June to 8th July 2018. A multi-disciplinary approach was adopted for data acquisition and ecological characterization which included climate/air quality, noise, vegetation and wildlife, aquatic, and hydrology, socio-economics and community health status. Each of these components of the environment was sampled in accordance with DPR EGASPIN (2002) (Part VIII) D (2) Guidelines and Standards for sampling and handling of samples.

Table 4.1 summarizes the methods and instruments used for sampling and analyzing the various environmental components identified. For socio-economic and health studies structured questionnaires (Appendix 3) were administered to a random sample of households.

Table 4.1: Environmental Components and Methods/ Instruments used for Sampling / measurement/ analysis

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
METEOROLOGY	Temperature	Traceable Thermometer	°C
	Windspeed & Direction	Digital anemometer and wind vane	m/s,
	Humidity, Atmospheric Pressure	Digital Acurite Weather Station	%
AIR QUALITY	Suspended Particulate Matter	Kanomax Handheld Laser Particle Counter, Model 3887	Mg/m3
	Nitrogen Oxides	Aeroqual Environmental Monitors (Series 500)	ppm
	Sulphur Oxides	Aeroqual Environmental Monitors (Series 500)	ppm

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	Carbon Monoxides	Aeroqual Environmental Monitors (Series 500)	ppm
	VOC/HC	Aeroqual Environmental Monitors (Series 500)	ppm
	Heavy Metals		
NOISE	Sound level	Extech Sound Level meter, model 340	dB(A)
Vegetation		Quadrant, Ropes, Measurement tape, Machete, polythene sampling bags, Plant press frames, Digital Camera; Binoculars	
SURFACE WATER		Hydrobios (2L) water sampler & ISCO Borehole Sampler	
	Temperature	YSI, Model 5220 multi probe meter	oC
	pH	YSI, Model 5220 multi probe meter	
	Total, Dissolved and Suspended Solid	YSI, Model 5220 multi probe meter	mg/l
	Total Alkalinity		mg/l
	Dissolved Oxygen	YSI, Model 5220 multi probe meter	mg/l
	Biological oxygen Demand (BOD5)		mg/l
	Total Hydrocarbon Content (THC)	Extraction / Spectrophotometer	mg/l

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
	Conductivity	Ex Tech Conductivity Meter.	
	Heavy metals	Flame Atomic Absorption Spectrophotometry	mg/l
SEDIMENTS	Sampling	Ekman Grab	
MICROBIOLOGY	Total heterotrophic bacteria, fungi, hydrocarbon Utilizing bacteria and fungi, total and faecal coliforms.	Composite samples for laboratory analysis	MPN/100 ml, cfu/ml and cfu/g
HYDROBIOLOGY	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, composite samples for laboratory analysis	
WILDLIFE	Conservation status (rare, threatened and endangered species), conservation areas (forest reserves etc), environmentally sensitive areas – wetlands and swamps), local conservation practices.	In situ observation, interviews, secondary data	

ENVIRONMENTAL COMPONENT	PARAMETER	EQUIPMENT	UNIT
SOCIO-ECONOMIC STUDIES	Population and socio-cultural characteristics, Community Governance and Institutions, Economic characteristics and livelihood, Social Infrastructure, Natural Resources and Land use, Perception of the project, The role of women and Youths.	Key informant interviews, Focus Group Discussion (FGD), direct observation, Administration of structured questionnaires and Collection of secondary data.	
HEALTH STUDIES	Demographic profile of the Community, Morbidity/Mortality Patterns, Healthcare facilities, 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.	

Table 4.2: Quantities of samples to be obtained during fieldwork

S/N	Environmental component	Total No. of sampling points	Control sampling points
1	Surface Water	4	2
2	Sediment	4	2
3	Ambient Air Quality	4	2
4	Hydrobiology	4	2
5	Social	Ogulagha community	
6	Health	Ogulagha community	

4.3 Quality Assurance and Quality Control

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

4.3.1 Field Procedures

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

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

Laboratory Procedures:

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

4.4 Climate and Meteorology

4.4.1 Climatic Conditions

The meteorological conditions of the area are described from secondary sources including long-term (1981 – 2011; 30-year) time-series data, from Federal Department of Meteorological Services, for Port Harcourt which is in the same rainfall area (Table 4.3); as well as from on-the-spot micro-climatic data collection during fieldwork. The FYIP projects environment lies in the swamp forest belt of Nigeria characterized by heavy rainfall with thunderstorms, high humidity and relatively moderate temperatures.

Table 4.3: Average Weather Condition for Port Harcourt from1981 – 2011

S/N	Month	Average Temp (OC)	Rainfall (mm)	Cloud Cover (oktas)	Pressure (mbar)	R/H (%)	Wind Speed (m/s)	Wind Dir.
1	January	33.7	15.3	6.8	1006.5	73	2.90	NE
2	February	34.0	74.0	6.8	1005.8	76	2.55	E
3	March	33.8	92.7	6.9	1005.6	81	3.62	SW
4	April	32.7	143.0	6.9	1005.7	84	3.41	SW

5	May	32.2	247.4	6.9	1007.4	87	4.30	SW
6	June	30.5	310.0	7.0	1008.4	89	4.40	SW
7	July	29.2	364.0	7.0	1009.7	91	4.96	SW
8	August	29.3	325.0	7.0	1009.6	91	4.88	SW
9	September	29.6	370.0	7.0	1008.9	91	4.45	SW
10	October	30.7	242.0	6.9	1007.7	88	3.59	SW
11	November	32.4	72.8	6.8	1006.8	84	2.58	NE
12	December	33.5	19.3	6.8	1006.7	75	2.75	NE

Source: Nigerian Meteorological Agency, Lagos

The climate of the study area is tropical and marked by the rainy and the dry seasons. The rainy season begins somewhat in March and lasts till November and the dry season commences in December and lasts till February of each year. The annual rainfall is in the order of 2395 mm at an average of 199.58 mm per month (Table 4.3). The relative humidity is typically lowest in January (69%) and highest in July and August (92% and 93% respectively). The mean relative humidity was 84.1%. The mean monthly air temperatures were similar and almost the same in some months as in February, May, July, August, September and October. The average monthly temperature is 27.6°C. The lowest temperature was in July (25.2°C) and August and September (25.7°C) and the highest was in February (29.4°C) and December (29.1°C). There are winds blowing from different directions during the year, namely; Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W), Northwest (NW) and North (N). The FYIP projects environment is dominated by South-west and North-east trade winds during the wet and the dry seasons respectively.

4.4.2 Micro-climatic Data

The average annual rainfall ranges from 3,000-3900 mm with a monthly mean of 270 mm. The mean annual maximum temperature is between 29-320C, while the mean minimum temperature is between 22-230C (SPDC, 2012). Ambient temperature during the study ranged from 26.3-29.3oC with an average value of 28.8 oC. Windspeed in the study area ranged from 3.1 - 4.6 m/s with a mean value of 3.9 m/s. The South westerly (SW) wind was the dominant wind direction in the study area during the study.

Table 4.4: Micro-climate Measurements for the Study Area

Parameters	AQ1	AQ2	AQ3	AQ4	AQ1C	AQ2C
Temperature (oC)	29	29.3	28.3	28.6	27.2	26.3
Wind Speed (m/s)	4.2	4.6	3.2	3.6	3.5	3.1
Wind Direction	SW	SW/SS	SW/SS	SW	SW	SW/SS

Source: Field Study FYIP EIA (2018)

4.5 Air Quality and Noise

Table 4.5 shows the results of Air quality and Noise measurements in the FYIP project location. Noise levels ranged from 62.1 - 69.2 dB(A) with no significant difference between the project location and control. Noise levels were within acceptable limits of 80-100 dB(A) and 90 dB(A) stipulated by DPR and FMEnv respectively.

Table 4.5: Air quality measurements in the FYIP project Field

Parameters	AQ 1	AQ 2	AQ 3	AQ 4	AQ C1	AQ C2	P values	DPR Limits	FMEnv Limits
Noise (dB(A)	66.9	68.2	62.4	68.2	69.6	62.1	0.765	80-100	90
NH4 (ppm)	0.84	1.22	1.42	1.32	1.14	0.25	0.691	NS	NS
SO2 (ppm)	<0.01	0.01	<0.01	0.13	0.02	0.01	0.5	0.04	0.01
NO2 (ppm)	0.02	0.02	0.01	0.01	0.12	0.01	0.563	0.08	0.04
VOC (ppm)	0.86	1.86	1.77	1.6	1.28	0.56	0.699	NS	0.09
SPM (µg/m3)	10.29	17.49	14.63	14.23	13.99	10.59	0.813	60-90	250
PM2.5 (µg/m3)	4.13	6.91	7.28	8.52	9.62	7.24	0.462	NS	NS
PM10 (µg/m3)	3.74	4.55	5.47	3.11	1.05	1.56	0.034	NS	NS
H2S, ppm	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	NS	NS

Source: FYIP EIA Field data (2018)

Air quality parameters monitored included sulphur dioxide (SO2), Nitrogen dioxide (NO2), Ammonia (NH4), Volatile Organic Compounds (VOC), Hydrogen Sulphide (H2S) and Suspended Particulate Matter (SPM). Sulphur dioxide levels ranged from 0.01-0.13 ppm and showed no significant difference between levels at project location and those of the control stations. All sample stations except AQ4, showed SO2 levels lower than DPR standard of 0.04 ppm. Nitrogen dioxide concentrations ranged from 0.01-0.12ppm. There was no significant difference between values at the project area and the control stations. All values were within DPR recommended limits except for one control station (AQ1).

VOC values ranged from 0.56 – 1.86 ppm. There was no significant difference between values at the project area and control. All stations showed VOC levels were high both within the proposed project location and control and all values were above the FMENv permissible limit of 0,09 ppm.

Ammonia (NH_4) ranged from 0.25-1.42 ppm with no significant difference between project area and control station while H_2S were not detected in the study area.

SPM ranged between 10.29 and 17.49 µg/m3 with no significant difference between proposed project location and control. All values were within the permissible limit of 60-90 µg/m3 and 250 µg/m3 stipulated by DPR and Federal Ministry of Environment respectively. Particulate Matter fraction, PM2.5 ranged from 4.13-9.62 µg/m3 at the project area and control stations with no significant spatial difference. The PM10 levels at the project area (3.11-5.47 µg/m3) were significantly higher ($P<0.05$) than those of the control stations (1.05-1.56 µg/m3). However, the PM2.5 and PM10 values obtained during the study were within EPA air quality limits of 35 µg/m3 and 150 µg/m3 for PM2.5 and PM10 respectively (Table 4.5).

Although the proposed project area is a brown field with several ongoing oil/gas and other maritime activities, the overall absence of significant differences in air quality between proposed project area and control can be attributed to air dispersion. Variable winds with speeds of 3.1-4.6 m/s were measured in the area during the present study which may be responsible for the uniformity in air quality of the area.

4.5.1 Trending of Air Quality in the FYIP NAG field

Measurements of Air quality parameters in the FYIP NAG Field area from 2001 to 2018 is detailed in Appendix 5 and summarized in Table 4.6. Parameters with sufficient data for trending included noise, Sulphur dioxide, nitrogen dioxide, volatile organic compounds and suspended particulate matter.

Table 4.6: Trending of air quality parameters at the FYIP NAG field (2001-2018)

Parameters	2001 EIA FYIP	2012 Dry		2012 Wet		2018 Wet		2018 Control		P Values	Limits	
		Mean	Std	Mean	Std	Mean	Std	AQ C1	AQ C2		DPR	FMEnv
Noise (dB(A)		62.75	1.91	62.7	0.14	66.42	2.75	69.6	62.1	0.607	80-100	90
CH4 ppm						1.2	0.25	1.14	0.25	0.165	NS	NS
SO2, ppm	<0.01	0.19	0.02	<0.001	0	0.07	0.08	0.02	0.01	0.081	0.04-0.06	0.01
NO2, ppm	<0.01	0.09		<0.001	0	0.02	0.01	0.12	0.01	0.34	0.08	0.04
VOC, ppm		2.95	0.49	2.49	0.26	1.52	0.45	1.28	0.56	0.06	NS	0.09
SPM, µg/m3		10.01	0.91	4.29	0.04	14.16	2.96	13.99	10.59	0.113	60-90	250
PM2.5, µg/m3						6.71	1.85	9.62	7.24	0.355	NS	NS
PM10, µg/m3						4.21	1.02	1.05	1.56	0.064	NS	NS
H2S, ppm	<0.01		0	<0.001	0	0.01	0	<0.01	<0.01	-	NS	NS
Wind Temp. OC						28.8	0.44	27.2	26.3	0.064		
Wind Speed, m/s						3.9	0.62	3.5	3.1	0.165		
Wind Direction								SW	SW/SS			
	Increasing Trend					Decreasing Trend						

Figure 4.2 shows the trending of noise in the FYIP NAG field. Noise followed a consistent increasing trend in the area. This may be attributed to increased maritime activities including operational activities of oil and gas and vessels traffic in the area.

Figure 4.3 shows the trending of suspended particulate matter in the area. Similar to the trend in noise, SPM also followed an apparent increasing trend in the area. The increasing trend in SPM in the area may be associated with the general particulate menace affecting Rivers State and environments. The SPM levels were markedly higher in 2018 notwithstanding the rainy season sampling regime when SPM should naturally drop, indicating the seriousness of the particulate pollution in the Niger Delta. The worsening particulate pollution has been attributed to a number of sources the most prominent being illegal refineries of petroleum products in the Niger Delta.

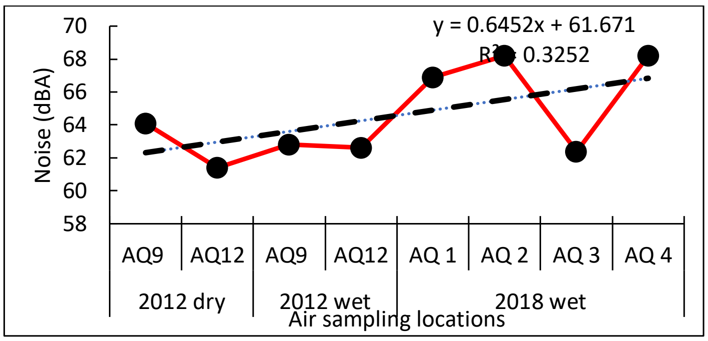


Figure 4.2: Noise trending in the FYIP NAG field (2012 to 2018)

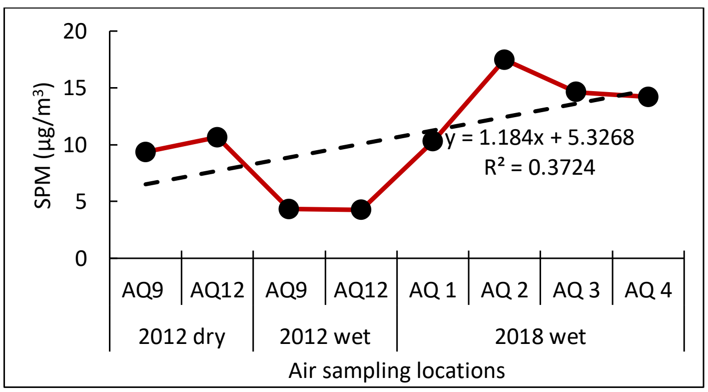


Figure 4.3: SPM trending in the FYIP NAG field (2012 to 2018)

In contrast to noise and SPM, VOC (Figure 4.4) showed the opposite trend decreasing consistently from 2012 to 2018. The remarkable decreasing trend in VOC levels may be associated with improved management of associated gas in the oil and gas industry following regulatory enforcement of reductions in gas flaring.

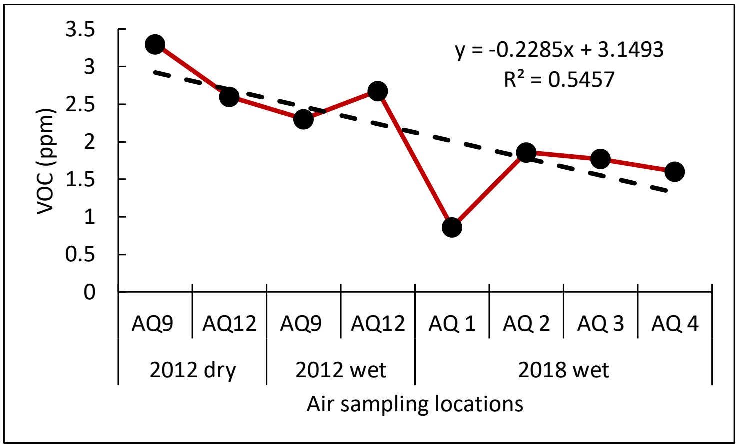


Figure 4.4: Trending of VOC in the FYIP NAG field (2012 to 2018).

Nitrogen dioxide (Figure 4.5) and sulphur dioxide (Figure 4.6) did not show any apparent trend annually or seasonally, indicating the wide variability in sources including natural sources from swamp and wetland ecosystems.

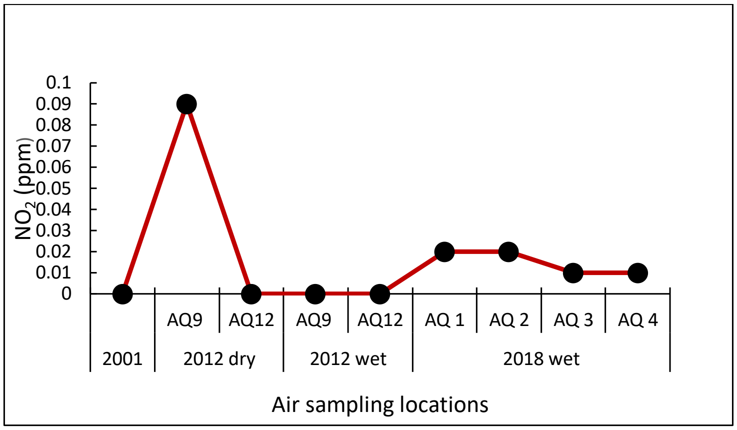


Figure 4.5: Trending of nitrogen dioxide in the FYIP NAG field (2001 to 2018)

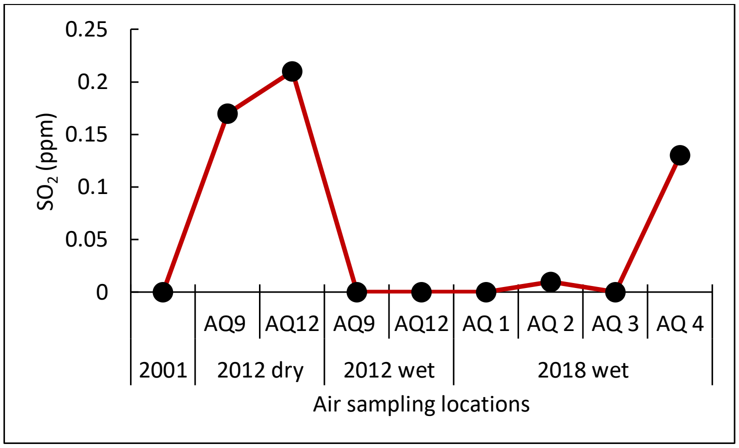


Figure 4.6: Trending of sulphur dioxide in the FYIP NAG field (2001 to 2018)

4.6 Aquatic Studies

4.6.1 Physicochemical Parameters of Surface Water

The results of physicochemical measurements in surface waters of the FYIP NAG Field are presented in Appendix 6 and summarized in Table 4.7.

Table 4.7: Summary of results of Physicochemical measurements in surface water of the FYIP NAG Field (2018)

Parameters	Proposed Project Area			Control			P Values	Limits
	MIN	MAX	Mean±SD	MIN	MAX	Mean±SD		NNPC/RPI (1985)
Temperature, oC	27.8	28.8	28.35±0.36	29.2	29.7	29.45±0.25	0.156	
pH	7.5	7.9	7.75±0.15	7.7	7.8	7.75±0.05	0.317	3.1-8.6
Electrical Conductivity, µS/cm	13650	42157	26752±12074	12040	23250	17645±5605	0	10-42100
Salinity, ‰	9.9	32.1	20.03±9.58	8.2	16.6	12.4±4.2	0.37	
Total Dissolved Solids (TDS), mg/l	7234	22260	14156±6372	6301	12322	9312±3011	0.18	2.0-35350
Turbidity, NTU	13.4	81.7	37.1±26.3	16.5	19.1	17.8±1.3	0.01	
Total Suspended solids (TSS), mg/l	19.8	34.6	27.9±5.8	24.2	26	25.1±0.9	0.655	
Colour, Pt.Co.	25	50	36±10	40	40	40±0	0.317	
Redox potential (±mV)	135.5	184.7	172.3±21.25	184.8	186.1	185.45±0.65	0.18	
Dissolved Oxygen, mg/l	5.4	5.43	5.42±0.011	5.38	5.38	5.38±0	0.18	
Biological Oxygen Demand (BOD), mg/l	4.11	8.31	6.01±1.84	6.27	6.27	6.27±0	0.18	

Parameters	Proposed Project Area			Control			P Values	Limits
	MIN	MAX	Mean±SD	MIN	MAX	Mean±SD		NNPC/RPI (1985)
Chemical Oxygen Demand (COD), mg/l	9.58	18.2	14.35±3.1	12.55	13.28	12.92±0.365	0.18	1.9-2460
Alkalinity, mg/l	400	460	430±22	220	420	320±100	0	
Bicarbonate (CO32-) mg/l	488	561.2	524.6±27.28	268.4	512.4	390.4±122	0.05	
Nitrate, mg/l	0.5	0.6	0.56±0.04	0.53	0.57	0.55±0.02	0.317	
Nitrite (NO2-), mg/l	0.01	0.03	0.02±0.01	0.02	0.02	0.02±0	1	
Phosphorus, mg/l	0.02	0.09	0.05±0.036	0.013	0.029	0.021±0.01	0.655	
Phenol, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	
MAJOR ANIONS								
Chloride (Cl-), mg/l	4.33	9235	3478.6±3561	4.254	53.18	28.72±24.46	0	
Sulphate (SO42-), mg/l	25.08	49.71	34.94±9.93	15.97	24.63	20.3±4.33	0.043	
MAJOT CATIONS								
Na2+, mg/l	3546	8461	5929±2340	1953	4333	3143±1190	0	
K+, mg/l	188.58	443.7	321.6±116.2	118.82	223.89	171.36±52.54	0	
Ca2+, mg/l	70.74	109.37	90.95±17.96	64.78	87.43	76.11±11.33	0.213	
Mg2+, mg/l	359.11	1280	822.5±431	287.34	355.39	321.37±34.02	0	

Parameters	Proposed Project Area			Control			P Values	Limits
	MIN	MAX	Mean±SD	MIN	MAX	Mean±SD		NNPC/RPI (1985)
HEAVY METALS								
Cadmium, (mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	1	
Zinc, (mg/l)	0.55	0.62	0.6±0.029	0.544	0.57	0.555±0.011	0.655	BDL-0.77
Iron, (mg/l)	0.45	3.68	1.431±1.32	0.5	0.64	0.57±0.07	0.655	BDL-4.75
Copper, (mg/l)	0.02	0.04	0.03±0.01	0.029	0.032	0.031±0.002	0.18	
Chromium, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	
Nickel, (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	1	BDL-0.52
Lead, (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	1	BDL-0.66
Vanadium, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	BDL-1.56
Arsenic, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1	
Mercury, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Barium, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Magnesium, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Silver, (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	
Cobalt, (mg/l)	<0.001	0.29	0.13±0.12	<0.001	0.25	0.25±0	0.317	
ORGANICS								

Parameters	Proposed Project Area			Control			P Values	Limits
	MIN	MAX	Mean±SD	MIN	MAX	Mean±SD		NNPC/RPI (1985)
Total Petroleum Hydrocarbon (TPH), (mg/l)	0.006	0.212	0.109±0.103	0.361	0.361	0.361±0	0.18	
Total Hydrocarbon Content (THC), (mg/l)l	0.118	0.241	0.193±0.053	0.29	0.61	0.45±0.16	0.18	
Oil and grease (O&G), (mg/l)	0.112	0.24	0.187±0.055	0.261	0.27	0.266±0.005	0.18	70.7
BTEX, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
PAH, (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Aliphatic Hydrocarbon, (mg/l)	<0.031	0.241	0.124±0.117	<0.031	0.305	0.305±0	0.18	
MICROBIOLOGY								
THB x 102cfu/ml	1	2	1.34±0.39	1	1	1±0	0.317	
HUB x 102cfu/ml	0	0	0±0	0	0	0±0	-	
Total Fungi x 102cfu/ml	1	1.05	1.02±0.02	0	0	0±0	0.94	
HUF, x 102cfu/ml	0	0	0±0	0	0	0±0	-	
Total Coliform, MPN/100ml	14	29	22.5±5.94	23	34	28.5±5.5	0.655	
Faecal Coliform Count, MPN/100ml	0	0	0±0	0	14	14±0	0.317	

Temperature

Temperature ranged from 27.8 to 29.7oC with no significant difference between the project location and control. The measured temperatures are normal for tropical coastal waters.

pH, Conductivity, Salinity, Total Dissolved Solids (TDS)

Hydrogen ion concentration (pH) varied between 7.5 and 7.9 with no significant difference between proposed project location and control. The pH is normal for tropical marine waters. According to CWT (2004), the pH of seawater is usually between 7.5 and 8.4. Wetzel (1983) reports that the pH of marine waters is similar to that of estuarine waters and is usually stable between 7.5 and 8.5 worldwide. NNPC/RPI (1985) reported a range of 3.1-8.6 for surface waters of the Niger Delta. Lethal effects of pH on aquatic life occur below pH 4.5 and above pH 9.5 (Researchgate, 2017).

Electrical conductivity, Salinity and Total Dissolved Solids are interrelated parameters of salt concentration. Electrical conductivity ranged from 12040 to 42150 µS/cm with significantly higher ($P<0.05$) values around the project location compared to control. The fact that conductivity was higher around the proposed project area than further offshore at SWC2 may indicate local influence of saline conditions due to tides or effluent discharges. NNPC/RPI (1985) reported a range of 10-42,100 µS/cm for surface waters of the Niger Delta. The observed conductivity values are typical of brackish waters. Estuaries usually have electrical conductivity typically from >1500 to 51,500 µS/cm with values increasing as salinity increases (NSW, 2010). The levels of salinity (8,2-32.1 ppt) and TDS (6301-22260 mg/l) are also characteristic of brackish waters (Fondriest Environmental Inc, 2014).

Dissolved oxygen (DO), Oxidation-Reduction Potential (EH), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD)

The levels of DO, EH, COD and BOD are all indicators of the redox conditions in the environment. Dissolved oxygen concentrations ranged from 5.38-5.43 mg/l with no significant difference between study locations and control. According to Chapman (1996) DO concentrations in unpolluted freshwaters are usually close to, but less than, 10 mg/l. Concentrations below 5 mg/l may adversely affect the functioning and survival of biological Community while levels below 2 mg/l may lead to the death of most fish. The observed DO levels are normal in brackish tropical waters. The moderately lower values may be attributed to the effect of salinity because the amount of oxygen that can dissolve in water, decreases as salinity increases (NOAA, 2017). NNPC/RPI (1985) reported a range of 2 to 9 mg/l for the Niger Delta. The present concentrations are normal for the study area.

The redox potential (EH) ranged from 135.5 to 186.1 mV with no significant difference between project location and control. According to Chapman (1996) surface waters containing dissolved oxygen are usually characterized by a range of EH values between +100 mV and +500 mV. The observed EH values are in tandem with the levels of DO in the waters.

Chemical Oxygen Demand varied between 9.58 and 18.2 mg/l while BOD ranged from 4.11-8.31 mg/l with no significant difference between facility location and control. According to Chapman (1996) the concentrations of COD observed in surface waters can reach up to 20 mg/l in unpolluted waters indicating that the waters were unpolluted by organic matter. Also, NNPC/RPI (1985) reported a range of 1.9 to 2460 mg/l in the Niger Delta waters indicating that the observed values are usual for the study area. The BOD values were also within levels that do not indicate organic pollution. Typical natural water has a BOD from 0.8 to 5 mg/l (Alken Muray, 2006).

Alkalinity

Surface water alkalinity ranged from 220-460 mg/l. Alkalinity is the measurement of the water's ability to neutralize acids. It represents the buffering capacity of water and its ability to resist a change in pH. According to USEPA (2006) alkalinity of seawater averages 116 mg/l with lower values in brackish water.

Turbidity and Total Suspended Solids (TSS)

Turbidity and TSS are related parameters indicating particulates load in water. Turbidity ranged from 13.4 to 81.7 NTU while TSS ranged from 24.2 to 34.6 mg/l. The USEPA guidelines on suspended solids for the protection of fisheries resources prescribes values below 25 mg/l as indication of no harmful effects. In Estuaries, turbidity less than 10 NTU is considered healthy while poor water quality is indicated by levels above 20 NTU (NSW (2010). For most surface waters, turbidity is usually between 1 NTU and 50 NTU with possibility of higher values after heavy rains when the water levels are high while lower values can be expected in still water where suspended particles have settled (Researchgate, 2017). The observed levels of turbidity and TSS are indicative of poor water quality but such levels are commonly encountered in natural tidal waters due to tide-induced resuspension of sediments.

Nutrients

Nitrate ranged from 0.5-0.6 mg/l with no significant difference between project location and control. Nitrate levels above 22 mg/l in natural waters normally indicates man made pollution (Chapman, 1996). In marine environments, levels of 0.44 to 0.89 mg/l are considered ideal (Alken Murray, 2006) indicating that the water was unpolluted with regards to nitrates. Nitrites ranged from 0.1-0.3 mg/l with no significant difference between project location compared to control. Nitrites occur in water as an intermediate product in the biological breakdown of organic nitrogen, their presence may infer recent input of organic wastes. According to Alken Murray (2006) the level of nitrite considered ideal for marine fish is between 0.04 and 0.15 mg/l. The observed levels should be expected because of multiple sources of organic matter inputs including tidal export from associated mangrove swamps.

Phosphate ranged from 0.013 to 0.09 mg/l with no significant difference between project area and control. According to Chapman (1996), phosphorus ranges from 0.02 to 0.06 mg/l in most natural waters. NNPC/RPI (1985) gave a range of 0.049 to 0.584 mg/l for phosphate in rivers of southern Nigeria. Present values are therefore normal for the Niger Delta.

Major Anions and Cations

Chloride ranged from 4.25 to 9235 mg/l while sulphate ranged from 15.97 to 49.71 mg/l with significantly higher levels at the project location compared to control. Chloride and sulphate are major anions which contribute to the salinity of marine waters. For typical ocean waters, average concentration of chloride is 19,345 mg/l and that of sulphate is 2,701 mg/l (Anderson, 2008). These typical ocean levels are usually diluted in estuaries and in the vicinity of large rivers discharging into the sea as is typical of the present study area (Mouth of Forcados River) (Garrison, 2005). RPI/NNPC (1985) reported values of 3 to 18,648 mg/l for chloride and BDL to 2,796 mg/l for sulphate in waters of southern Nigeria. The values of chloride and sulphate obtained are normal for the study area. However, the observation of higher values of chloride and sulphate within the proposed project area compared to control (SWC2) which is further offshore may indicate local saline intrusion due to tides or saline discharges.

Sodium, potassium, calcium and magnesium are major cations that contribute to the salinity of marine waters. Sodium ranged from 1953 mg/l to 8461 mg/l, potassium ranged from 118.82 to 443.7 mg/l, calcium ranged from 64.78 to 109.37 mg/l and magnesium ranged from 2.72 to 2.83 mg/l with significantly higher values at project location compared to control. Levels of major cations in sea water (Hem, 1985) average 10500 mg/l for sodium, 380 mg/l for potassium, 410 mg/l for calcium and 1350 mg/l for magnesium. Concentrations of major cations were within normal levels for nearshore waters. Lower values compared to average sea water is associated with riverine dilution. Figure 4.7 shows the spatial distribution of major cations in the surface water. Although SWC2 is the farthest offshore location and should naturally show the highest levels of major cations, concentrations at SW2 and SW3 within the proposed project area were the highest. A similar trend was found in conductivity, chloride and sulphate levels. This may be attributed to variations in tidal conditions during sampling or saline effluents from variable marine operations in the area.

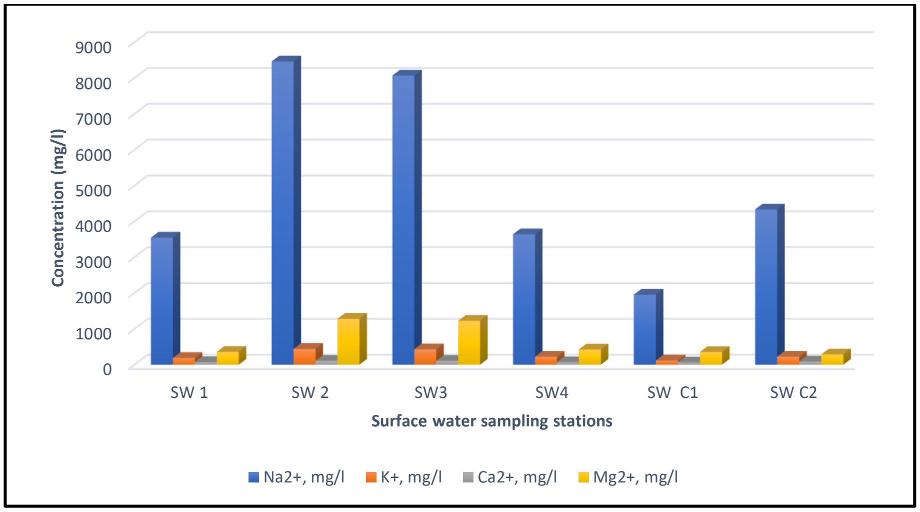


Figure 4.7: Spatial distribution of major cations in surface water of the FYIP NAG field (2018)

Heavy metals

The level of dissolved metals in seawater is normally quite low (Turekian 1977). Cadmium, chromium, nickel, lead, vanadium, arsenic, mercury, barium, manganese and silver were not detected in the water samples. Zinc ranged from 0.55 to 0.62 mg/l, iron ranged from 0.45 to 3.68 mg/l and coper ranged from 0.02 to 0.04 mg/l with no significant difference between project location and control. Cobalt ranged from undetectable concentrations to 0,29 mg/l with no significant difference between project location and control. NNPC/RPI (1985) reported iron and zinc levels of BDL to 4.75 and BDL to 0.77 mg/l respectively for Niger Delta area indicating that the measured levels were within normal values for the study area. The level of zinc is well below harmful concentrations to aquatic biota of 120 mg/l (Alken Muray, 2006).

Organics

Levels of organics including Oil and grease (0.11-0.27 mg/l), Total Hydrocarbons (0.006-0.361mg/l) and Total Petroleum Hydrocarbons (0.118-0.61 mg/l) at the project location were not significantly different from those of the control. Polycyclic Aromatic Hydrocarbons and BTEX were generally below detection limits. The recommended maximum concentrations of mineral oil for drinking water supplies and fisheries protection are generally between 0.01 and 0.1 mg/l. Concentrations of 0.3 mg/l or more of crude oil can cause toxic effects in freshwater fish (Alken Muray, 2006). Variable levels of oil pollution are usual in the Niger Delta area. NNPC/RPI (1985) reported average value of 70.7 mg/l of oil and grease for water of the Niger Delta indicating that the observed concentrations are normal for the study area.

Microbiology

Total Heterotrophic Bacteria (THB) counts ranged from 1.0 to 3.0 x 102 cfu/ml, Total Fungi (TF) ranged from 0 to 1.05 x 102 cfu/ml. THB and TF did not show any significant difference between project area and control. According to Omiema and Ideriah (2012) viable bacteria in overlying water are typically about 106 and 107 cells per ml. For sea water, bacteria numbers generally range from 103 to 106 per ml (Azam et al., 1983). Bacterial abundance is also related to the organic matter concentration and to hydrological phenomena (Azam et al., 1983). The counts of bacteria and fungi were generally low which may be attributed to low levels of organic carbon and nutrients in the water. Hydrocarbon Utilizing Bacteria (HUB) and Hydrocarbon Utilizing Fungi (HUF) were not observed in the project area and control. The distribution of hydrocarbon-utilizing microorganisms is known to reflect the historical exposure of the environment to hydrocarbons (Atlas and Barth a, 1972). Absence of HUB and HUF are indicators of unpolluted environment with respect the petroleum hydrocarbons.

4.6.2 Trending of surface water parameters

Results of different Environmental studies of surface water at the FYIP NAG project area are presented in Appendix 7. Table 4.8 shows a comparison of water quality from baseline, environmental monitoring data (2001) to the present EIA (2018). Significant differences were observed in a number of parameters.

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Table 4.8: Trending of surface water physicochemical and microbiological parameters in FYIP NAG Field (2001-2018)

Parameters	Baseline 2001	2012 Dry	2012 Wet	2018 Wet	2018 Control	P Values
pH	7.903a±0.27	7.36b±0.23	7.35b±0.13	7.75a±0.17	7.75a	0.000
Temperature, oC	27.19b±1.46	28.68a±0.2	28.69a±0.42	28.35a±0.42	29.45a	0.001
Electrical Conductivity, µS/cm	12120c±6330	13563.1b±3231.58	11627.6b±4760.45	26751.75a±13941.85	17645b	0.000
Turbidity, NTU		1.29±0.12	89.06±276.5	37.1±30.41	17.8	0.000
Dissolved Oxygen, mg/l	8.85b±0.67	7.67b±0.91	9.34a±1.58	5.42c±0.01	5.38c	0.000
Biological Oxygen	4.081b±0.86	2.31c±0.53	0.72d±0.18	6.01a±2.12	6.27a	0.000

Parameters	Baseline 2001	2012 Dry	2012 Wet	2018 Wet	2018 Control	P Values
Demand (BOD), mg/l						
Chemical Oxygen Demand (COD), mg/l	104.69a±64.79	9.14a±2.58	7.91a±2.09	14.35a±3.57	12.92a	0.000
Total Dissolved Solids (TDS), mg/l	7891c±4090	7189.76b±1712.78	5813.8b±2380.22	14156a±7357.66	9311.5b	0.000
Total Suspended solids (TSS), mg/l	24.88a±23.06	8.19b±1.51	8.97b±0.75	27.9a±6.7	25.1a	0.000
Colour, Pt.Co.				36.25±11.09	40	0.623
Odour					0	
Alkalinity, mg/l				429.96±25.82	319.97	0.24
Appearance					0	
Nitrate, mg/l	0.74b±0.3	10.83a±4.94	2.72b±1.94	0.56b±0.05	0.55b	0.000
Phosphorus, mg/l	0.50b±0.24	1.24a±0.77	0.05b±0.04	0.05b±0.051	0.02b	0.000
Carbonate, mg/l		<0.001±0	<0.001±0	<0.02±0	0	0.000
Salinity, oo/o				20.03±11.06	12.4	0.355
Redox potential (±mV)				172.3±24.53	185.45	0.064

Parameters	Baseline 2001	2012 Dry	2012 Wet	2018 Wet	2018 Control	P Values
Phenol, mg/l		<0.001±0	<0.001±0	<0.01±0	0	0.000
Chloride, mg/l		7331.57±3624.4	5879.2±2958.49	3478.58±4112.06	28.72	0.05
Sulphate, mg/l		372.87±102.23	284.9±132.93	34.94±11.46	20.3	0.006
Nitrite, mg/l				0.02±0.01	0.02	0.317
Bicarbonate mg/l				524.6±31.5	390.4	0.24
Sodium, mg/l				5929±2702.4	3143	0.355
Potassium, mg/l				321.57±134.16	171.36	0.355
Calcium, mg/l				90.95±20.74	76.105	0.355
Magnesium(mg/l)				822.49±497.79	321.365	0.064
Cadmium, (mg/l)	<0.01a±0	0.003c±0	<0.001c±0	<0.005b±0	0b	0.000
Zinc, (mg/l)	<0.01d±0	0.23b±0.07	0.06c±0.025	0.60a±0.03	0.56a	0.000
Iron (mg/l)		0.02±0	0.009±0.004	1.43±1.52	0.571	0.000
Copper (mg/l)	<0.01b±0	0.0075c±0	0.005c±0	0.029a±0.01	0.03a	0.000
Chromium (mg/l)	<0.01a±0	0.006b±0	<0.001b±0	<0.001b±0	0b	0.000
Nickel, (mg/l)	<0.01a±0	<0.001c±0	<0.001c±0	<0.002b±0	0.0020b	0.000

Parameters	Baseline 2001	2012 Dry	2012 Wet	2018 Wet	2018 Control	P Values
Lead (mg/l)	<0.01a±0	<0.001c±0	0.002±0	<0.002b±0	0b	0.000
Vanadium (mg/l)	<0.01a±0	<0.001b±0	<0.001b±0	<0.001b±0	0b	0.000
Arsenic (mg/l)		<0.001±0	<0.001±0	<0.001±0	0	1
Mercury, (mg/l)				<0.001±0	0	1
Barium (mg/l)	<0.01a±0	<0.001b±0	<0.001b±0	<0.001b±0	0b	0.000
Manganese (mg/l)		0.01±0.01	0.002±0.001	<0.001±0	0	0.35
Silver, (mg/l)				<0.002±0	0	1
Cobalt (mg/l)				0.129±0.147	0.246	0.81
Total Petroleum Hydrocarbon (TPH)	<0.01b	<0.001c±0	<0.001c±0	0.11b±0.15	0.361a	0.000
Total Hydrocarbon Content, mg/l				0.19±0.07	0.45	0.064
Oil and grease, mg/l		<0.001±0	<0.001±0	0.19±0.07	0.266	0.000
BTEX, mg/l				<0.001±0	0	1
PAH, mg/l		<0.001±0	<0.001±0	<0.001±0	0	1
Aliphatic Hydrocarbon, mg/l				0.124±0.16	0.31	0.325
Microbiology:					0	

Parameters	Baseline 2001	2012 Dry	2012 Wet	2018 Wet	2018 Control	P Values
HUB, x 102cfu/ml		3.51±0.49	3.05±0.32		0	0.002
THB, x 102cfu/ml		0.6±0.11	0.52±0.11	1.34±0.45	1	0.002
HUF, x 102cfu/ml		0.07±0.04	0.13±0.08		0	0.002
Total Fungi x 102cfu/ml		2.41±0.57	1.77±0.24	1.02±0.02	0	0.000
Total Coliform, MPN/100ml		36.4±6.85	16.6±4.99	22.5±6.86	28.5	0.001
Faecal Coliform Count, MPN/100ml					14	0.157
A,b,c = significant differences. Same letters = no significant difference			Increasing Trend		Decreasing Trend	

Hydrogen ion concentration: The pH trend (Figure 4.8) showed an initial decrease till 2012 followed by an increasing trend to 2018. The increase in pH in 2018 may be associated with tidal conditions during sampling regime. Flood tidal conditions usually show higher pH than ebb tidal conditions due to the influence of sea water.

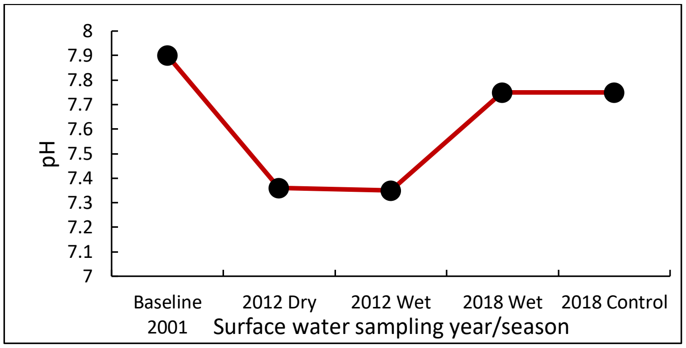


Figure 4.8: Trending of surface water pH in the FYIP NAG field

Electrical conductivity: Electrical conductivity showed a consistent increasing trend from baseline in 2001 to present EIA in 2018. The increase in 2018 may be attributed to tide-related sea water influence particularly noting that the conductivity at the project area was significantly higher than that of the control (Figure 4.9). One of the controls is very close the shore where riverine dilution is high compared to the proposed project area. Local saline intrusion from effluents associated with various maritime activities in the area may also contribute to the observed trend.

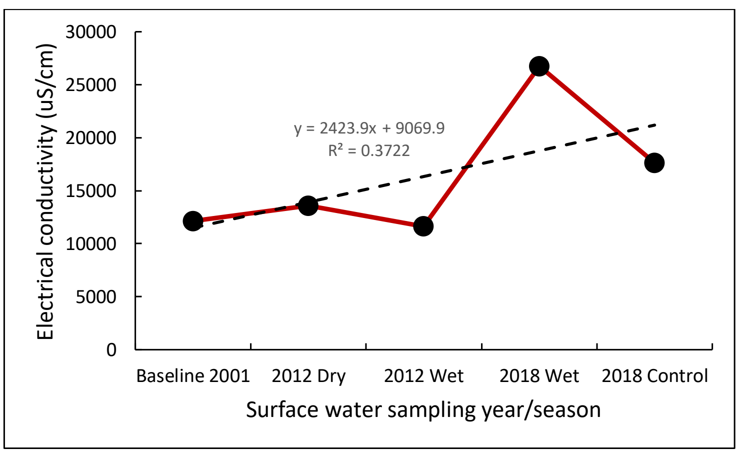


Figure 4.9: Trending of surface water conductivity in the FYIP NAG field

Dissolved Oxygen: Figure 4.10 shows the trending of surface water DO levels in the FYIP NAG field. Dissolved oxygen showed a significant decreasing trend with highest values during the baseline in 2001 and lowest values during the present EIA in 2018. The decrease in DO concentration in 2018 at the proposed project location was similar to the situation at the control so it cannot be attributed to activities around the project location. It reflects a general deterioration in water quality possibly associated with chronic organic inputs from riverine discharges and surface run-off.

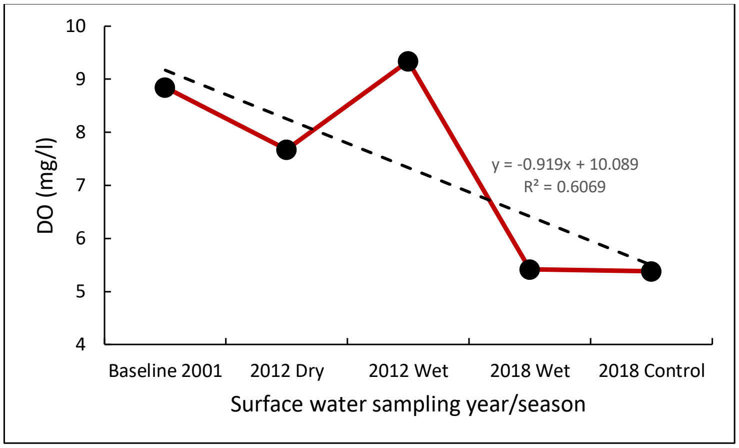


Figure 4.10: Trending of surface water DO in the FYIP NAG field

BOD: BOD showed an increasing trend (Figure 4.11) beginning from 2012 with highest levels during the present EIA. The increase in BOD during the present EIA at the proposed project location was also similar to that of the control indicating a general deterioration in organic pollution in the study area which may be attributed to chronic discharges of organic effluents and waste from rivers and surface run-off.

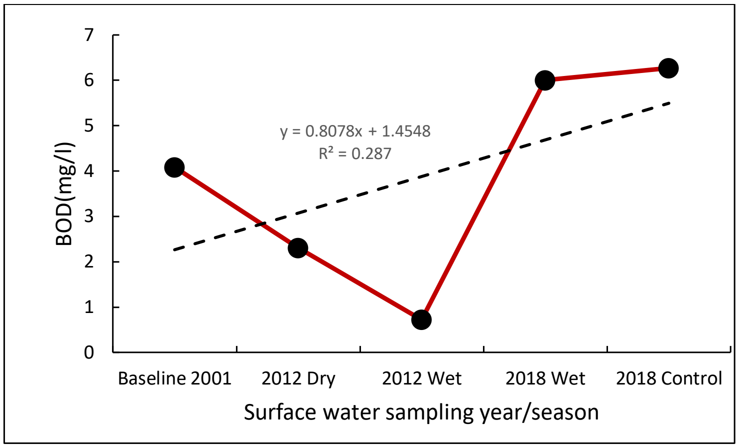


Figure 4.11: Trending of surface water BOD in the FYIP NAG field

Nutrients: Phosphate showed a consistent decreasing trend from highest values in 2012 to lowest values in 2018 (Figure 4.12). However, when considering only the rainy season, there is no difference between 2012 and present EIA indicating that the lower value in 2018 is associated with the rainy season dilution of concentrations. The situation may also arise in connection with its assimilation during microbial degradation of organic matter since the trend was similar to that of dissolved oxygen. Lowest levels were observed at the control during the present EIA indicating that the activities at the proposed project locations are not responsible for the trend.

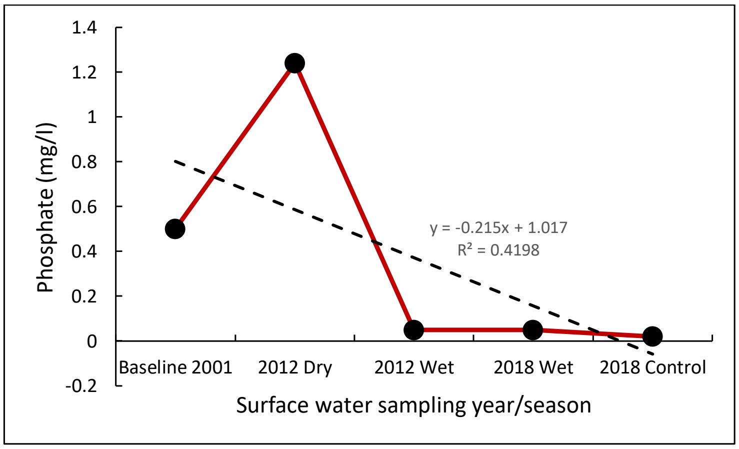


Figure 4.12: Trending of surface water phosphate in the FYIP NAG field

Heavy metals: Figure 4.13 shows the trending for surface water Zinc, iron, and copper concentrations. Although copper was at trace levels, all three metals displayed an increasing trend with highest levels obtained during the present EIA. For zinc and iron, the levels in the proposed project area were higher than those of the control indicating a possible dilution effect from riverine discharge at the control or local contamination around the proposed project area.

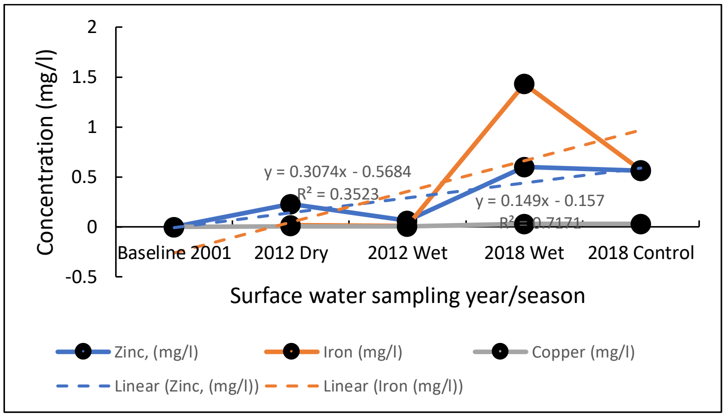


Figure 4.13: Trending of surface water zinc and iron in the FYIP NAG field

Organics: Petroleum hydrocarbons were not detected in surface water during the previous studies. Their presence during the present EIA studies points to a deterioration in water quality with respect to hydrocarbons which may be attributed to increase land-and marine based pollution. Oil pollution in the Niger Delta has increased markedly due to illegal bunkering and refining of crude.

Microbiology: Figure 4.14 shows the trending for surface water total heterotrophic bacteria counts. The bacterial counts showed consistent increasing trend with highest counts in 2018 during the present EIA. The relatively lower counts at the control compared to the proposed project area during the EIA is an indication of greater microbial activity around the proposed project area possible associated with elevated organic matter levels.

Total coliforms (Figure 4.15) did not show any apparent trend. Values decreased form 2001 to lowest in 2012 followed by an increase to a second peak in 2018 during the present EIA. The relatively higher values obtained at the control compared to the project location may be attributed to the proximity of one of one of the controls to the shore with potentially higher influence of land-based pollution including coliform bacteria.

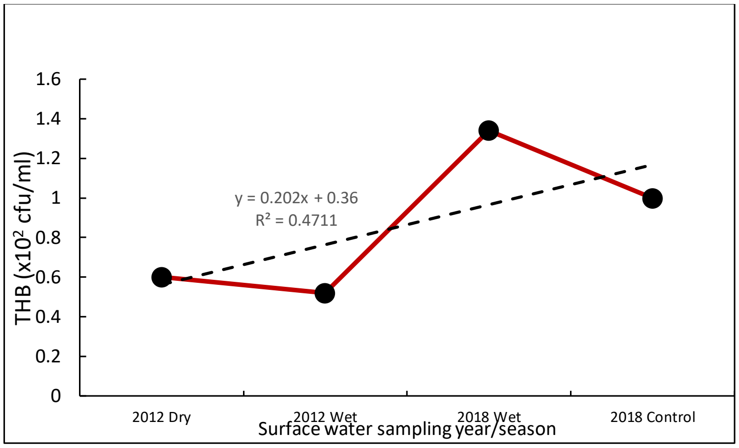


Figure 4.14: Trending of surface water THB in the FYIP NAG field

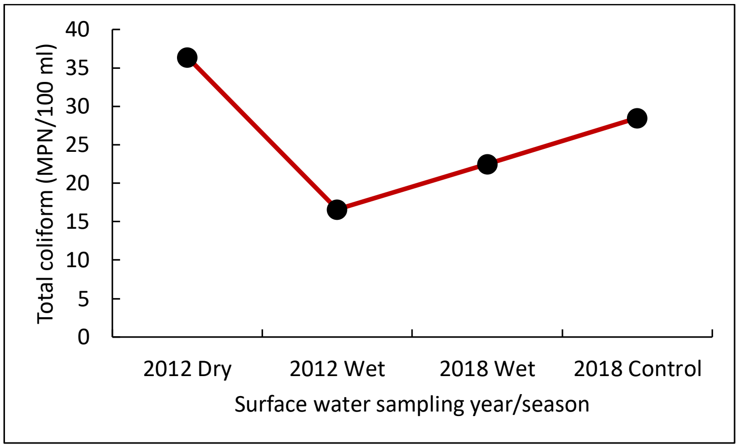


Figure 4.15: Trending of surface water total coliform in the FYIP NAG field

4.7 Sediments

4.7.1 Physicochemical Parameters

The results of physicochemical measurements in sediments of FYIP NAG Field are detailed in Appendix 8 and summarized in Table 4.9.

Table 4.9: Summary of results of Physicochemical measurements in sediments of the FYIP NAG Field (2018)

Parameters	Proposed Area Project			Control			P Values	Limits	
	Min	Max	Mean±SD	Min	Max	Mean±SD		NNPC/RPI (1985)	Sediment Quality Guidelines (SQG)
Texture	Sandy-sandy clay			Sandy-sandy clay					
pH	6	6.7	6.33±0.26	6.1	6.6	6.35±0.25	0.795		
Redox Potential (mV)	102.2	155.33	119.48±21.23	107.35	126	116.68± 9.33	0.611		
TOC, (%)	0.036	0.08	0.06±0.02	0.036	0.089	0.06±0.03	0.76		
Exchangeable Cations (mg/kg)									
Sodium	2134	2811	2488±252	3017	4630	3824±807	0.29		
Potassium	1130	1382	1282±93	1485	2251	1868±383	0.378		

Parameters	Proposed Project Area			Control			P Values	Limits	
	Min	Max	Mean±SD	Min	Max	Mean±SD		NNPC/RPI (1985)	Sediment Quality Guidelines (SQG)
Calcium	252	319	292±27	233	323	278±45	0.896		
Magnesium	792	1026	910±107	931	2452	1691±761	0.536		
Anions									
Chloride, mg/kg	1544	2268	1981±306	710	2197	1453±744	0.446		
Sulphate, mg/kg	14.23	148.2	105.6±54.7	126.8	149.2	138.01±11.19	0.3		
Nitrate, mg/kg	1.89	2.65	2.32±0.27	4.92	5.17	5.05±0.13	0.023		
Carbonate, %	0.02	1.55	0.62±0.64	0.36	1.27	0.82±0.46	0.984		
Organics, (mg/kg)									
Aliphatic hydrocarbon	18.52	36.22	26.14±7.81	4.44	9.58	7.01±2.57	0.325		

Parameters	Proposed Project Area			Control			P Values	Limits	
	Min	Max	Mean±SD	Min	Max	Mean±SD		NNPC/RPI (1985)	Sediment Quality Guidelines (SQG)
Oil and Grease	19.58	45.28	33.44±11.63	4.09	16.24	10.17±6.08	0.082		
TPH,	20.2	44.03	32.33±10.74	5.03	12.14	8.59±3.56	0.029		50***
THC,	18.52	39.54	30.4±8.5	4.78	14.62	9.7±4.92	0.058		
BTEX	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-		
Phenol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-		
PAH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-		1610*
Heavy Metals (mg/kg)									
Iron	2214	2844	2559.75±270.04	2709	3405	3057±348	0.583		2%**
Zinc	36.72	91.05	63.44±19.42	30.96	186.11	108.53±77.58	0.531	1/8/1976	121*
Cadmium	0.99	1.31	1.17±0.12	0.97	1.85	1.41±0.44	0.784	BDL-8.0	0.99*

Parameters	Proposed Project Area			Control			P Values	Limits	
	Min	Max	Mean±SD	Min	Max	Mean±SD		NNPC/RPI (1985)	Sediment Quality Guidelines (SQG)
Copper	4.87	10.63	8.76±2.29	8.61	9.22	8.91±0.31	0.649		31.6*
Chromium	8.95	12.81	10.78±1.38	11.33	12.1	11.72±0.38	0.087	BDL-8	43.4*
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	BDL-28.6	27.7*
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	BDL-37	35.8*
Vanadium	12.35	15.87	14.13±1.37	12.9	15.62	14.26±1.36	0.969	BDL-40.8	
Arsenic	54.91	80.82	69.55±9.43	70.6	134.17	102.39±31.78	0.599		9.79*
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-		0.18*
Barium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-		
Manganese	16.24	22.71	19.36±2.31	28.38	34.93	31.65±3.272	0.274		460**
Silver (Ag)	<0.010	0	±	0	0	±	-		

Parameters	Proposed Project Area			Control			P Values	Limits	
	Min	Max	Mean±SD	Min	Max	Mean±SD		NNPC/RPI (1985)	Sediment Quality Guidelines (SQG)
Cobalt (Co)	12.49	19.76	15.5±2.71	15.88	17.76	16.82±0.94	0.904		
Microbiology									
THB x104cfu/g	1	3.5	1.89±1.01	4.5	4.7	4.6±0.1	0.118		
HUB, x104cfu/g	0	1.07	1.04±0.03	1.2	1.2	1.2±0	0.5		
TF x104cfu/g	1	2.1	1.31±0.46	3	3.2	3.1±0.1	0.055		
HUF, x104cfu/g	0	1	1±0	0	0	0	-		
SRB, x103cfu/g	0	0	0	0	0	0	-		

* McDonald, et al., 2000;** Persaud et al. (1993);*** Massoud, et al., (1996); SQG: Sediment Quality Guideline

Sediment pH, Total Organic Carbon (TOC) and redox potential

The sediments ranged from sandy to sandy-clay texture. The pH of the sediments ranged from 6.0 to 6.7 with no significant difference between project location and control. Zobel (1946) reports that pH values in recent sediments generally ranged from 6.4 to 9.5. The observed pH values are generally acidic which is related to that of the overlying water (section 4.1.1). Sediment pH is a master variable controlling the speciation and bioavailability of metals.

Total Organic Carbon (TOC) ranged from 0.04 to 0.09 % with no significant difference between project location and control. USEPA (2002) recommended the following assessment categories for TOC in sediments:

- Low: ≤ 1%,
- Intermediate: 1 to 3%,
- High: >3%.

The 3% level is usually taken as the threshold between pristine and contaminated sediments. All levels were within normal values for unpolluted sediments.

Redox Potential ranged from 102.2 to 155.3 mV. According to DeLaune et al. (1999) the redox conditions of estuarine sediment varies widely from approximately +500 mV (surface sediments) to approximately -300 mV (strongly reducing sediments). All measurement of redox were oxidizing as expected in oxygenated surface sediments. According to Zobel (1946) positive EH values are generally characteristic of bottom deposits which are well oxygenated, or those which consist of coarse sediments. This is in line with the sediment textures of the study area characterized by coarse (sandy) materials and low organic matter (<1% TOC) content.

Exchangeable Cations and Anions

Chloride ranged from 710 to 2268 mg/kg with no significant difference between project location and control. Sulphate ranged from 14.23 to 149.2 mg/kg, Sodium ranged from 2134 to 4630 mg/kg, Calcium ranged from 233 to 323 mg/kg while magnesium ranged from 792 to 2452 mg/kg with no significant differences between project location and control. There are no environmental limits for major ions in sediments. Their levels are related to those of the overlying water. The observed levels are normal for brackish environments. The major cations are important with regards to buffering processes involving neutralization of acidic conditions.

Nutrients

Nitrate ranged from 1.89 to 2.65 mg/kg in the project area and from 4.92 to 5.17 mg/kg at the control with significantly higher ($P<0.05$) concentrations in the control locations compared to the project area (Figure 4.16). There are no limits for nutrients in sediments, but their levels are important for biochemical processes within the sediment particularly as it relates to microbial degradation. Lower nitrate levels in project area may suggest greater microbial assimilation/activity. Total fungi were higher in project area and hydrocarbon utilizing fungi was only observed in the project area (see 4.2.4).

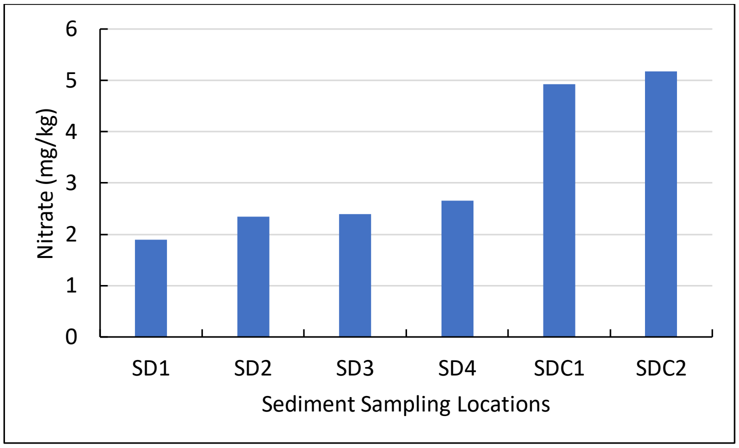


Fig. 4.16: Spatial distribution of nitrate in the FYIP NAG field (2018)

Heavy metals

Nickel, lead, mercury, barium and silver were not detected in the sediment samples. The absence of nickel is a pointer to absence of petroleum pollution in the sediments since nickel is closely associated with crude oil and Ni:V ratios have been used to infer crude oil pollution. Iron ranged from 2214 to 3405 mg/kg with no significant difference between project area and control. Iron concentrations in sediment were within geochemical background of 2% (i.e. 20,000 mg/kg) (Persaud et al.,1993). Manganese ranged from 16.24 to 34.93 mg/kg with no significant difference between project location and control. All values were within those expected in natural unpolluted sediments of 460 mg/kg. Zinc ranged from 30.96 to 186.11 mg/kg with no significant difference between project area and control. Although some concentrations were higher than the maximum reported for the Niger Delta (76.0 mg/kg-NNPC/RPI, 1985) all values were within levels in unpolluted sediments (121 mg/kg-McDonald et al., 2000). Cadmium ranged from 0.97 to 1.85 mg/kg with no significant difference between project area and control. Values were within those of previous report for the Niger Delta (BDL-8.0 mg/kg) but some concentrations were above the recommended levels in unpolluted sediment of 0.99 mg/kg. The highest cadmium level of 1.85 mg/kg was obtained in the offshore control station SWC2 indicating that activities around the proposed project area are not responsible for the observed levels. Copper ranged from 4.87 to 10.63 mg/kg with no significant difference between project area and control. Copper concentrations were generally within the recommended limits in unpolluted sediments of 31.6 mg/kg. Chromium ranged from 8.95 to 12.81 mg/kg with no significant difference between project location and control. Values were relatively higher than historical report for the Niger Delta of BDL-8.0 mg/kg but within recommended limits for unpolluted sediment of 43.4 mg/kg. Vanadium ranged from 12.35 to 15.87 mg/kg with no significant difference between project area and control.

Levels of vanadium were within those of previous report for the Niger Delta of BDL-40.8. Cobalt ranged from 12.49 to 19.76 mg/kg with no significant difference between project area and control.

Organics

Benzene, toluene, ethylbenzene and xylenes (BTEX) and Polycyclic Aromatic Hydrocarbons (PAH) were not detected in the sediments indicating absence of recent and residual petroleum pollution. Figure 4.17 shows the spatial trend of hydrocarbon levels in the study area. Total Petroleum hydrocarbons (TPH) ranged from 5.03 to 44.03 mg/kg. Total Hydrocarbons (THC) ranged from 4.78 to 39.54 mg/kg while oil and grease (O&G) ranged from 4.09 to 45.28 mg/kg. Concentrations of TPH was significantly higher at the project area ($P<0.05$) (particularly SW2 and SW3) than at the control indicating low level contamination around the proposed project area. However, the concentration of TPH was well below the stipulated limit for unpolluted sediments of 50 mg/kg indicating absence of petroleum pollution in the sediment.

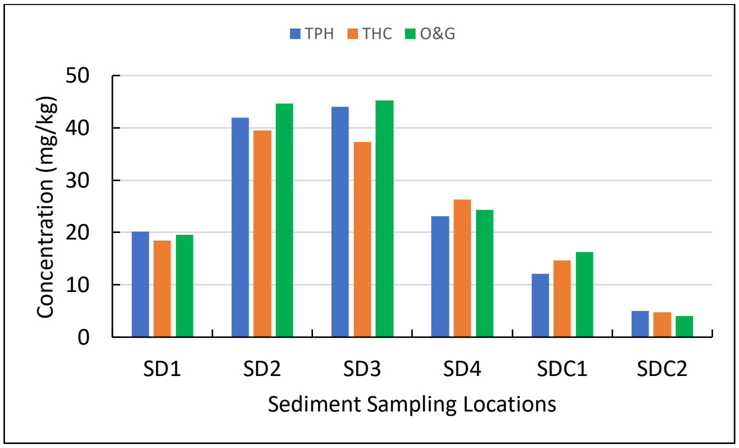


Figure 4.17: Spatial distribution of hydrocarbons in the study area (2018)

Microbiology

Total Heterotrophic Bacteria (THB) ranged from 1 to 4.7 x 104 cfu/g, HUB ranged from 0 to 1.2 x 102 cfu/g, TF ranged from 1 to 3.2 x 104 cfu/g and HUF ranged from 0 to 1.0 x 104 cfu/g. There were no significant differences between project and control in bacterial counts but fungal counts of TF was marginally higher ($P=0.055$) at control location than project area while HUF was only detected at the project area. According to Omiema and Ideriah (2012) viable bacteria in shallow surface sediments usually range in number between 109 and 1010 cells per cm3 For sea water, bacteria counts up to 109 per gram are recorded for sediments (Azam et al., 1983). Bacterial abundance is also related to the organic matter concentration and to hydrological phenomena (Azam et al., 1983). The counts of bacteria and fungi were generally low which may be attributed to low levels of organic carbon in the sediments. The distribution of hydrocarbon-utilizing microorganisms is known to reflect the historical exposure of the environment to hydrocarbons (Atlas and Barth a, 1972). The ratios of HUB to THB were very low (<<10%) suggesting absence of petroleum pollution in the sediments.

4.7.2 Trending of sediment parameters

Results of various Environmental studies for sediments at the FYIP NAG project area are presented in Appendix 9. Table 4.10 shows a comparison of sediment quality from baseline, environmental monitoring data (2001) to the present EIA (2018). Significant differences were observed in a number of parameters.

Table 4.10: Trending of Physicochemical and microbiological parameters in the FYIP NAG Field sediments

Parameters	Baseline (2001)	EE-EIA (2012)		EIA-Revalidation (2018)	EIA-Revalidation (2018)	P-value
		Dry season	Wet season	Wet season	Control	
pH	7.25±0.3a	6.27±0.62b	6.83±0.33a	6.33±0.3b	6.35±0.35b	5.97E-05
Redox (±mV)				119.48±24.51	116.68±13.19	0.700106
TOC, %		2.62±0.64	2.02±0.56	0.06±0.02	0.06±0.04	0.001113
Sodium mg/kg	877.4±511.98c	490.82±197.64c	389.85±182.44c	2488.25±290.93b	3823.5±1140.56a	0.000492
Potassium mg/kg	194.4±163.34c	249.46±91.77c	130.59±62.02c	1281.75±107.31b	1868±541.64a	0.000745
Calcium mg/kg	312.73±210.89a	144.6±45.93b	81.4±29.81b	292.07±31.09a	277.8±63.34a	0.000588
Magnesium mg/kg	999.13±506.88b	223.8±113.32c	170.88±89.45c	909.57±123.48b	1691.49±1075.52a	7.01E-05
Chloride, mg/kg				1980.75±353.44	1453.3±1051.76	0.347558
Sulphate, mg/kg				105.59±63.13	138.01±15.83	0.354539

Parameters	Baseline (2001)	EE-EIA (2012)		EIA-Revalidation (2018)	EIA-Revalidation (2018)	P-value
		Dry season	Wet season	Wet season	Control	
Nitrate mg/kg	3.71±0.39			2.32±0.32	5.05±0.18	0.001851
Carbonate, %				0.62±0.74	0.82±0.64	0.638592
Aliphatic hydrocarbon, mg/kg				26.14±9.02	7.01±3.63	0.060289
TPH, mg/kg		2.39±0.65	1.82±0.51	32.33±12.4	8.59±5.03	0.001318
THC, mg/kg				30.4±9.82	9.7±6.96	0.064078
O&G mg/kg		2.9±0.76	2.41±0.5	33.44±13.43	10.165±8.59	0.002543
BTEX, mg/kg						
Phenol, mg/kg						
PAH, mg/kg						
Cadmium, mg/kg		1.34±0.52a	0.61±0.57b	1.17±0.14a	1.41±0.62a	6.38E-07
Zinc, mg/kg	13.6±7.61c	22.62±7.99c	16.14±7.49c	63.44±22.43b	108.53±109.71a	0.000602
Iron, mg/kg		370.56±82.56	211.12±53.2	2559.75±311.82	3057±492.15	0.000147
Copper, mg/kg	3.82±2.18b	2.35±1.01b	0.68±0.63b	8.76±2.64a	8.91±0.43a	0.000686

Parameters	Baseline (2001)	EE-EIA (2012)		EIA-Revalidation (2018)	EIA-Revalidation (2018)	P-value
		Dry season	Wet season	Wet season	Control	
Chromium, mg/kg	7.46±4.01b	1.6±1.54c	0.94±1.63c	10.78±1.59a	11.72±0.54a	0.000243
Nickel, mg/kg	7.46±4.01a	1.07±0.39b	0.43±0.31b		0b	1.47E-05
Lead, mg/kg	3.63±1.3a	2.09±1.49a	0.81±0.91b		0b	0.001314
Vanadium, mg/kg	12.85±5.44a	0.01±0b		14.13±1.58a	14.26±1.93a	7.59E-07
Arsenic, mg/kg				69.55±10.88	102.39±44.95	0.001206
Mercury, mg/kg						1
Barium, mg/kg	15.17±4.86a	2.63±1.26b	0.65±0.57b			6.51E-05
Manganese, mg/kg	66.2464±21.74		55.31±17.2	19.36±2.66	31.65±4.63	0.003173
Silver, mg/kg						
Cobalt, mg/kg				15.5±3.13	16.82±1.33	0.354539
HUB, x104 cfu/g				1.04±0.04	1.2±	0.814337
THB, x104 cfu/g	3.633±0.88		3.37±0.93	1.89±1.17	4.6±0.14	0.044526
HUF, x104 cfu/g	6.752±1.99		5.45±1.57	1±		0.00229

Parameters	Baseline (2001)	EE-EIA (2012)		EIA-Revalidation (2018)	EIA-Revalidation (2018)	P-value
		Dry season	Wet season	Wet season	Control	
TF, x104 cfu/g	1.341±0.4		0.83±0.49	1.313±0.53	3.1±0.14	0.014671
SRB, x103 cfu/g	2.95±0.81		2.38±0.87			0.002155
A,b,c = significant differences. Same letters = no significant difference			Increasing Trend		Decreasing Trend	

Hydrogen ion concentration: pH decreased from a mean of 7.25 during the baseline studies to 6.33 during the present studies showing a distinct decreasing trend (Figure 4.18).

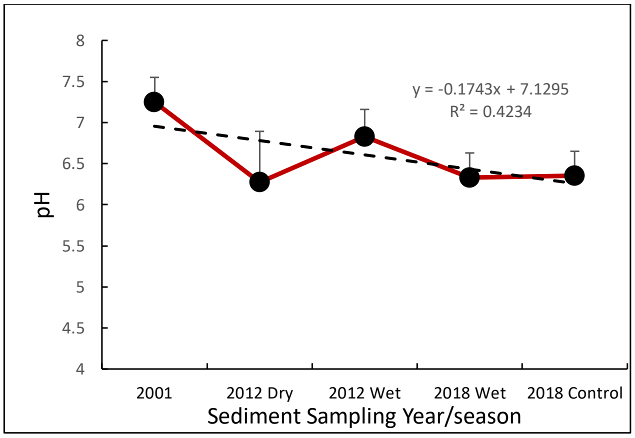


Figure 4.18: Trending of pH in the FYIP NAG field

The FYIP NAG project area operations cannot be linked to this trend since there was no significant difference between pH at the project locations compared to control during this EIA (see section 4.7.2). This trend may be linked to increasing degradation of coastal forest (e.g. clearing, dredging etc) leading to chronic discharge of humic materials and acidic muds into the coastal waters.

TOC: Total Organic Carbon, also showed a decreasing trend with lowest levels during the present EIA. (Figure 4.19). There was however, no significant difference in TOC levels between the project location and control (see section 4.7.2) indicating that the field operations are not responsible for the trend. As observed in the case of pH, the decreasing trend may be attributed to low levels of organic matter in catchment sediments eroded into the coastal waters.

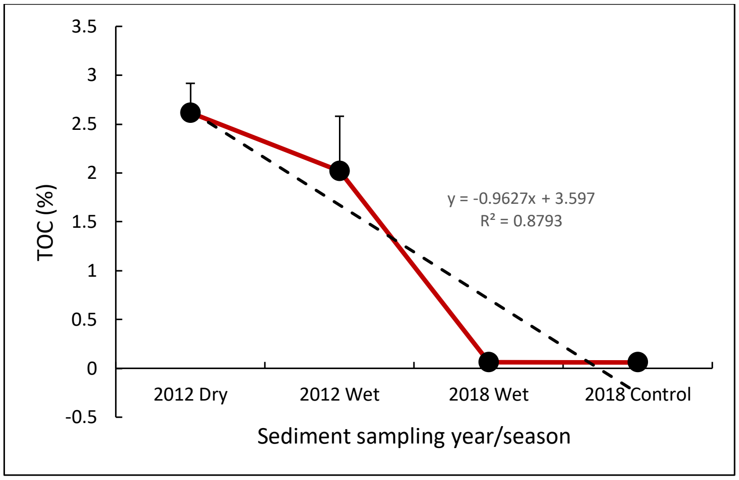


Figure 4.19: Trending of TOC in the FYIP NAG Field

Exchangeable Cations: Figure 4.20 shows the trending in sodium concentration. Potassium, calcium and magnesium all showed similar increasing trends in the present EIA following initial decreasing trends from 2001 to 2012. The increasing trend cannot be attributed to operations in the FYIP NAG field since there were no significant differences between cation levels in operation area and control (section 4.7.2). Differences in overlying water salinities due to tidal conditions during sampling campaigns in addition to local saline discharges may contribute to the observed trend.

Heavy metals: Trends in sediment heavy metals generally followed those of zinc (Figure 4.21) as observed in the trends of copper and chromium (Figure 4.22). Heavy metal levels in sediments increased markedly in 2018 following an initial decrease from baseline to 2012. Since there were no significant differences in heavy metal levels in sediment between the project location and control (section 4.7.2), the observed increasing trend cannot be linked to operations in the proposed project area. Although the levels of heavy metals were within recommended sediment guidelines (except cadmium), increasing trends in heavy metal is a cause for concern because of their persistence and toxicity and adequate attention should be paid to pollution control measures particularly during the proposed NAG well drilling.

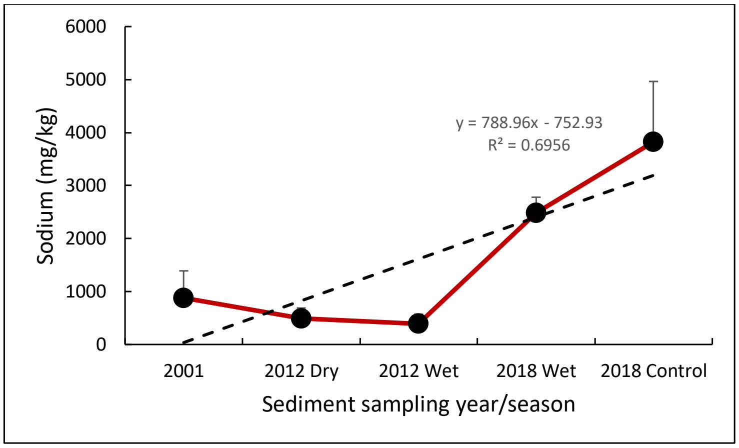


Figure 4.20: Trending of Sodium in the FYIP NAG Field sediments

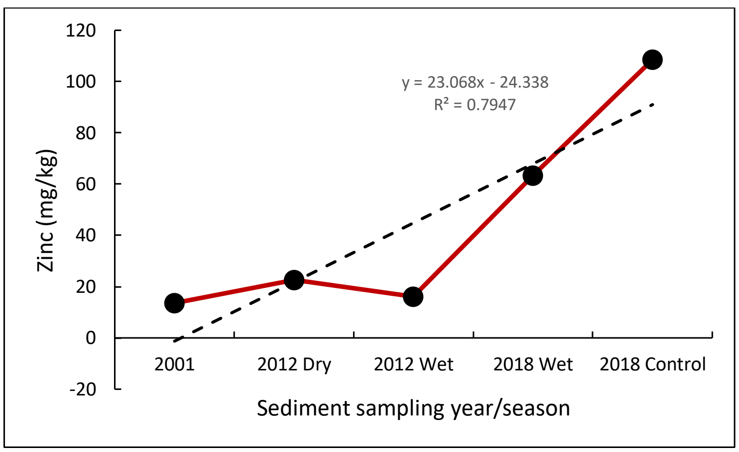


Figure 4.21: Trending of zinc in the FYIP NAG Field sediments

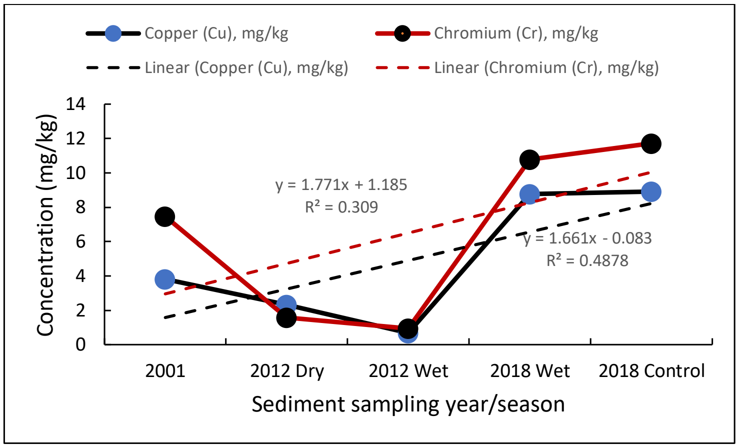


Figure 4.22: Trending of copper and chromium in the FYIP NAG Field sediments

Organics: The trending in TPH was characterized by a significant increase in 2018 compared to 2012 studies (Figure 4.23). THC and Oil and grease followed the same trends. The present EIA also showed significantly higher levels in the FYIP NAG project area compared to control (see section 4.7.2) indicating possible impact from ongoing operations around the proposed NAG well area. Such operations may include discharge of deck/ballast effluents from vessels as well as operational effluents from existing oil and gas facilities in the area. Although the present levels of TPH were within sediment quality guidelines, the increasing trend calls for close attention to pollution control measures in the area particularly with during the proposed NAG well drilling.

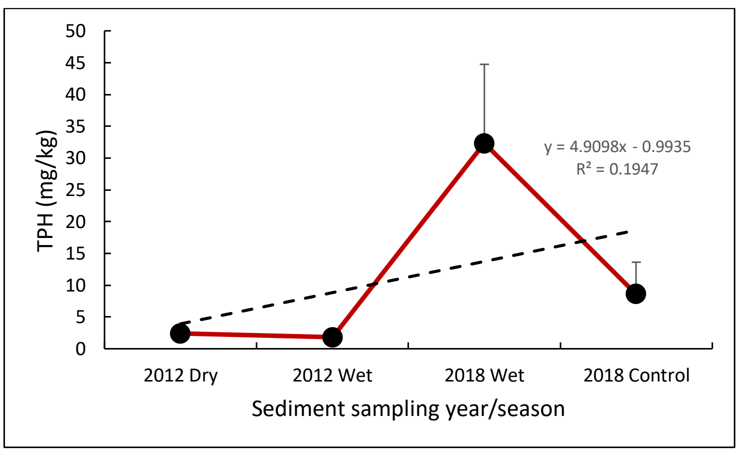


Figure 4.23: Trending of total petroleum hydrocarbons in the FYIP NAG Field sediments

Phytoplankton

The checklist of phytoplankton from the FYIP NAG field is presented in Appendix 10. Figure 4.24 shows the distribution of major phytoplankton taxa in the proposed project area and control. The phytoplankton was represented by five major families namely: Bacillariophyta, Cyanophyta, Chlorophyta, Dinophyta and Euglenophyta which conforms with other reports in Nigerian waters (Chowdhury, 2007, Nwankwo et. al., 2008, Akoma and Opute, 2010).

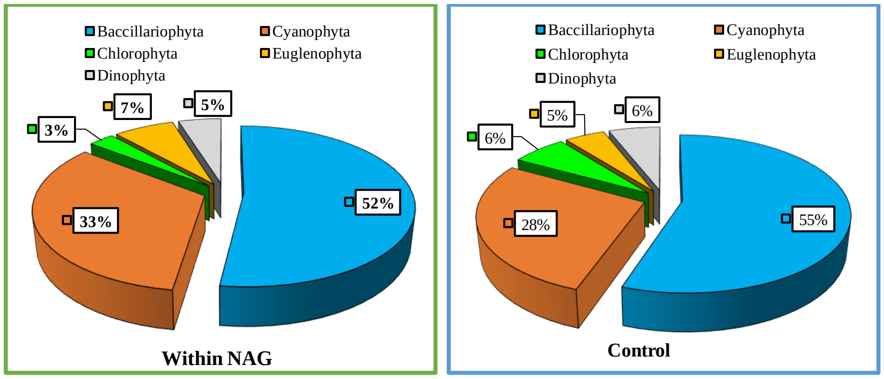


Fig 4.24: Percentage relative abundance of phytoplankton

Baccillariophyta was the most dominant taxon constituting 52% of the total phytoplankton density in the project area and 55% in the control. Diatom dominance in phytoplankton of Nigerian waters is widely reported (Akoma and Opute 2010, Dike and Adedolapo 2012). The major species of Bacillariophyta include Pleurosigma angulatum (3.28%), Pinnularia interrupta (2.25%), Thalassiosira sp. (1.23%), Cymbella ovals (1.94%) and Cyclotella meneghianina (1.86%). The dominance of diatoms is usually considered an indication of unpolluted waters.

Cyanophyta was the next dominant family after Bacillariophyta, with 28 species making up 33% of phytoplankton in the project area and 28% in the control. The Cyanophyta was dominated by Oscillatoria pseudominma. (2.05%), Oscillatoria limosa (2.02%), Oscillatoria princeps (2.00%), Phormidium forseolarum (1.92%), isocystis planktonica (1.92%), Oscillatoria terebriformis (1.61%) and Merismopedia elegans (1.59%).

The spatial variation in total phytoplankton density and species count are presented in Fig 4.25. Phytoplankton density varied between 1932 cells/l in station SW 2 to 2347 cells/ml in SW 4 at the project area and from 2373-3224 cells/l at the control. A total of eighty-seven (87) species of phytoplankton were recorded in the project area (Appendix 10) ranging from 56 species in station SW3 to 64 species in SW4 with no significant difference between project location and control.

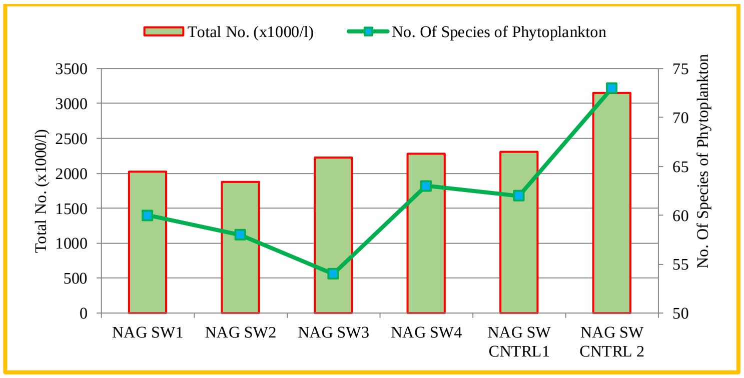


Fig 4.25: Variation in phytoplankton density and species count in the FYIP NAG field

Margalef's index of species richness ranged from 7.114 to 8.112 in the project area and 7.977-9.036 in the control while Menhinick's diversity index ranged from 1.173 to 1.342 in the project area and 1.293-1.303 in the control (Figure 4.26). The lowest indices of Margalef and Menhinic occurred in SW3 in the project area. The Shannon Weiner Index ranged from 3.819-3.993 in the project area and from 3.937-4.104 in the control with no significant difference between project location and control. Shannon's index (H_) encompasses species richness and spices evenness components as overall index of diversity. The higher values of Shannon's Index (H_), indicated the greater species diversity. In Shannon Wiener legislation, the aquatic environment is classified as – very good when H´ is > 4, good quality 4- 3, moderate quality 3-2, poor quality 2-1 and very poor quality <1 (Ashutosh et al., 2010). This index also determines the pollution status of a water body. The values of the index greater than 3 indicate clean water; 1-3 indicate moderate pollution and value less than 1 are characterized as heavily polluted (Wilham and Dorris, 1968) indicating that the surface water of the project area and control were not polluted.

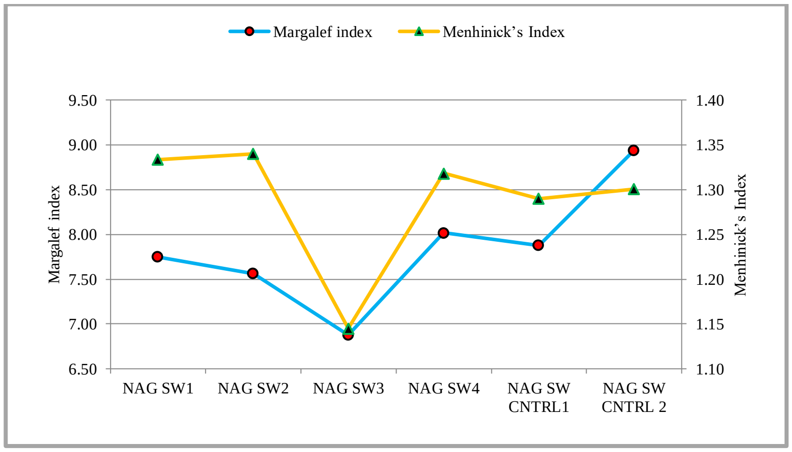


Fig 4.26: Variation in phytoplankton species diversity indices of in the FYIP NAG field

Zooplankton

Zooplankton Abundance: A checklist of the zooplankton species in the study area is presented in Appendix 11. The zooplankton belonged to six (6) taxa namely; Copepoda, Hydrozoa, Mollusc larvae, Decapod larvae, Rotifera, and Chaetognatha. (Appendix 11, Fig 4.27). The percentage composition of zooplankton taxa is presented in Fig 4.27. Rotifera were the most dominant with 12 species accounting for 33% of the zooplankton in the project area and 32% in the control. Most dominant members of the rotifers included Lecane climacois (6.14%), Kelicottia longispina (4.78%), Monomaratta longiseta (4.02%), Euchlanis dilatata (3. 56%) and Keratella testudo (3.11%).

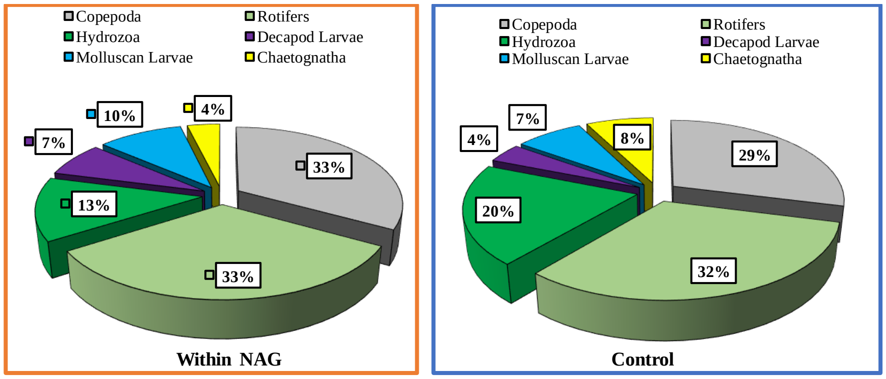


Fig 4.27: Relative Abundance of zooplankton in NAG and control

Copepods were the second in dominance with 14 species including Cycopina longicornis (5.91%) Scaphacalanus magus (5.08%), Calanus finmarchicus (3.49%), Copila mirabilis (2.96%) and Euchaeta marina (2.89%)

Spatial variation in zooplankton density in the study area is presented in Fig 4.28. The lowest zooplankton density of 262 cells/ml was recorded in SW 4 and the highest count of 417 cells/ml was recorded SW 2 within the project area with no significant difference between project area and control.

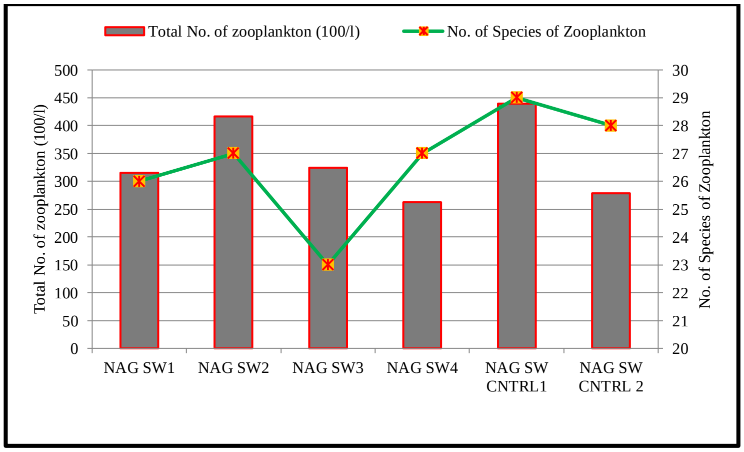


Fig 4.28: Variation in zooplankton density and number zooplankton species of zooplankton

Figure 4.28 also shows the variation in number of species of zooplankton in the study area. Species number ranged from 23 to 28 in the project area and 26 to 29 in the control with the control showing a marginally significantly higher species number than project area. According to GESAMP (1993), UNEP (1990), Nwankwo (1993) and Davies et al. (2009) density and diversity of zooplankton are governed by a number of factors which include high influx of allochthonous and autochthonous materials within zooplankton grazing area.

Figure 4.29 shows the variation in Margalef's and Menhinick's diversity indices. Margalef's index ranged from Margalef's index varied form 3.804 – 4.669 in the project area and 4.442-4.6 in the control with no significant difference between project area and control. Menhinick's index ranged from 1.276 to 1.668 in the project area and from 1.383-1.559 in the control. The Shannon Weiner Index ranged from 2.775 to 3.08 in the project area and from 3.031 to 3.098 in the control with no significant difference between project location and control. Based on the Shannon index, with values ranging from 2 to 3, the water may be classified as moderately polluted in the project area and unpolluted in the control.

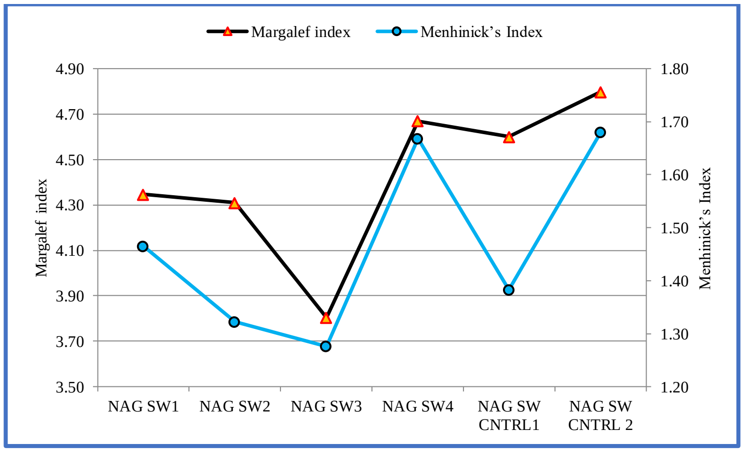
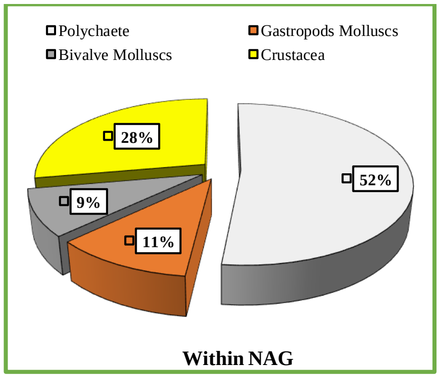


Fig 4.29: variation in diversity of zooplankton in study area

Benthos

The benthos of the study area was composed of a total of fifty-four (54) organisms in the project area and 27 organisms in the control. Benthic fauna were largely larval forms including, polychaetes, crustaceans, gastropod and bivalve molluscs. The polychaetes with a relative abundance of 52% were the most dominant in the project area and while crustaceans with an abundance of 41% were dominant in in the control (Fig 4.30, Appendix 12). Dean (2009) has reviewed the use of polychaetes as indicators of pollution in aquatic environment and has shown that they are very important indicators of organic enrichment, heavy metals and hydrocarbons. Their dominance in the project area may be an indication of a relatively more polluted sediment conditions compared to the control.



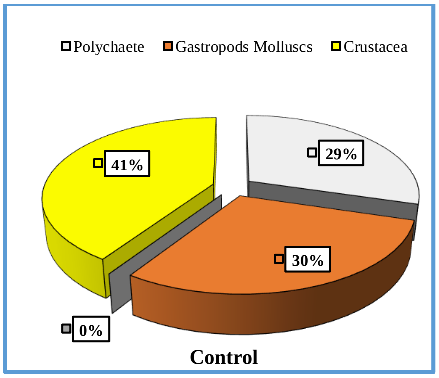


Fig 4.30: Relative Abundance of benthos in study area and Control

The spatial variation in the density of benthos in the study is presented in Fig 4.31. Benthic faunal density varied between 11 and 15 organisms/m2 in the project area and between 12 and 15 organisms/m2 in the control with no significant difference between project area and control. Similar densities for macro-benthic organisms in Niger Delta have been reported (Victor and Ogbeibu, 1985; Olomukoro and Ezemonye, 2007; Emere and Nasiru, 2008).

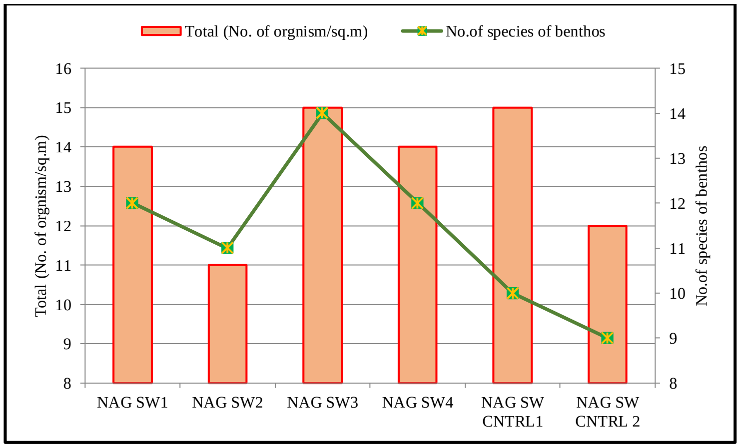


Fig 4.31: variation in density of benthos in the FYIP NAG field (2018)

The community structure of benthos as estimated using the Margalef's and Menhinick's diversity indices are presented in Fig 4.32. The Margalef's diversity ranged from4.168-4.801 in the project area and from 3.219 to 3.323 in the control. Menhinick's index ranged from 3.207 to 3.315 in the project area and from 3.582-3.598 in the control with no significant differences between project area and control. The Shannon Weiner Index ranged from 2.441-2.616 in the project area and from 2.138 to 2.154 in the control with no significant difference between project location and control. The range of Shannon indices is indicative of moderately polluted sediment conditions.

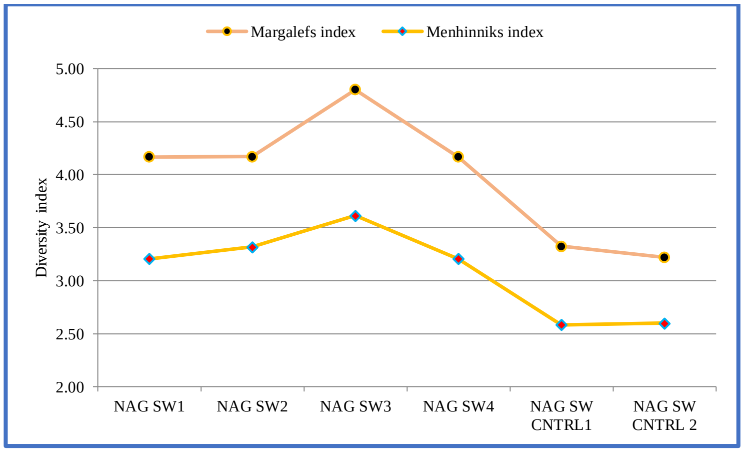


Fig 4.32: Variation in Margalef's and Menhinick's indices in the FYIP NAG field (2018)

Generally, the Margalef and Menhinic indices were closely related showing lowest values for phytoplankton and zooplankton at SW3 and highest values of macrobenthos at the same station a possible indication of the pollution status of the station. Since the macrobenthos was dominated by polychaetes in the project area, it follows that station SW3 may be the most contaminated sediment in the study area. Station 3 sediments had the highest levels of TPH, zinc, copper, chromium and lowest level of TOC.

Fisheries

Fishes of the study area include both fin and shell fishes. The shellfishes include the crustaceans namely, blue swimming crab (Callinectes spp.), the mangrove swamp crabs (Cardiosoma sp and Sesarma sp), the shrimps (Penaeus notialis, Parapaeneopsis atlantica and Palaemonetes africanus) and prawns (Macrobrachium spp. and Nematopalaemon hastatus). The molluscs include cockles (Senilia senilis), whelks (Thais sp.), oysters (Crassostrea gasar) and the periwinkles (Tympanotonus fuscatus and Pachymelania aurita). The fin fishes include bonga fish, croakers, gobies, groupers, grunts, snappers, sole, shad, mullets and tilapias. Fishes such as the bonga-Ethmalosa fimbriata migrate along the nearshore-inshore axis in relation to changes in salinity, food availability and age.

Fishing gears of the area are many and varied, but commonly include gillnets, tow nets, cast nets, beach seines, lift nets, traps, hooks and lines, fences and stakes. Fishes are processed for preservation by gutting or merely washed in water for smoke-drying.

4.8 Vegetation Study

The study area is located within the western coastal plain of the Niger delta and is covered by the wetland vegetation ecosystem. It is situated close to a state level conservation area, Uremure Yokri forest reserve, which is near Yokri-Sobo (UNDP, 2010). This terrain is characterized by a long rainy season from April through October and is rated as one of the wettest areas in Africa (Barbour et al., 1982); the study area is set on the sea coast (Plate, 4.1).

The study area is covered by two major types of wetland forests:

- The Tropical fresh water swamp, and
- The Mangrove swamp forest.

4.8.1 Freshwater Swamp Forest

The freshwater swamp is the dominant vegetation cover in the study area extending from Yokri to Sokebolou and Ogbotobo, and parts of Forcados.

Structure

Plate 4.1 provides a panoramic view of the swamp forest in the study area. The physiognomy of the fresh water swamp vegetation in the study area is varied and at different stages of re-growth and maturity. It varies from the secondary stage forests (55%) through the secondary forest regrowths (20%) and swamp forest regrowths (35%). Generally, the secondary forest reveals a vertical forest profile that is fairly differentiated into two distinct strata, the canopy strata and the emerging strata; and is very visible around the VG 31, 33, 35 area (Plate 4.1). Here the canopy layer is dense with a vegetation cover of between 75 - 85%; the vegetation is of an average height of about 20 meters. Emerging above the forest canopy are fairly scattered trees reaching up to a height of about 26 meters.

The structure of vegetation can also be described based on the Raunkiaer life form classification system (1934). This system places emphasis on the form, and the dominance of the life forms of the plants present in a given vegetation system thus providing insight into the adaptation patterns, climate, terrain, and forest physiognomy. The life form spectrum of mature vegetation in the fresh water swamp of the study area, generally, indicates that the dominant life form is mesophanerophyte (80-90%) while nanophanerophytes (<2 meters height) makes up to 10% of the vegetation represented by the shade loving ferns, and hydrophytes including Cyrtosperma senegalensis, and Sagittaria sagittifolia (Plate 4.2). Epiphytes are also present on most of the palm trees dominated by tree ferns. Tree density reaches 900 trees/ ha. The forest floor was found to be more or less flooded during most parts of the year particularly in wet season. This is attributable to the low-lying terrain, abundant rainfall and numerous small streamlets that supply the terrain and establish the prevailing hydrologic regime.

There is a very low tree density (140 – 170 trees/ha) in areas of regrowth, and a more or less open forest canopy. In these areas, the shrub layer is dominated by shrubs and aquatic macrophytes. Vegetation cover density however is over 75% in most places.

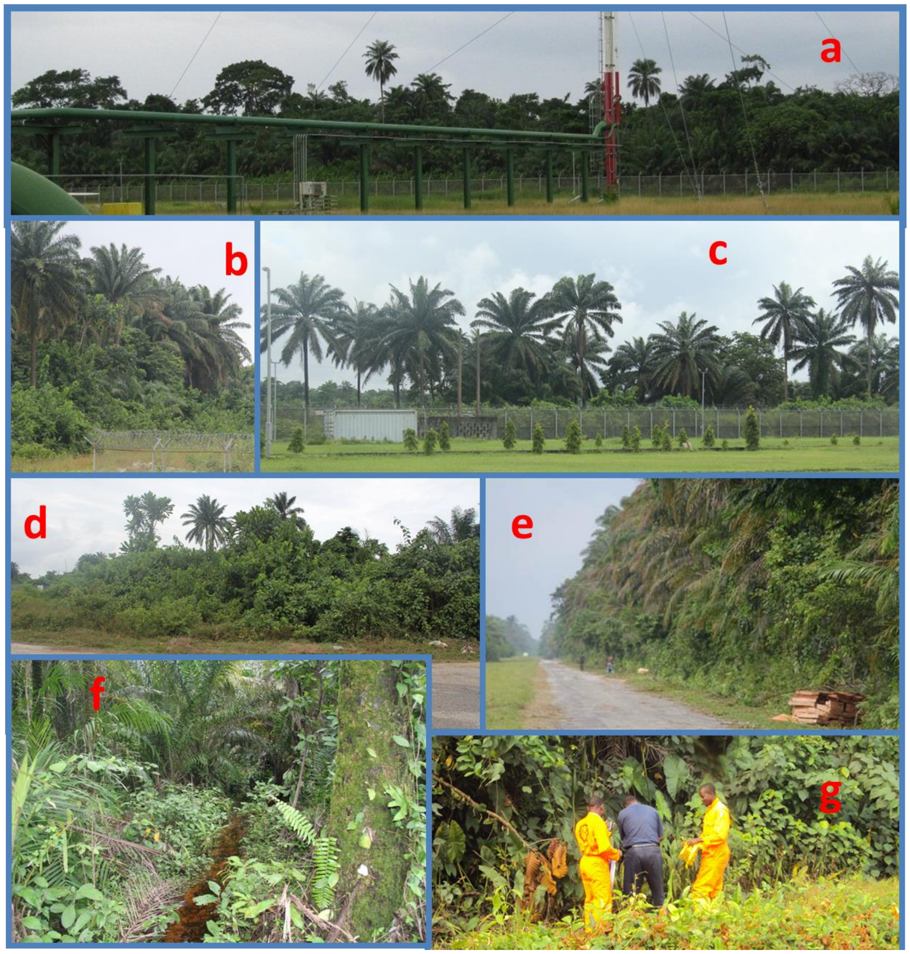


Plate 4.1: A Panoramic View of the Fresh Water Vegetation Cover in the Study Area: (a) VG 31; (b) VG 27; (c) VG 28; (e) VG 35; (f), (g) Swamp Forest Floor at Yokri.

Floristic Composition

A total of 33 species belonging to 23 families where identified in the forest. A species check list and classification is presented in Table 4.11. Due to this swampy terrain, it is common to find tree species possessing plank-like buttresses, stilt roots, or elaborate fibrous root system which help them to anchor on the swamp. This swamp however is observed to be palm (Elaeis guineensis) dominated (Plate 4.3a-e). Among the few emergent species are: Albizia adianthifolia, Uapaca guineensis, Cyclodiscus gabonensis, Pycnanthus angolensis, Dracaena mannii, and Alstonia boonei. A few oil palms are also seen emerging above the swamp forest canopy. Very common canopy tree species include Alstonia boonei, Ceiba pentandra, Lophira alata, Anthocleista djalonensis, Cleiostopholis patens, Fleroya ledermanii, and Cynometra megalophylla. Others are Cola sp., Tricoscypha arborea, Symphonia globulifera, Chytranthus talbotii, Terminalia superba and Musanga cecropioides. The shrub layer is dominated by Alchornea laxiflora (especially in forest gaps and margins), and saplings of tree species especially Alstonia boonei. Epiphytes such as Asplenium africanum, Nephrolepis biserrata, Diplazium sammatii grow on the forest trees along with other tree fern, while Cyrtosperma senegalensis and Sagittaria sagittifolia are among the hydrophytes on the swamp floor.

Table 4.11: Check List of Species in the Estuarine Water Swamp Vegetation Ecosystem.

SPECIES NAME	COMMON NAME	FAMILY	ECONOMIC VALUE
TREES			
Elaeis guineensis	Oil Palm	ARECACEAE	Palm Oil, Kernel Oil, Palm Kernel cake, fibre for domestic handicraft
Alstonia boonei	Stool wood	APOCYNACEAE	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.
Anthocleista vogelii	Cabbage tree	GENTIANACEAE	
Schummaniophyton magnificum		RUBIACEAE	Antivenom
Cynometra megalophylla		CAESALPINIOIDEAE	

SPECIES NAME	COMMON NAME	FAMILY	ECONOMIC VALUE
Albizia adianthifolia		LEGUMINOSAE	Bark medicinal; arthritis, rheumatism; wood: construction
Uapaca guineensis		EUPHORBIACEAE	Red cedar, false mahogany, Sugar plum. Commercial hard wood durable. Edible sugary fruits: monkey delicacy; root aphrodisiac, rheumatism, and piles.
Cyclodiscus gabunensis		LEGUMINOSAE	Leaf: concoction for treating inflammation of the vagina and uterus.
Pycnanthus anglolensis		MYRISTICACEAE	Medicinal: Skin infections; seed: spice/additive; Leaves and stem: Diabetes 1 & 2. Bark decoction: treat wound, arthritis, leprosy, stomach ulcer, and antidote for poisoning.
Dracaena mannii		AGAVACEAE	Source of Dyes and stains
Ceiba pentandra		BOMBACACEAE	Soft wood: Carvings, light construction, ply wood, veneer, particle boards, hand dug canoe ; Kapok; bee tree; Medicinal: in preparations for leprosy, Dysmenorrhoea, hypertension, fever,

SPECIES NAME	COMMON NAME	FAMILY	ECONOMIC VALUE
			wound healing, and hypertension.
Lophira alata		OCHNACEAE	Commercial Hard wood: One of the hardest and most resistant wood species
Anthocleista djalonensis		GENTIANACEAE	Cabbage tree: abortifacient, skin infections, antipyretic, antidotes
Cleistopholis patens		ANNONACEAE	
Fleroya ledermanii		RUBIACEAE	Furniture, pulp and paper making.
Cola spp.		STERCULIACEAE	
Tricoscypha arborea		EUPHORBIACEAE	Fuel wood, and poles.
Musanga cecropioides	Umbrella tree	EUPHORBIACEAE	Medicinal: leprosy
Terminalia superba		COMBRETACEAE	Timber
Symphonia globulifera		CLUSIACEAE	
Chytranthus talbotii		SAPINDACEAE	
Funtumia elastica	Lagos rubber	APOCYNACEAE	
SHRUBS			
Alchornea laxiflora		EUPHORBIACEAE	

SPECIES NAME	COMMON NAME	FAMILY	ECONOMIC VALUE
Coffea canephora	Wild Coffee	RUBIACEAE	Coffee beans
HERBS			
Aframomum spp		ZINGIBERACEAE	
Costus afer		ZINGIBERACEAE	
Maranthocloa purpurea		MARANTHACEAE	
AQUATIC MACROPHYTES			
Cyrtosperma senegalensis		ARACEAE	
Sagittaria sagittifolia		ARACEAE	
Nymphaea lotus	Water lilly	NYMPHAEACEAE	
FERNS			
Asplenium africanum		ASPLENIACEAE	
Nephrolepis biserrata		DRYOPTERIDACEAE	
Diplazium sammatii		ATHYRIACEAE	

4.8.2 Mangrove Vegetation

This kind of vegetation cover is observed mostly west of the Forcados tank farm. Mangroves are naturally near homogenous vegetation systems. They are adapted to the hostile environmental conditions characterized by variable salinity, hypoxia (oxygen deficient), waterlogged soil strata, tidal pressures, strong winds and sea waves. Such adaptations include possession of Stilt roots for anchorage; prop roots, and root pneumatophores for dealing with anaerobic mud conditions, and lenticels on the bark to aid aeration; high water retention in succulent leaves to keep salt levels diluted; rhizofilteration to exclude salt during uptake of water; possession of salt glands for secretion/excretion of salt onto their leaf surfaces, or bark, or accumulating salt in older leaves which are discarded as leaf abscission takes place (Liang Shan, et al., 2008). The combination of these mechanisms differs from one species to another. Mangroves are among the most productive terrestrial ecosystems, sustain a huge hydrobiological system and play a very important role in stemming coastal erosion and land formation; as well as providing the quiet back waters for spawning of many marine species.

Vegetation Structure

The vegetation structure is differentiated according to the peculiar nature of the terrain at the sites sampled; varying from the wet to the drier areas. The microphanerophytes constitute over 70% of the vegetation in the areas around VG 6 and 3 while in others, the nanophanerophytes make up to 80% of the vegetation at VG 4. There is an almost even distribution of these life forms in the area around VG 9. Several plants association occur within the mangrove tidal/non-tidal, and transitional dry habitats found within the study area. A total of 20 plant species belonging to 10 families were identified and in the study area (Table, 4.29). There are two major vegetation systems in this area:

Mangrove Hinterland Vegetation

The mangrove hinterland represents the early stages of terrestrial systems. It is a transition zone between purely mangrove species and terrestrial species. Based on the extent and duration of flooding, there are two sub-systems: the low/intermediate and the dry areas; both of which are observed to be present.

Plate 4.2. (a): Basin Forest; (b-d): Mangrove Hinterland Vegetation Found in the Study Area.

A mangrove hinterland vegetation system is present at the south bank area at VG 6 (Plate, 4.4). The prominent community here consists of two dominant species, the shrubby herb Acrostichum aureum, occurring in association with Black mangrove trees (Avicennia germinans). They are either very gregarious in occurrence, or in near even distribution; the terrain is nearly always dry with mud flats in some areas. The upper canopy of black mangroves reaches an average height of 12 meters. While the lower canopy of herbaceous plants (Acrostichum aureum) reaches a maximum height of 1.5 meters. The overall vegetation cover is over 80%. This terrain is interspersed by bare flats. Other opportunistic species present here include the facultative hydrophytes: Rhynchospora corymbosa and Ludwigia abissinica on extended areas on the margins.

At a higher stage of succession is the coastal mangrove thicket observed at VG 6 and 3 (Plate, 4.4c,d) and around VG 5 (Plate, 4.4a). Vegetation cover is over 70% with plants height in the range of 1.7– 3.5 meters. Species here are mangrove associates dominated by Chrysobalanus icaco var. orbicularis and include thickets of Hibiscus tiliaceous and Dalbergia ecastaphylum. Other common species include Phoenix reclinata, Dactyladenia barteri, Chytranthus talbotii, the liane Tetracera alnifolia, and Cyperus squarrosus. Avicennia spp and Elaeis guineensis found in this location are reaching heights of 12 meters around VG 5 (Plate, 4.3). Around VG 8 the black mangrove occurs in association with Laguncularia racemosa; this forest is fringed by the mangrove thickets (Plate 4.3); with average tree height of 13meters and tree density of 625 trees/ ha.

The Fringe Mangrove Swamp Forest

This vegetation type is characterised by the dominance of Rhizophora racemosa and is very similar to the vegetation around VG 7 near a perennial pond with more less brackish water supply (Plate, 4.4). The average height of the vegetation is 10 meters. Other mangrove species present include the mangrove grass (on the mudflats that intersperse the water body), mangrove fern, and the invasive Nypa fruticans. Opportunistic species here include Machaerium lunatum, Anthocleista nobilis, and the facultative aquatic macrophyte Nymphaea lotus.

Coastal Scrub-Shrub Forests

Tidal Salt Water Scrub-Shrub: Tidal areas dominated by halophytic shrubs or immature trees that are less than 6 meters. Vegetation is composed of halophytic species, mainly shrubs and other herbaceous species (FGDC, 2012). The water in this system is stagnant or just very slowly flowing. This is a back-swamp basin forest dominated by dense stands of salt-tolerant plants such as herbs, grasses, or low shrubs (Adam, 1990). This herbaceous vegetation was observed at VG 4, south bank, as a near homogenous population of Acrostichum aureum. (Plate, 4.4). Average height of the vegetation is about 1.6 meters and vegetation cover is over 85%. A few stands of Rhizophora spp are sparsely scattered across the vegetation with a density of 8 trees/ ha.

Dwarf Mangrove: Tidally influenced, dense, tropical or subtropical areas dominated by dwarf or short mangroves (and associates) that are generally less than 6 meters in height. Areas characterized by tall mangroves (> 6 meters) are placed in the Tidal Mangrove Forest Biotic Group (FGDC, 2012). The intertidal Mangrove forest is found around VG 4 (Plate, 4.4). The dominant species is Rhizophora mangle and terrain is perennially flooded with a variable depth reaching 0.6

meters. The height of the vegetation reaches 3 meters and species density is an average of 625 trees/ ha.

Table 4.12: Check List of Plant Species in the Mangrove Vegetation Ecosystem

	Habitat	Species	Family
A	DWARF MANGROVE VEGETATION		
	Dominant	Rhizophora mangle	RHIZOPHORACEAE
	Tidal Salt water Scrub-Shrub		
	Dominant	Acrostichum aureum	PTERIDACEAE
		Rhizophora spp	RHIZOPHORACEAE
B	FRINGE MANGROVE (Brackish Tidal)		
	Dominant	Rhizophora racemosa	RHIZOPHORACEAE
	Associates	Acrostichum aureum	PTERIDACEAE
		Paspalum vaginatum	POACEAE
	Opportunistic spp	Machaerium lunatum	FABOIDEAE
		Anthocleista nobilis	GENTIANACEAE
		Nymphaea lotus	NYMPHACEAE
	Invasive spp	Nypa fruticans	ARECACEAE
C	MANGROVE (Hinterland Forest)		
	Dominant	Avicennia germinans	AVICENNACEAE
	Dominant	Acrostichum aureum	PTERIDACEAE
	Facultative hydrophytes	Rhynchospora corymbosa	CYPERACEAE
		Ludwigia abissinica	ONAGRACEAE
	Coastal Bush		
		Chrysobalanus icaco var. orbicularis	CHRYSOBALANACEAE
		Hibiscus tiliaceous	MALVACEAE
		Avicennia germinans	AVICENNACEAE

	Habitat	Species	Family
		Dalbergia ecastaphylum	FABOIDEAE
		Phoenix reclinata	ARECACEAE
		Dactyladenia barteri	CHRYSOBALANACEAE
		Chytranthus talbotii	SAPINDACEAE
		Tetracera alnifolia	DILLENIACEAE
		Cyperus squarrosus	CYPERACEAE
		Elaeis guineensis	ARECACEAE

Plate 4.3: A Cross Section of the Different Mangrove Swamp Vegetation Community in the Study Area Around South Bank and Focardos. (a) VG 5; (b) VG 4; (c) VG 8, (d), (e) VG 7.

Bush Fallow Vegetation

Bush fallow secondary vegetation and farmlands vegetation types occur in dredged areas, cleared areas and in the Community. This bush fallow / farmlands vegetation type is characterised by grasses, herbs and few scattered tree crops. The floristic composition consists dominantly of Alchornea cordifolia (Christmas bush), Phyllanthus discoides, Rauvolfia vomitoria, Chromolaena odoratum (Awolowo plant), Pennisetum purpureum (Elephant grass), Musanga cecropoiodes

(Umbrella tree), Elaeis guineensis (Palm oil trees),Mangifera indica (Mango), Cocos nucifera (Coconut tree). Aspilia africana, Sida acuta, Calopogonium mucunoides, Sporobolus pyramidalis, Chloris pilosa and Paspalum vaginatum, Aframomum sp., Costus afer., Dalbergia sp.

The vegetation types were same for both dry season and wet season. The height of these plants generally ranged from <1 m to 3 m. The life-form spectrum shows high incidence of nanophanerophytes, chamaephytes, hemicrytophytes and cryptophytes (Plate, 4.5). The bush fallow type is common around Youbebe. Major food crops in the community are cocoyam (Colocasia esculenta), Yam (Dioscorea spp), and plantain (Musa paradisiaca) (Plate, 4.5).

Plate 4.4: (a) Bush Fallow (b) Common Fruit Trees in the Community.

Ethno-Botany and Dynamics of the Vegetation System.

The vegetation cover of the study area is interspersed by Community in a linear manner along the road that cuts through the vegetation linking Yokri and North bank areas. Forests have always been a source of vital resources for humans and this can be unique to specific civilisations based on the indigenous culture and appreciation of the values of the species present in the vegetation system around them. The structure of the forests is thus closely linked to forest resource utilisation patterns particularly the extent to which they interfere with the integrity of the vegetation system. This information is drawn up from the focus group discussions and physical observations during the field survey. Plate 4.6 shows the evidence of lumbering activities which also accounts for the extent of degradation observed in the vegetation cover especially in the freshwater swamp regrowth.

Plate 4.5: Lumbering and Logging Activities

Although the entire island towards Yokri and North Bank, has been designated as 'Uremure yokri forest reserve', the lumbering and denudation of the forest cover of timber species like Uapaca guineensis, Lophira alata, and Alstonia boonei, continues to be of critical implications on the structure of the forest and accounts for gaps in the forest canopy driving a change in primary species composition (Plate, 4.4c,d). The mangrove forest in the area is observed to be the source of wood for domestic fuel and sustaining the local fish processing industry; this unregulated harvest of mangrove twigs (Plate 4.4b) also critical to the structure and stability of the mangrove high marsh areas.

4.8.5 Phyto-pathological Studies

The disease symptoms and microorganisms isolated from diseased plants from the study areas for the two sampling seasons are presented in Table 4.12. Visual and on-sight pathological assessment of the area showed that leaf spots were the most dominant disease symptoms affecting several plants. Laboratory pathological analysis showed that several organisms are associated with these symptoms. Generally, fungal diseases were most prevalent.

The diseases observed on the crops and plants species are comparable for the two seasons; both in nature and severity though more fungal genera were recorded during the rainy season studies. This may be due to the high humidity during the season, which favours fungal growth. The state of health of the overall vegetation appeared normal. None of the diseases isolated were unusual to the plant species. There is no evidence of endemic vegetation problems in the area. However, it is noteworthy that the cassava mosaic virus and such fungal pathogens as Phomopsis sp., Fusarium sp., Cercospora sp., Mycosphaerella sp. and Colletotrichum sp., were isolated from some species.

Table 4.12: Diseases of Some Crops and Plants Within the Area, and Causative Agents

Plant part Sampled (leaves)	Disease Symptoms	Organism (s) Isolated
Elaeis guineensis	Leaf spot Cercospora elacidis	Aspergillus spp.
Musa paradisiaca	Leaf spots.Marginal leaf scratching andchlorosis	Fusarium spp. Probable mineral deficiency
Musa sapientum Sigatoka	leaf spots	Fusariumspp. Probable mineral deficiency
African cassava	Mosaic virus.	Curularia spp., Aspergillus spp.
Alchornea cordifolia	Dark, sunken necrotic patches and leaf spots.	Colletotrichum spp., Aspergillus flavus,
Raphia hookeri	Black leaf spots	Fusarium spp., Aspergillus spp., Penicillium spp.
Cola Sp.	Powdery mildews, Leaf spot	Podosphearia spp.

Plant Tissue Analysis

Table 4.13 shows the level of heavy metals (Cd, Cu, Fe, Mn, Ni, Pb, and Zn) in plant leaves. The concentration of iron in the leaves ranged from 30 – 188 mg/kg with an average of 110.34 mg/kg; these concentrations are well below the critical levels for Iron in plant leaves (300 – 500mg/kg), (Dobermann and Fairhurst, 2000). The average level of Zinc is 44.82 mg/kg, which is within the normal level (12 – 60 mg/kg) in plants (Alloway, 1995). Toxic levels were observed in samples taken from VG 28 and VG 32, both in Yokri.

Copper levels ranged from 0.75 – 22 mg/kg; the average was 4.57 mg/kg in plant tissue all within the normal range of 5 – 12mg/kg (Fifield and Haines, 2000). Manganese was present in the leaves sampled, at an average concentration of 90.19 mg/kg, and a range of 20 – 260 mg/ kg. It is the sample, VG 50, from Ogbotobo I that had a concentration of 260mg/kg, falling outside the range for normal concentrations (20 – 240 mg/kg) (Dobermann and Fairhurst, 2000). Cadmium levels were below 0.01 mg/kg in all the samples from outside Youbebe while the samples from Youbebe had levels between 0.02 – 0.04 mg/kg well below the critical level for plant concentrations (5.30 mg/kg, Alloway, 1995). Nickel levels ranged from 0.01 – 0.3mg/kg averaging 0.06 mg/kg in tissues sampled; and were below detectable levels in only 3 samples from some parts of Ogbotobo I and Yokri; however, these levels where well below the toxicity level in plants. Lead had average concentration of 0.14mg/kg in leaves with a range of 0.01 – 0.5mg/kg well below the toxic level in plants; however concentrations were below 0.01 mg/kg randomly in 8 samples.The results for phytochemical screening therefore shows that there wasn't toxicity in the plants of the study area.

Table 4.13: Concentration of Heavy Metals in Foliar Samples of Plants in the Study Area

Sample Number	Identity of Plant species	Heavy Metal and their Concentrations (mg/Kg)						
		Fe	Zn	Cu	Mn	Cd	Ni	Pb
Sample 1	Alchornia cordifolia-– Yobebe	139	25	2.5	72	0.02	0.02	0.50
Sample 2	Elaeis guineensis- – Yobebe	188	20	3	115	0.02	0.02	0.35
Sample 3	Manihot esculenta- SB/FS	105.6	22	2.4	98	0.04	0.06	BDL
Sample 6	Musa sapientum- – Yobebe	130.4	18	1.3	60	0.02	0.02	0.01
Sample 7	Panicum maximum- Forcados	154.2		0.75	90	BDL	0.08	BDL
Sample 8	Chromoleana odorantum Forcados	83.2	50	4	25	<0.01	0.04	0.01
Sample 11	Psidium guajava (Guava) - Forcados T.	55.3	25	3	20	0.01	0.02	0.06
Sample 12	Elaeis guineensis- Forcados T	60.0	20	8.5	50	<0.01	0.02	0.02
Sample 13	Mangifera indica – Forcados	165.1	20	4	95	0.01	0.01	0.06
Sample 17	Elaeis guineensis- NB	30.0	35	3	50	<0.01	0.03	0.3
Sample 18	Alchornia cordifolia- NB	169.0	55	4	125	0.01	0.01	0.2
Sample 19	Elaeis guineensis- NB	165.5	43	22	30	<0.01	0.01	0.07
Sample 21	Manihot esculenta Ogbotobo 1	74.9	30	5	175	BDL	0.05	<0.01
Sample 22	Musa sapientum- Ogbotobo 1	160.0	30	3	90	BDL	<0.01	0.05
Sample 23	Cocos nucifera – NB area	100.5	45	4	125	BDL	0.02	<0.01

Sample Number	Identity of Plant species	Heavy Metal and their Concentrations (mg/Kg)						
		Fe	Zn	Cu	Mn	Cd	Ni	Pb
Sample 26	Acrostichum aureum- Yokri F/S	44.7	45	5	35	BDL	0.17	0.01
Sample 27	Cocos nucifera- Yokri	161.0	35	4	40	BDL	0.01	0.05
Sample 28	Funtumia sp. - Yokri F/S	151.6	210	3	45	<0.01	0.06	<0.01
Sample 31	Alchornia cordifolia- Yokri F/S	165.2	40	3	95	0.01	0.02	0.02
Sample 32	Elaeis guineensis- Yokri	44.4	104	2	65	<0.01	0.06	0.17
Sample 33	Manihot esculenta- NB Area	58.3	30	3	130	0.01	0.3	<0.01
Sample 36	Musa sapientum- NB	70.0	40	5	80	0.01	0.2	0.17
Sample 37	Panicum maximum- NB F/S Area	55.9	45	13	135	BDL	0.07	<0.01
Sample 38	Christmas bush – Ogbotobo 2.	30.6	45	5	50	BDL	<0.01	0.04
Sample 41	Cassava (M. esculenta) Ogbotobo 2	115.0	35	3	135	BDL	0.05	0.17
Sample 45	Elaeis guineensis - Ogbotobo 1	140.0	43	4	145	BDL	0.04	0.02
Sample 50	Cocso nucifera- Ogbotobo 1	190.4	55	3	260	BDL	<0.01	<0.01
Average Concentrations in leaves		110.34	44.82	4.57	90.19	0.02	0.06	0.14

Key: NB: North bank; F/S: Flow station; SB: South bank; T: Terminal; BDL: Below Detectable Levels = < 0.01 mg/kg.

4.9 Wildlife Studies

The wildlife of the study area includes both vertebrates and invertebrates. The study reveals four phyla of vertebrates, and phylum arthropoda (invertebrate). The species composition of the study area is therefore discussed under the five major categories: mammals, birds, reptiles, amphibians, and arthropods.

Mammals

Fifteen species of mammals belonging to 10 families were recorded during the survey. However,From focus group discussions and interviews of hunters, the antelopes (family Bovidae) and bush pigs (family Suidae) are the only Artiodactyla (even-toed ungulates), reported to occur in the area. Cane rats, and antelopes, are more abundant during the rainy season and their burrows are easily seen near settlements (Plate, 4.7). Several mammals are believed to be extinct in the wild in the locality as the respondents claimed never to have seen or heard of any account of such animals in the area. Such mammals include the gorillas, chimpanzees, leopards, buffalo, and hippopotamus. However, a lot of Mona monkeys were observed along the Yokri – North Bank forest stretch (Plate, 4.7).

Table 4.14: Species of Mammals in the Study Area

Family	Scientific names	Common names	Abundance status	Conservation status
Cercopithecidae (monkeys)	Cercopithecus mona	Mona Monkey	Abundant	Endangered
Manidae	Manis tetradactyla	Long-tailed Pangolin	Rare	Threatened
Cricetidae	Cricetomys emini	Emin's Giant-rat	Abundant	Least Concern
Thryonomidae	Thryonomys swinderianus	Greater Cane Rat	Abundant	Least Concern
Sciuridae	Protexerus strangeri	Giant Forest Tree-squirrel	Rare	Threatened
	Heliosciurus rufobrachium	Red-legged Sun-squirrel	Rare	Threatened
Muridae	Rattus rattus	Black Rat	Abundant	Least Concern
	Mastomys natalensis	Multimammate Mouse	Abundant	Least Concern
	Mus minutoides	Pygmy Mouse	Abundant	Least Concern
	Hbyomys trivirgatus	Three-striped Mouse	Abundant	Least Concern
	Viverra civetta	African Civet	Rare	Threatened

Family	Scientific names	Common names	Abundance status	Conservation status
Viverridae (civet, genets & mongoose)	Atilax palidinosus	Marsh Mongoose	Rare	Threatened
Suidae (pigs)	Potamochoerus porcus	Red River-hog	Abundant	Not threatened
Bovidae (Antelopes)	Tragelaphus scirptus	Bushbuck	Common	Not threatened
	Philantomba maxwelli	Maxwell's Duiker	Common	Not threatened


b

Plate 4.6: (a) A Burrow Indicating the Presence of Emin's Giant Rat in the Area; (b) Mona Monkey (Cercopithecus mona) Encountered at Yokri.

Birds

A total of 39 species of birds was recorded during the sampling exercise. Thirty-four (34) species were recorded during the dry season and thirty-two (32) in the rainy season. A taxonomic checklist of birds encountered is shown in Table 4.15.

Table 4.15: Species of Birds Found in the Project Area

Family	Common name	Scientific names	Status					
			Normal	Threatened	Endangered	Extinct	Rainy season	Dry season
Ardeidae	Little Egret	Egretta garzetta garzetta					+	+
	Grey heron	Ardea cinerea					+	+
Anatidae	Hartlaub's Duck	Pteronetta hartlaubii	X				+	+
Accipitridae	Hooded Vulture	Necrosyrtes monachus		x			+	+
	Yellow billed Kite	Milvus aegyptius parasites		x			+	+
Jacanidae	African jacana	Actophilornis africana	X				+	
Columbidae	African Green Pigeon	Treron calva	X				+	+
	Tambourine Dove	Turtur tympanistria	X				+	+
	Red-eyed Dove	Streptopella semitorquata	X				+	+
	Vinaceous Dove	Streptopella vinacea	X					+
Psittacidae	Grey Parrot	Psittacus erithacus			x		+	+
Musophagidae	Great Blue Turaco	Corythaeola cristata			x		+	
Cuculidae	Senegal coucal	Centropus senegalensis	x				+	+

Family	Common name	Scientific names	Status					
			Normal	Threatened	Endangered	Extinct	Rainy season	Dry season
Apodidae	African Palm Swift	Cypsiurus parvus	x				+	
Alcedinidae	Blue-breasted Kingfisher	Halcyon malimbica	x				+	+
	Malachite Kingfisher	Corythornis cristata	x				+	+
Bucerotidae	African Pied hornbill	Tockus fasciatus	x				+	+
Capitonidae	Naked-faced Barbet	Gymnobucco calvus	x				+	+
Picidae	Gabon Woodpecker	Dendropicos gabonensis	x				+	
Hirundinidae	White-throated Blue Swallow	Hirundo nigrita	x					+
	Barn Swallow	Hirundo rustica	x				+	+
Motacillidae	Yellow Wagtail	Motacilla flava	x					+
	White Wagtail	Motacilla alba	x					+
	Yellow-throated Longclaw	Macronyx croceus	x				+	+
Turdidae	Forest Robin	Stiphrornis erythrothorax	x				+	
	Nightingale	Luscinia megarhynchos	x				+	+
	African Thrush	Turdus pelios					+	+
Sylviidae	Red-faced Cisticola	Cisticola erythrops		x			+	

Family	Common name	Scientific names	Status					
			Normal	Threatened	Endangered	Extinct	Rainy season	Dry season
Muscicapidae	African Forest-flycatcher	Melaenornis ocreatus	x				+	+
Nectariniidae	Brown Sunbird	Anthreptes gabonicus	x				+	+
	Pygmy Sunbird	Anthreptes platurus	x					+
	Copper Sunbird	Nectarinia cuprea	x					+
	Superb Sunbird	Nectarinia superba	x					+
	Beautiful Sunbird	Nectarinia pulchella	x				+	+
Corvidae	Pied Crow	Corvus albus	x				+	+
Passeridae	Bush Petronia	Petronia dentate	x				+	+
Ploceidae	Orange Weaver	Ploceus aurantius	x				+	+
	Village Weaver	Ploceus cucullatus	x				+	+
Estrildidae	Bed-billed Fire-finch	Lagonosticta senegala	x				+	+

Reptiles

The reptilian fauna includes snakes, lizards, crocodiles, turtles, and tortoises. Important species in this category include the culturally respected Python sebae (the royal python), and the three (3) species of crocodiles known in West Africa. A total of 16 reptile species were identified in the study area as listed in Table 4.16.

Table 4.16: Reptile Species in the Study Area

Scientific Name	Common Name		Status		
		Normal	Threatened	Endangered	Extinct
Crastropyxis smaragdina	Emerald snake	x			
Crocodylus niloticus	Nile Crocodile			x	
Dendraspis viridis	Green mamba	x			
Lepodochelys olivacea	Olive Ridley turtle	x			
Pelusios niger	Mud turtle	x			
Python sebae	African Rock python			x	
Trionyx trienguis	Softshell turtle	x			
Varanus niloticus	Nile montor lizard			x	
Grayia smythi	Smyth's water snake	x			
Naja melanoleuca	Black cobra	x			
Naja nigrocollis	Spitting cobra	x			
Python regis	Royal Python			x	
Crocodylus cataphractus	Slender-snout crocodile	x			
Osteolaemus tetraspis	Dwarf crocodile	x			
Kinixys erosa	Serrate Hinge-back tortoise Tortoise	x			
Cheloma mydas	Green turtle	x			

Amphibians

There are nineteen (19) amphibian species in Nigeria of which 5 are endemic to the Niger Delta (IUCN, 1988). The species found in the study area are listed in Table 4.17.

Table 4.17: Amphibian Species in the Project Area

Scientific Name	Common Name	Status			
		Normal	Threatened	Endangered	Extinct
Bufo regularis	Common Toad	X			
Xenopus tropicalis	Web-toad frog	X			
Hyperolius species	Tree frog	X			
Ptychadena bibrioni	Long-legged frog	X			
Hylarana albolabris	True frogs	X			
Dicroglossus occipitalis	True frogs	X			

4.10 Socio-Economic Characteristics

4.10.1 Population Dynamics and Socio-Cultural Characteristics

Population Structure and Distribution

The population of Ogulagha was projected using the exponential growth rate model based on the 1991 population census figure with an annual growth rate of 3.2% as shown in table 4.18.

Table 4.18: Distribution of Population and Sex Structure in the Project Area

Community	1991			2001	2006	2013	2015
	Male	Female	Total				
Ogulagha	3,285	2,664	5,949	8,152	9,542	11,896	12,670

Source: Computed from CBN, 1991 and 2006

Age and Sex Composition of the Respondents

Age and sex are important demographic variables in the study of demographic classification, mortality, fertility, and nuptiality. Majority of respondents (68.9%) were adults aged between 30-59 years, about one fifth (18.9 %) are youngsters (20-29 years) while those aged 60 years and above constitute only 12.2 %(Figure 4.25).

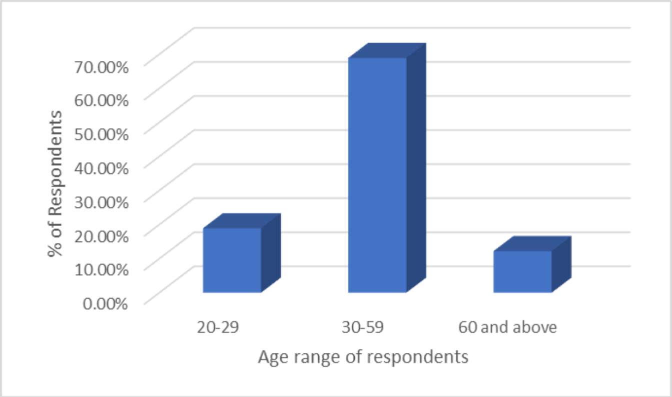


Fig. 4.25: Age Structure of Sampled Respondents in The Project Community

The household age structure and composition of the population in the coastal community conform to the overall Niger Delta and indeed Nigeria's pyramidal structure. Population is rather overwhelmingly loaded from the lower age-cohorts. About 39.2% of the household population comprise persons aged less than 15 years, with persons in the productive age bracket of 15-59 years constituting is 55.4%. Those respondents aged 60 years and above were the fewest(4.3%) in the population pyramidal structure. A further analysis of the age and sex composition indicates that the female gender was mainly of lower age bracket comprising newly married women and adolescent girls (Fig.4.26). The overall implication of the age profile is that the population is young and growing and places a heavy burden on the adult population.

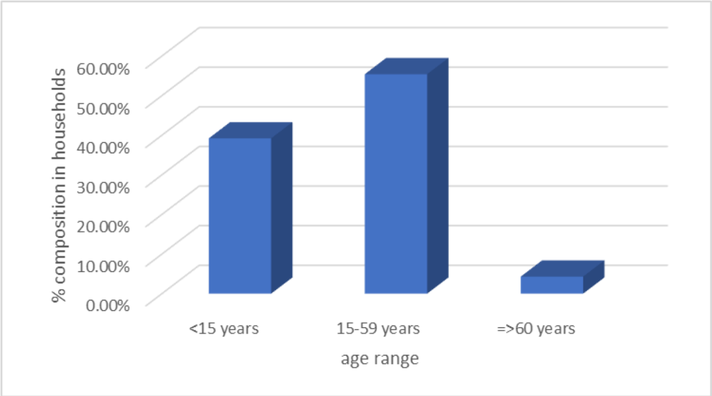


Fig. 4.26: Age and Sex Composition of Households in The Project Community

Gender Distribution and Sex Ratio

Gender distribution of the population in Ogulagha reveals a male dominated structure. The overall sex structure in Fig.4.27 revealed that 51.6% are males as against 48.4% females. This data generally agrees with the earlier results of 49% and 51% females in Burutu LGA in 1991 and 2006 respectively.

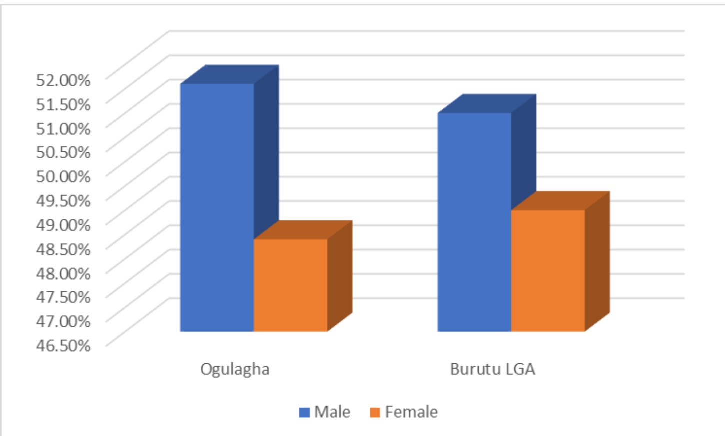


Fig.4.27: Gender Distribution of Respondents in Surveyed Project Community

Settlement Pattern and House Ownership.

Ogulagha community is an Ijaw Community. The few non- Ijaw speaking tribes commonly found in the area are Ibos and Hausas. The coastal sub-Community in the study area are essentially linear in their settlement formation with houses built along the rivers, streams and creeks with few buildings extending inwards.

Further observation shows that in the study area over 90% of the community members live in their own houses while less than 10% live in rented accommodations. A significant proportion of the residential buildings are usually flooded during the rainy season due to topography of the area (Plates 4.11a-c). The low relief and poor ground drainage in the area are the primary factors responsible for the low number of large settlements in the Niger Delta region (NDES, 2000; NDDC, 2006, and UNDP, 2006).



Traditional House b) Semi-Bungalow c) Modern Storey Building

Plate 4.7 (a –c): Housing Structures in The Project Community

With respect to the housing structure the predominant housing types found in the proposed project area are traditional houses mostly found in smaller settlements with walling and roofing materials made from reeds, thatch and wood/planks. There were also the semi-modern (bungalows)sighted made with walls and roofs constructed with makeshift materials like old wooden planks, disused corrugated iron roofing sheets, and roofed with corrugated iron sheets. Modern (bungalows) houses were about 30% of the houses in the area and were made with cement screed floors, concrete block walls and corrugated iron sheets/ aluminium roofing sheets. Figure 4.28 clearly illustrates these statistics and indicates only marginal improvement in the structural and physical conditions of housing in the area when compared with the situation reported during the 2012 study which had traditional compound houses constituting 52.24 %, semi- modern bungalows 29.85% and modern houses comprising 17.91%.

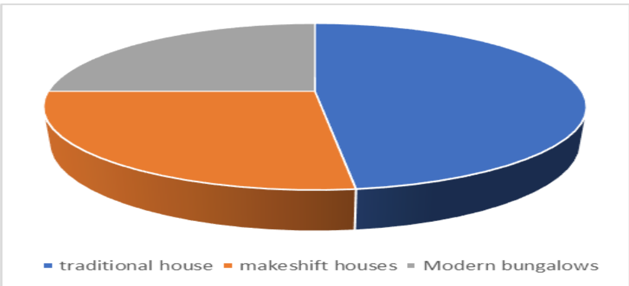


Fig. 4.28: Pie Chart Showing Housing Structure in the Project Area

Education status

Delta State the location of the proposed project has long been recognized as an educationally advantaged state (UNDP, 2006). The State's overall human development index (HDI) of 0.615 was highest in the Niger Delta coming only second to Akwa Ibom with 0.636 (UNDP 2006). The result of data analysis indicates 80.50% of the respondents have primary school education, 38% have secondary school education, 28.25% have tertiary education, while less than 20.0% of the respondents are without any form of formal education (Figure 4.29). Only an insignificant 15.0% of respondents have some form of informal technical education in the areas of welding, electrical/electronic engineering, drilling, pilling, carpentry, auto repairs and body works. The level of educational attainment was found to be significantly higher among the male population, 65.0% with secondary school leaving certificate compared to the modal literacy level of 50.0% among females and lower among married women (33.5%). These data sharply contrast with the 2012 findings of 22.4%(tertiary education), 24.1%(secondary education), 6.50%(vocational education) and 32.70% (no formal education), which shows that literacy level amongst the population is improving particularly in the areas of secondary and technical education. These improvements may be adduced to the high premium given to education as evidenced from the physical and environmental quality of existing public primary and secondary educational institutions visited in the area.

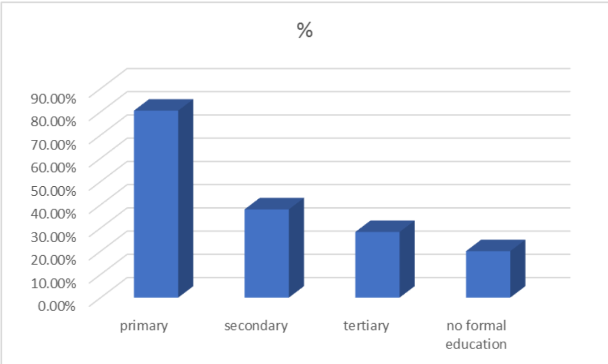


Fig. 4.29: Educational Attainment of Respondents

Marital Status and Household Size of Respondents

The marital status and household size of respondents derived from this study showed statistical difference from the 2012 study findings. In the 2012 EES, 39.8 % of the respondents were married while 20.4 % were of the single status as compared with 52.50%(married) and 48.0%(single) in 2018. The proportion of respondents divorced/separated from their spouses or widowed constituted 3.0% and 5.3% respectively in 2012 compared with 5.0% and 8.25% respectively in 2018.

For the male-headed households, approximately 53% were married to one wife, 31% married to two wives, while 16% were married to three wives. However, the number of children found in each household in the area was an average of six (6) excluding relatives, while the average total household size was an average of 8 persons.

Religion, Culture and Belief System

Christianity is the dominant religion in the project environment: Christianity (92%), African Traditional Religion (6.0%), and Muslims (2.0%). Traditional worship hitherto rooted in the culture of the people is fast disappearing though its relic is still retained in existing festivals and ceremonial dances and attended by acclaimed Christians participate in the community festivals at different levels of commitment. Several communal deities and shrines, sacred bushes, sacred streams and waters are still found in the study area. Some of these deities and shrines are communally owned while others are kept in the custody of specific families. Associated with these deities and shrines are annual festivals, rites and rituals, which define the traditional religious worship, practiced in each community. These annual festivals are considered important for warding off evil, promoting fertility in marriages and profitable enterprise in fishing, farming and other activities. Polygamy is commonly practiced in the community; the number of wives being directly related to the status of the individual. Households are Patri-lineal and Patri-local. The marriage custom of bride price payment is widely practiced within Ogulagha.

Community Governance and Institutions

Leadership Structure and Governance

The traditional leadership and governing system in Ogulagha Kingdom is structured into hierarchies with about five functional organs; the paramount chief/king (the clan head), the traditional council (a cabinet of council of chiefs, community EXCO, youth EXCO, and women leaders), Ogulagha Development Organisation (ODO), a Representative Council, an Advisory Council, Youth Body and the Women Group respectively (Fig.4.31). The paramount ruler and his 18-man Ogulagha Kingdom Traditional Council of Chiefs wields much influence in the traditional governance of the Ogulagha Kingdom and must be consulted for any successful project implementation in the area. The Ogulagha Development Organisation is the 'brain' of the community and is directly in charge of development matters while the Representative Council functions as the legislative arm with inputs from both the Advisory Council and members of the community in general. The women and youth groups complement the activities of the leadership.

Once the issues are deliberated and agreed upon, the town crier proclaims this to the whole community. The Community executive council has a three-year tenure while the youth association has two-year tenure. The position of treasurer is reserved for the women in the community executive council. The women association headed by their executives complements the efforts of the other organs of leadership. The women also play key roles in developmental programmes, contributing their quota to enhancement of community welfare.

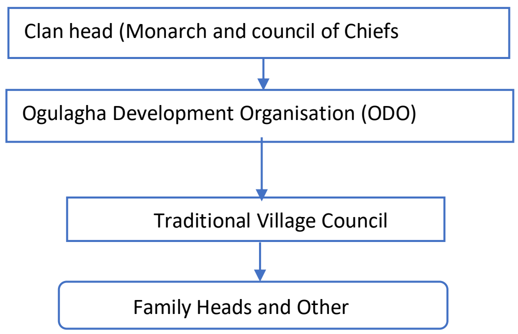


Fig 4.31: Administrative and Power Structure in Ogulagha Kingdom

Community Organizations

Various non-governmental organizations (NGOs) and community-based organizations (CBOs) are found in the study area and represent a wide array of interests (Table 4.19). The clan's student's association is very active in the community in prospecting and canvassing the community student interests in tertiary institutions.

Table 4.19: Non-Governmental and Community-Based Organisations (NGOs and CBOs) in Ogulagha Kingdom

S/N	NGOs and CBOs	Interest Represented
1	Ogulagha Clan Women Consultative Forum	Political empowerment and economic advancement of women in Ogulagha clan
2	Women Snailery and Resource Center	Capacity building and skill acquisition for utilization of available resources e.g. snail farming
3	Town Executives	Economic advancement and development of the respective Community
4	Youth Associations	Economic advancement, skill acquisition, employment of youths in the various Community
5	Lift Above Poverty (LAPO)	Poverty eradication in the Niger Delta
6	BOLOUEBI	Women empowerment in Ogulagha
7	SEIBI (Cultural Dance Group)	Preservation of cultural and traditional values and practices

S/N	NGOs and CBOs	Interest Represented
8	National Association of Ogulagha Clan Students (NAOCS)	Encouraging education, promotion of awareness and represents interests of Ogulagha students in tertiary institutions
9	Ogulagha Clan Youth Drama Groups	Preservation of cultural and traditional values and practices
10	DEENET	Environmental awareness and monitoring (independently conducted QAQC of field sampling and analytical procedures for FYIP EIA)
11	Nigeria Popular Theatre Alliance	Preservation of cultural and traditional values and practices

Source: Field Survey data, 2018

Community Conflicts and Resolutions

Conflicts in the study area predate the advent of crude oil exploration and production. Most of the conflicts were mainly related to issues of land ownership, quests for autonomy and struggles for leadership. Some conflicts in the community are directly or indirectly caused by coil and gas activities. In other words, crisis had been magnified by oil and gas exploitation in the Niger Delta over the years. Causes of conflict between Community and companies include but not limited to the following:

- Non-recognition of community as stakeholder
- Oil spillages
- Border/land disputes
- Agitation for employment
- Refusal of companies to repair damaged roads
- Non-payment of compensation
- Non-compliance with court rulings and orders
- Failure to honour MoUs
- Perceived intimidation of the Community
- Perceived "divide and rule tactics"
- Ineffective communication channels

Before the late 1990s, the conflict resolution strategies of Community in the study area were through dialogue in special meetings summoned by the elders-in-council, council of chiefs, elders and chief's assembly, religious leaders, juju priests, youth council and women groups. Presently, issues not resolved at the lower levels of family, age grade and women associations are taken directly to the community council for discussions. Appeals against decisions taken at the community council are entertained and are further deliberated / resolved by the council. Issues are referred to the police and courts, when they are criminal offences that are mandatory to be reported and or when the resolution of such conflicts is not successful at the community leadership level. Conflict resolution at community level could attract penalties such as fines, seizures of assets and ostracism.

Issues of potential conflicts were narrated during focus group discussions and personal interviews. The youth groups though appreciative of SPDC's assistance to the community in the areas of electricity, improved water supply, education, health and roads raised a number of complaints:

- eroding coastline/shoreline claimed to be caused by natural forces but being exacerbated by the activities of oil and gas operators
- declining soil fertility
- low fish catch by fishermen
- general loss of livelihoods caused by oil pollution issues
- scarce employment opportunities/benefits and royalties for members of the community

Occupation and Economic Livelihood

Occupation and Employment in the Study Area

Economic conditions prevailing in an area determine the quality of life of the people as it directly affects employment opportunity, livelihood, nutrition and health of the population.

The livelihood of the people in the project area is largely based on the primary natural resources available in the area. Fishing and trading were observed to be the major occupations of respondents in Ogulagha. The availability of large expanse of water, tracts of forests and limited land have made fishing the predominant economic activity and encouraged the farming of plantain and oil palms / oil processing as well as logging/lumbering activities to a lesser extent at the subsistence level in the area (Plate 4.12a-e).


Water Transport and Fishing Equipment b) Fish Smoking by the Women



c) Oil Palm Processing d) Lumbering Activity e) Animal Husbandry

Plate.4.8: Economic Activities in the Project Community

Aside from the traditional occupations, other income generating activities identified include contracting, transportation (boat driving), and technical and artisanal works like tailoring, welding, engine boats repairs/maintenance, electrical works, carpentry, government civil service and oil and gas.

The high rate of unemployment may account for the rising level of youth restiveness and continued illegal bunkering activities observed in the area. During the series of consultation held with various groups in the area certain factors contributing to youth unemployment were identified and these include but not limited to the following:

- Lack of local industries to create employment;
- Lack of marketable skills due to non-availability of vocational skill development programmes;
- Inadequate mobilization, support and incentives for self-employment through Small and Medium Enterprises (SMEs);
- Lack of poverty-reduction programmes such as micro-credit schemes in the region;
- Abandonment of traditional occupations, which are low yielding, fraught with hardship and no longer command respect;
- Attraction for better paying and more dignifying jobs in the oil sector;
- Limited job opportunities provided by oil and gas sector and

- The boom and bust patterns of oil company temporary contract jobs

Income Distribution of the Respondents

Income is an important demographic variable that affects the socio-economic status of individuals and its distribution pattern has potential effects on other demographic parameters. It is observed that personal income levels of self-employed rural households is always difficult to assess because many local people do not keep records and are therefore uncertain of the gross or net amount actually earned from self-endeavours. This notwithstanding the monthly income from the occupational activities of respondents is presented in Fig 4.33. About 24.50% of the respondents earn less than N20000 monthly, 35.25% earn between N21-30000, 10.0%(N31-40000), 6.0%(N41-50000), 7.0%(N51-60000), 2.10%(N61-70000) while 3.50% earn from N71000 to N80000 monthly(Table 4.85).These income data largely corresponds with the findings of the 2012 EES (SPDC 2012) which found that 17.3 % of the people in the area earn between N10,000 - N20,000, 16.8 % earn (N20,000 - N30,000), 7.8 %(N31-40000) and6.5 % earn above N100,000.

Compared with the findings of previous FYIP project studies the income level of the people in the study area shows rising poverty level among the lower and higher income groups- for instance findings from this study indicates that 59.75% of respondents earn less than N30000 compared with 33.1% and 43.4% that earn the same amount in 2012 and 2001respectively. Similar trend is observed with the respondents that earn N80000 monthly and above.

Table 4.20: Comparison of Income Levels of the Respondents in 2001, 2012, 2018)

Year	Income Level (N' 000)									
	10 -20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	> 100
2001	23.9	19.5	13.9	9.7	10.4	3.8	7.8	0.5	3.8	0
2012	17.3	16.8	7.8	5.5	6.7	1.2	2.7	3.7	4.2	6.5
2018	24.5	35.25	10.20	6.0	7.0	2.1	3.5	2.8	3.2	5.5

Household Expenditures and Consumption

The breakdown of household income expenditures as expressed by heads of household was consistent with qualitative information on household spending priorities found for other rural areas of the Niger Delta (E.g see Ojile, 2008; Ebong, 2010). Food was listed by heads of households as the most important spending priority, while entertainment was considered the least important priority in the surveyed community. Food is the largest single expenditure item accounting for 30% of monthly household expenditure in the households. This is followed by education (20.25%), utility/transportation costs (10.5%), leisure/entertainment (4.20%) while healthcare expenditure amounted to 8.0% (possible due to self- medication and use of traditional prescriptions) (Figure 4.34). A substantial percentage of income is used to provide for the family, leaving little or no money for saving purposes.

Recent analysis of poverty in Nigeria revealed that the poverty incidence has come down from 70% in 1999 to 54 % in 2004, but with regional differences. In the south-south, the poverty level was 13.2 % in 1980, increased to 45.7% in 1985, dropped down to 40.8% in 1992, then rose again to 58.2 % in 1996 before a slide down to 35.1 % in 2004 (Soludo, 2007).

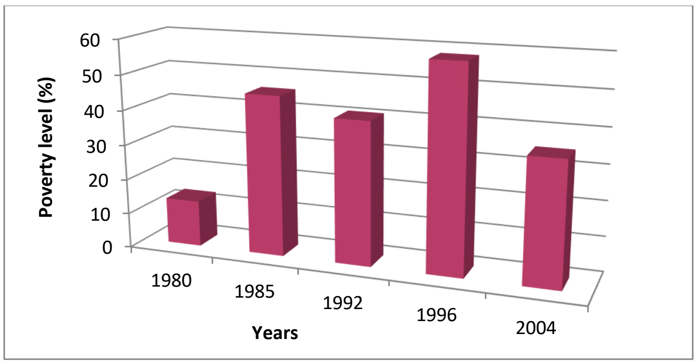


Fig. 4.34: Poverty Status in South-South Region, Nigeria (Soludo, 2007)

Saving Mode of the Sampled Community

Despite the prevailing poverty conditions in the project area a cross-section of the people in the study area adopt various form of income saving practices. These practices include Osusu (contributions) (48.50%), deposits in banks (28.2%), buying & storing of products for future sales including petroleum products (20.5%), while less than 3.0% prefer to keep their savings at home for future demands. These findings align with the data obtained during the 2012 EES (SPDC, 2012) as shown in table 4.21.

Natural Resource Utilization

The natural resource endowments available in the project area determine to a large extent the culture, economic activities undertaken by the people and their means of livelihood.

Land Use Pattern

Land use is the way land is owned, used and controlled in the project area. Community and families own and control land including the stretches of rivers and creeks adjoining such land and lakes in the Niger Delta. The portion owned by the families is allocated to any household member that wants to use and or build or develop. However, land may be leased to non-indigenes by the Community Chief on the provision of some gift items as may be prescribed from time to time and as agreed by each community. Although agriculture and fishing are fast giving way to oil and gas related industries/occupations a lot of potentials still exist in aqua-culture and farming in the project area as evidenced from the high concentration of economic trees such as oil palm, large timber trees and coconut trees in the area. These observations similar to findings in 2012/2013 EE based EIA.

Forest Resources

The presence of several mangrove and freshwater forests in the study area provide avenues for hunting of several species of mammals such as monkeys and crocodiles, birds, and reptiles for consumption and sales. Although indiscriminate hunting of wildlife is destructive, it forms an important aspect of their food for many households in the study area. The forest in the project area are also extensively exploited for timber and non timber products (e.g fuelwood, wild fruits, medicinal plants, vegetables and spices) which are utilized and sold by the local population. It is important to note that the people have complete access to the use of these natural resources at their disposal except timber exploitation which the Delta State Forestry Department exerts some forms of control.

Community Infrastructure and Communication System

Availability and access to basic social infrastructural facilities and reasonable level of incomes have been used to measure the quality of life of the people. In Ogulagha community, a number of social infrastructure or services were encountered in course of the field data gathering exercises. Focus group and key informant discussions revealed that significant number of the available infrastructure are provided by the oil and gas multinationals operating in the area including SPDC, NDDC and DESOPADEC. Other agencies including government, have intervened in the provision of social facilities in the project area include federal, state and local governments (Table 4.21). The community was particularly grateful to the SPDC for the numerous support/assistance projects in the areas.

Education Institutions

Ogulagha community has several public and private schools. Some new school buildings have been constructed while, those in deplorable conditions renovated and equipped through the intervention efforts of SPDC. Staff accommodation facilities are provided as component part of existing public educational institutions, in the form of principal, headmaster and teachers' quarters in Ogulagha(Plate 4.13a-e). It was also observed that perimeter walls were recently constructed around the school premises to provide security. Similarly, new boreholes were sunk to provide water for the use of equally newly constructed ventilated improved latrines with the public-school premises. There is also a vocational training center (Youth Development Scheme) established by SPDC to train youths from Ogulagha and several neighbouring Community (SPDC.2004).

a) Primary School at Ogulagha

b) Teacher's Quarters at Ogulagha

c) Ogulagha Secondary School

d) Proposed Technical College

Plate 4.9: (a-e): Educational Facilities at the FYIP Project Community

A technical college building was erected years ago but, the school is yet to take off. Children within the clan villages or sub-Community in particular without educational institutions are sent to Ogulagha main town where such schools exist for their studies.

Table 4.21 Summary of Infrastructural Facilities in Ogulagha

Infrastructure	2012	2018
Electricity	Available from SPDC to about 80% of the population	Generator provided by defunct OMPADEC and serviced by SPDC
Water	Provided by SPDC and serves about 60% of population	Available from OMPADEC and SPDC water wells Creeks and rain water
Roads	Major ones tarred by SPDC	The major road tarred by SPDC
Transportation	Intra-community is by motor cycles and on foot Inter-community is by speed boats	Intra-community is by foot Inter-community is by speed boats and canoes
Housing	Modern bungalows and semi- modern bungalows abound the community.	Walls and roofs of most are built of corrugated zinc sheets
Education	One public primary school One public secondary school One private nursery/primary school	One public primary school
Health *	Cottage Hospital provide by SPDC	PHC provided by OMPADEC
Recreation Centre	Town hall, guest houses, drinking spots, open fields	Town hall, guest houses, drinking spots, open fields Viewing centre

Source: Field Survey Data, 2012 and 2018

Electricity Supply

Ogulagha community has regular and reliable energy supply courtesy of the SPDC. The energy for the generation of the electric power is supplied from the Forcados Terminal Gas Turbine Plant. The energy supply is responsible for observed high number of thriving small and medium scale enterprises. Welding and fabrication shops, fashion, hair making saloons, restaurants and bars operate easily in the community.

Water Supply Facilities

Increasing access to improved drinking water is one of the Millennium Development Goals that Nigeria and other nations worldwide have adopted. The SPDC installed water treatment facilities in the project community in an attempt to improve the portability of borehole water though some of them have become Non-functional with time. The population now relies on water from SPDC's Terminal water scheme supplied through mono-pumps. Some members of the Community complained that the water supplied was hot and required cooling down before use.

Plate 4.10: Sampled Water Facilities in the Study Area

Transportation and Communication

Transportation used includes hand-dug canoes and outboard engine boats. There are tarred and concrete paved roads in Ogulagha (Plate 4.15). Inter and intra community feeder road links exist from Ogulagha to the neighbouring Community as well as within the town and thus allow for commercial motor-cycles to take passengers from the new jetty down to the Community. Major functional concrete landing jetties are available at Ogulagha.

Plate: 4.11: Tarred Road at Ogulagha Community

GSM communication is available in the study area. Ogulagha hosts two (2) base stations/masts of the GSM providers (Plate 4.16).The resident populations have access to either Glo and Airtel networks

Plate 4.12: Ogulagha Community and the GSM Base Stations/Masts

Health Care Facilities

Ogulagha community has a modern well-equipped and furnished cottage hospital courtesy of the community developmental efforts of SPDC and NDDC. At present, it is relatively well staffed with doctors, nurses and paramedical staff. It handles cases ranging from child delivery to surgery. There are also private hospitals such as Island Clinic and Ufoma Clinic in the community.

Recreational Facility

There are no formal planned public open spaces like parks and recreational centres, however there exists avenues in the community for leisure activities like meetings and dancing spots used by members in the project community. These include town halls/auditoriums, rest houses/drinking palours and viewing centres. Communal meetings and other social events are organized in community halls and other social centres as shown in Plate 4.17. A new modern town hall with complete meeting accessories was built recently by NAOC. Primary and secondary school playgrounds are also sometimes used as civic gathering places, especially when large audiences are expected. Leisure activities like football, snooker games, dancing and masquerade displays are organized for recreation during festive periods (4.17)

Plate 4.13: Community Town Halls in the Study Area

Community Expectations

The Ogulagha and its ancestral Community expect SPDC to assist them in the provision of:

- shoreline stabilization and proper drainage facilities;
- a well-equipped community secretariat for easy administration of the community affairs;
- increased coverage of electricity supply;
- sand filling for swampy areas for infrastructural development;
- complete landing jetty
- modern and public sanitary toilet in the community to prevent indiscriminate defecation into the surrounding watercourses with its attendant increase in the cases of water borne diseases.

Consultations

Consultations were done to ensure the people's involvement in this participatory process of the environmental impact assessment study in the project area and to "guarantee freedom to operate" in the project area. The key roles to be played by the various stakeholders in project implementation process were also assessed. In the course of execution of the FYIP, SPDC shall maintain regular consultation with all the stakeholders as SPDC recognizes effective consultation as a continuous and progressive process.

4.11 Health Studies

Health data for Ogulagha community was collected from a variety of sources, including:

- Disease Surveillance and Notification (DSN) activities in the Community
- Data generated by the Health Management Information System (HMIS)
- Population demography from the National Population Commission (NPC);

A review of relevant literatures

Gaps in these data were filled through a Community survey carried out between Friday 22nd and Monday 25th June 2018 in Ogulagha community of Burutu Local Government Area of Delta State.

Data collection during the Community survey was carried out using both quantitative and qualitative methods. Emphasis was however given to participatory rapid appraisal methods, because they are encouraged by regulators, to ensure the inputs of members of the impacted Community.

The following rapid appraisal methods were used during the Community survey:

- Focal Group Discussion
- Key informant interviews,
- On-the-spot observations

The Focus Group Discussions was held at the house of the community chairman. The discussion sessions were held with male and female members of the Community, as well as with women and youth groups of the Community.

Plate 4.14: Focus Group Discussions in the Community

The key informant interviews were held with:

- Members of the Community Council,
- Workers in the health facilities that serve the Community,
- Traditional medicine practitioners in the Community, especially Traditional Birth Attendants,
- Owners and staff of private health facilities in the Community; and
- Other opinion leaders of the Community, chosen for their ability to provide the needed information.

Plate 4.15: Key informant interviews of doctor of Island hospital Ogulagha

Direct observations were used to assess:

- The quality of health services in the health facilities that serve the Community, using a checklist
- The practices of patent medicine dealers and Traditional Birth Attendants in the Community; and
- The environmental health conditions in the Community, especially the layout of the buildings, the source of drinking water, the method of refuse disposal, and sanitation facilities

The HIA team was assisted by a local guide moved around the Community, taking note of these and taking photographs where possible.

Questionnaires were distributed to all heads of the household present at the meeting. To prevent bias, efforts were also made to administer the questionnaire to other heads of household in the Community who were not present during the meeting, through a contact person, who was given a brief training on key aspects of the questionnaire. An average of fifty (50) questionnaires was administered.

Socio-demographic characteristics of the Community

The Community are rural and populated predominantly by people of the Ijaw ethnic group, who are mainly farmers, fisher folks, traders and marine transporters. Members of the Community are subsistent farmers of cassava, sweet potato, maize and vegetable. The production of palm oil, from wild oil palm trees, was also noticed in the Community. Fishing is, however, the main occupation of most members of the Community, carried out in the sea, the estuaries and the several impounded water bodies in the Community. Respondents in the Community, however, complained during the field study of dwindling

Access to safe drinking water

Members of the Community meet their drinking water needs from a variety of sources including sachet, bottled water, Community water borehole, and rain. Most of the sachet water consumed in the Community is produced by a factory in Ogulagha that gets it water supply from the Forcados Terminal.

Plate 4.16: Some of the sources of drinking water in the Community: Rainwater (Left), Sachet water (Middle) and Private borehole (Right)

Several water borehole facilities were sighted in the Community during the field study, most were however not functional, except the reticulated water facility that was built, operated and maintained by SPDC in each of the Community. The water facilities were said to yield the best quality water in the Community because they are equipped with treatment facilities to deal with the high saline and iron content of the groundwater of the area. Members of the Community, however, complained of inadequate supply and inconsistencies in quality of water supplied from the water facilities.

Plate 4.17: The Community water facility and with its water treatment facility

Access to sanitation facility

Open defecation is common at the beach in Ogulagha Community. The use of jetty-type (over-hung) is also common in the Community, especially by residents of the Community residing close to the bank. Latrines and flush toilets are also present within the community.

Plate 4.18: Open defecation in one of the Community

Housing condition

Most houses in the Community were built with metal/wooden walls and metal roof because the sand in the Community is unsuitable for building purposes. On the average, the roofs of the houses in the host Community were constructed mostly with corrugated roofing sheets, while their floors were constructed with cement, mud or wooden planks

Vector/pest control:

Vectors in the study area include Anopheles mosquito, Culex mosquito, Aedes mosquito, Tsetse fly, Sand flies and Housefly. The prevalence of the various vector-borne diseases, except for malaria and filariasis has remained low in the Community. This is as indicated by health facility data and key informant interviews conducted. No case of trypanosomiasis (sleeping sickness), filariasis, leishmaniasis, dengue fever or yellow fever was reported to the **health offices of Burutu Local Government Council of Delta State.**

Air quality:

The use of firewood as the predominant source of fuel for domestic use in the Community

Plate 4.18: Firewood being displayed for sale in Ogulagha Community

The use of firewood and other biomass fuel as domestic fuel is a major cause of indoor air pollution, with wide-ranging health implications (WHO, 2003), one of which is an acute respiratory infection in under-five children.

Waste management

The wastes generated in the Community are mainly garbage, and they were mostly dumped close to their houses, or at the bank of the river.

Although the wastes generated in the Community are mainly garbage, leaches from them can be a major source of contamination of the water bodies in the Community. fish, and therefore capable of causing human diseases when consumed.

Use of alcohol

Alcohol is commonly taken in the Community, like most other Community in South-south Nigeria. Alcoholic beverages, including imported gin and the locally distilled gin called kai-kai or ogogoro, are available in the Community. Alcoholic beverages are used during social functions and even in ancestral worship in the Community. Alcohol is also a ubiquitous solvent for several traditional medicines, ranging from pain relief to aphrodisiac.

Use of tobacco

Cigarette smoking common with the average smoker smoking at most three sticks of cigarette a day. Indigenous women of the Community still do not smoke cigarette, at least openly, while the use of snuff (grind tobacco) is still restricted to a few very elderly women, who were said to find it increasingly difficult to buy the snuff, because it is no longer profitable to stock.

Sexual behavior

Polygamy is still common in the Community; most adult males and single girls in the Community still have multiple sexual partners, and infidelity among the men of the Community is still very high, even as it remained an abomination for married women of the Community.

Knowledge of HIV/AIDS and Sexually Transmitted Infections

Oil/gas facilities in the Niger Delta have been found to increase HIV transmission rate, especially with the presence of Commercial Sex Workers close to the facilities (Nwauche and Akani 2006).

All the discussants in the focus group discussions conducted with members of the Community acknowledged that they have heard of HIV/AIDS and STIs; some of them knew someone suspected to have the diseases, or to have died of HIV/AIDS; and about 90% of the discussants knew the routes of transmission of HIV/AIDS.

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

Household food security is said to have deteriorated in the Community and was attributed to the security problem in the area, and incessant crude oil spills from oil bunkering activities. Only about 60% of households in the Community were said to be food secure.

Morbidity pattern

The health problems reported by the discussants were substantiated by records of the health facilities that serve the Community. By combining these different sources of data, the top five causes of ill health in the Community as follows:

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

Mortality pattern

Discussants at the Focus Group Discussions held with members of the Community acknowledged that women still die while pregnant or in labor, but this numbers are lower than previous times. An average of one woman was said to die in the Community for every 400 deliveries, which gives a maternal mortality ratio of 250 per 100, 000 live births. This decrease in maternal mortality was attributed to the speed with which emergencies are recognized and taken to Warri for appropriate treatment.

Under-five mortality was said to be high in the past but was acknowledged during the field study to have reduced considerably in recent years, from immunization and better medical care. The common causes of under-five mortality include: malaria and its complications, especially anemia and febrile convulsion, gastroenteritis (diarrhoea and vomiting), acute lower respiratory tract infection; and vaccine-preventable diseases (eg. Measles).

The health system:

Primary and Secondary Health Care services in the Community

Ogulagha Community is served by the Ogulagha Cottage Hospital. The Ogulagha Cottage Hospital is a secondary health care facility built and equipped by SPDC, but currently being managed by the Delta State government. It offers good quality primary and secondary health care services, made possible by the specialized equipment provided by SPDC that exceed the equipment required for a secondary healthcare facility.

The Ogulagha Community also has a private hospital (Island Hospital), with round the clock doctor coverage, and equipped with the relevant medical facilities. The services of the hospital are open to members of the Community, even as the hospital was originally set up to provide medical retainer services to the service companies of the Forcados Terminal.

Plate 4.19: Cottage Hospital, Ogulagha

Medical Emergency Evacuation System:

There is no formal medical emergency evacuation system in the Community. The Ogulagha Cottage Hospital has a boat ambulance, provided by the SPDC, which was non-functional at the time of the field study. The private clinic in Ogulagha Community (Island Hospital) also has an ambulance for the emergency evacuation of their patients. Most members of the

Community, however make their own private arrangement in convening their sick for appropriate treatment.

Tertiary healthcare facilities

Members of the Community still access tertiary health care services in Warri, especially at Central Hospital Warri, as was reported in the previous environmental studies (SPDC, 2013). The Central Hospital Warri has the manpower and facilities expected of a small tertiary healthcare facility. It has the capacity to attend to accident and emergency cases and offers in-patient and out-patient services in most of the medical and surgical sub-specialties.

CHAPTER FIVE
POTENTIAL AND ASSOCIATED ENVIRONMENTAL IMPACTS

5.1: Introduction

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

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

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.

5.3: Impact screening

Comprehensive checklists of developmental activities and possible environmental/health/social impacts were produced and based on past experience and reviews of literature and Impact Assessment reports on similar projects; these lists were tailored to specific project components and associated historical effects.

Basis for Screening:

The rationale for assessing the likely impacts of the proposed project derives from the following considerations:

- Knowledge of the project activities, equipment types, material inputs/outputs and operational procedures;
- Provide an initial assessment of the likely key environmental considerations;
- Findings of other EIA studies on similar projects and other literature findings on the primary project activities;
- Comparison with Environmental Guidelines and Petroleum Industries in Nigeria, 2002;
- Series of expert group discussions

The criteria applied to the screening of various activities are:

- Magnitude - probable level of severity.
- Prevalence - likely extent of the impact.
- Duration and frequency - likely duration - long-term, short-term or intermittent.
- Risks - probability of serious impacts.
- Importance - value attached to the undisturbed project environment.

In assessing potential impacts, cognizance was taken of the inherent judgmental subjectivity involved; consequently, the analytical results of field studies, relevant literature reviews and observations of existing facilities and practices were used to assess the level of potential impacts of the proposed project.

5.4: Determination of project activities

This involves the determination of individual project activities to be undertaken in the respective phases as described in Chapter 3. A list of activities which interact with the biophysical, social and health environments either due to their nature or due to timing is summarized in Table 5.1.

Table 5.1: Phases of project development activities used in Interaction Matrix

S/N	Project phase	Project activities
1	Mobilization	Movement of equipment and personnel, Rig movement
2	Construction	Route & location clearing (site preparation), Dredging & Sand filling, Pilling, Concrete and asphalt works, Excavation, Backfilling, Pipeline coating, Stringing & welding; Drilling and well hook-up, Well testing, Commissioning & Handover
3	Demobilization	Movement of equipment and personnel, Rig movement
4	Operation	Well work-over, Gas production,
5	Decommissioning and abandonment	Plugging of wells, Site restoration,

5.5: Determination of sensitivities

The determination of sensitivities that characterize the biophysical and social environment was carried out by the environmental consultant teams (biophysical, social and health) using their knowledge of the integrated baseline data. Table 5.2 presents the list of environmental sensitivities.

Table 5.2: Sensitivities describing Biophysical, Social and Health Environments of the FYIP

S/N	Environmental components	Environmental sensitivities
1	Biophysical Environment`	Air quality, Level of noise and vibrations, Surface water quality, and sediment quality, biodiversity (vegetation and wildlife)
2	Social Profile	Access to ancestral and culturally significant sites, Safeguarding traditional occupations, Cost of living/Inflation, Opportunities for economic enhancement, Skill Acquisition, Access to sanitation and waste management, Balance in gender, Lifestyle (use of alcohol, drugs, physical activities etc.), Morals and family values, Current levels of youth restiveness, Current level of workers safety
3	Health Profile	Access to and quality of clean drinking water, Exposure to nuisance (dust, noise etc.), Level of disease & disease vectors (including STDs), Access to primary health care, Access to traditional medicine

Interaction Matrix

Interactions between project activities and sensitivities were determined by a group of experts using their background knowledge of the project and its biophysical, social and health environment. Each interaction was discussed followed by an assessment as to whether the effect of the interaction was expected to be positive or negative. The identified impacts were further listed according to the phases of the project in which they are likely to occur in order to identify those impacts which cut across different phases of the project activities. The interaction matrix is presented in Table 5.3. In the interaction matrix, the following codes are used:

- (+) = likely positive effect of the project;
- (-) = likely negative effect/interaction of the project,
- (+/-) = when the interaction can both be positive and/or negative.

Table 5.3: Interaction Matrix

Project Phase	Project Activity	Description of Impact	Nature of Impact
Mobilization	Movement of equipment and personnel, Rig movement	Loss of livelihood	(-)
		Increase in traffic, potential for accidents and injuries	(-)
		Influx of people causing Pressure on health and other Infrastructure	(-)
		Increase in sexually transmitted disease and other communicable diseases	(-)
		Reduction in air quality	(-)
		Loss of vegetation and wildlife	(-)
		Habitat fragmentation	(-)
		Loss of aquatic species (Fisheries, Planktons and benthic fauna)	(-)
		Distortion of aquatic environment (physical components)	(-)
		Increase in noise and vibration	(-)
Construction - Drilling	Drilling and well hook-up	Increase in noise & vibration nuisance	(-)
		Increase in light nuisance	(-)
		Generation of drilling waste	(-)
		Contamination of environment (soils/surface and groundwater)	(-)
		Work related injury/fatality of workforce	(-)
		Non work related injury/fatality of workforce	(-)
		Increase in explosion potential (Well blowout)	(-)
		Increase in diseases STIs, HIV/AIDS	(-)
		Increase in endemic diseases	(-)

Project Phase	Project Activity	Description of Impact	Nature of Impact
		Emergent Infectious diseases resulting from displacement of disease vectors (rodents and monkeys)	(-)
		Loss of biodiversity	(-)
		Potential for development of infrastructures and economic enhancement	(+)
		Increase in traffic volume & accident potential/injuries	(-)
		Tank leaks	(-)
		Influx of insect pests	(-)
		Opportunity for direct and indirect Employment (Unskilled labour)	(+)
		Opportunity for wealth creation	(+)
		Opportunity for Corporate Social Responsibility	(+)
		Gender imbalance	(-)
		Potential for skills acquisition	(+)
		Pressure on existing infrastructure and services (Water)	(-)
		Third party agitation	(-)
		Attack from wild/predatory animals (Snakes, Scorpions)	(-)
		Exposure to radioactive materials	(-)
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy)	(-)
	Well testing, Commissioning & Handover	Potential for explosion	(-)
		Exposure to radioactive material	(-)

Project Phase	Project Activity	Description of Impact	Nature of Impact
		Increase in business opportunities	(+)
		Gas flaring from well tests	(-)
		Increase in noise & vibration nuisance	(-)
		Generation of waste (Pigging waste, domestic waste, metal scraps, plastics)	(-)
		Contamination of environment (soils/surface and groundwater)	(-)
		Work related injury/fatality of workforce	(-)
		Non work-related injury/fatality of workforce	(-)
		Increase in explosion potential	(-)
		Increase in diseases STIs, HIV/AIDS	(-)
		Increase in endemic diseases (Malaria, Typhoid, RTI)	(-)
		Development of infrastructures and economic enhancement (PGMoU)	(+)
		Increase in traffic volume & accident potential/injuries	(-)
		Tank leaks	(-)
		Opportunity for direct and indirect Employment (Unskilled labour)	(+)
		Opportunity for wealth creation	(+)
		Loss of Employment (local labor)	(-)
		Third party agitation	(-)
		Attack from wild animals (Snakes, Scorpions)	(-)

Project Phase	Project Activity	Description of Impact	Nature of Impact
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy)	(-)
		Increased exposure to carcinogenic substances	(-)
		Alcohol and drug abuse	(-)
Demobilization		Increase in traffic, potential for accidents and injuries	(-)
		Reduction in air quality	(-)
		Increase in noise and vibration	(-)
		Increase in refined hydrocarbon contents of soil and vegetation	(-)
		Increase in crime rate	(-)
		Contamination of groundwater	(-)
		Soil compaction	(-)
		Waste generation (Scrap metals, Woods, Food waste)	(-)
		Opportunity for contracting	(+)
		Opportunity for direct and indirect Employment (Unskilled labour)	(+)
		Loss of Employment (local labor)	(-)
		Third party agitation	(-)
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy)	(-)
		Increase in RTIs due to dust particles	(-)
		Social dislocation	(-)
		Increased exposure to carcinogenic substances	(-)

Project Phase	Project Activity	Description of Impact	Nature of Impact
		Alcohol and drug abuse	(-)
Operation	Well work-over, Gas production,	Potential for environmental contamination due to gas leaks	(-)
		Increase in business opportunities	(+)
		Increase in potential for injury/fatality of workforce & third parties	(-)
		Revenue generation for government and SPDC	(+)
		Increase in potential for sabotage of facilities	(-)
		Reduction in gas flaring	(+)
		Increase in diseases STIs HIV/AIDS	(-)
		Prevalence in endemic diseases (Malaria, Typhoid, RTI)	(-)
		Opportunity for contracting	(+)
		Opportunity for direct and indirect Employment (Unskilled labour)	(+)
		Third party agitation	(-)
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy) and other social vices	(-)
		Waste generation (Scrap metals, Woods, Food waste)	(-)
		Increased exposure to carcinogenic substances	(-)
		Alcohol and drug abuse	(-)
		Contamination of surface water/Sediment	(-)
Decommissioning and abandonment	Removal of surface installations	Increase in potential for soil and water contamination	(-)
	Plugging of wells	Increase in litigation potential	(-)

Project Phase	Project Activity	Description of Impact	Nature of Impact
	Site restoration	Loss of revenue for Govt. & SPDC	(-)
		Loss of job by community surveillance team	(-)
		Increase in usable land resource to the community	(-)
		Opportunity for contracting	(+)
		Opportunity for direct and indirect Employment (Unskilled labor)	(+)
		Third party agitation	(-)
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy) and other social vices	(-)
		Waste generation (Scrap metals, Woods, Food waste)	(-)
		Increased exposure to carcinogenic substances	(-)
		Alcohol and drug abuse	(-)
		Prevalence of STIs HIV/AIDS	(-)

5.6: Impact Qualification

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

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

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

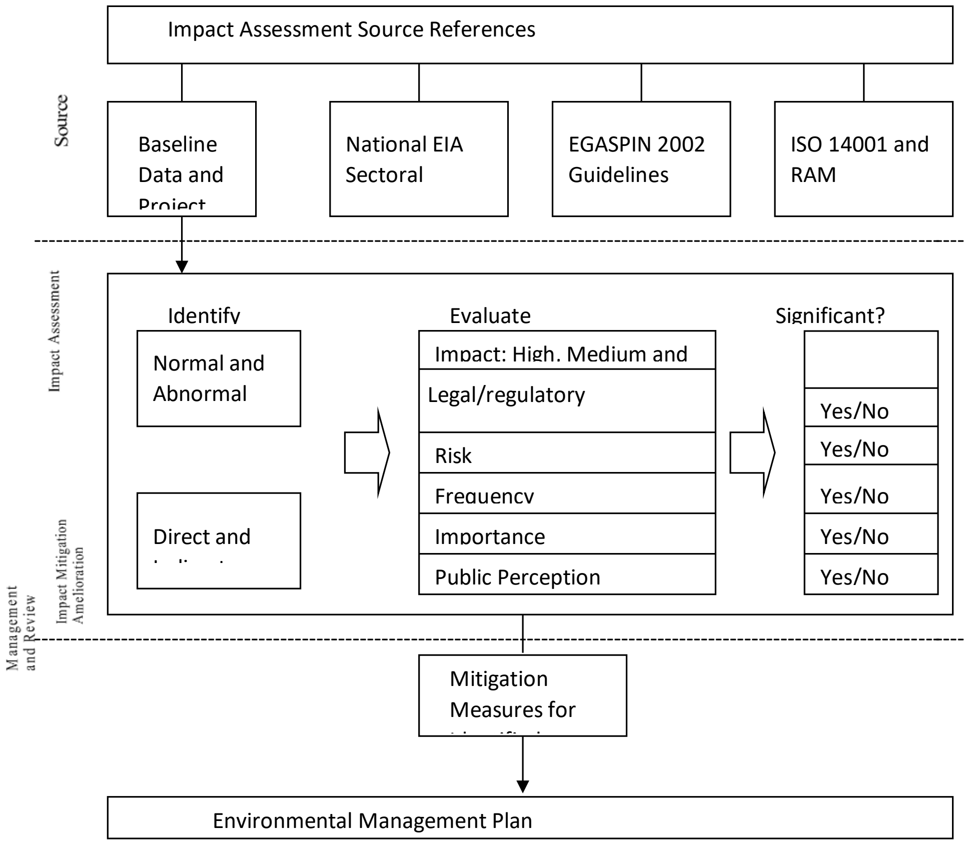


Fig. 5.1: Approach to Impact Assessment

5.7: Risk Assessment for Environmental Consequences

Risk (R) – What is risk/hazard rating based on Risk Assessment Matrix (RAM) (Table 5.3 and Table 5.4). The risks/hazards associated with the project were rated as follows:

1= Low risk

3 = Medium/intermediate risk

5 = High risk

The severity of risks/hazards was further defined as in Table 5.3 and Table 5.4.

Table 5.4: Risk Assessment Matrix

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

Table 5.5: Further definition of consequence – severity rating for risk matrix

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

Source: SIEP (1996)

5.8: Impact Assessment Methodology

Stage one: Classification

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

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

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

Stage two: Significance

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

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

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

Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit required?

- 0 = There is no legal/regulatory requirement
- 3 = There is legal/regulatory requirement
- 5 = There is a legal/regulatory requirement and permit required

Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix?

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

Frequency of Impact (F) – What is the frequency rating of impact based on the Risk Assessment Matrix?

- 1 = Low frequency (rare)
- 3 = Intermediate frequency (likely)
- 5 = High frequency (very likely)

Public interest/perception (P) – What is the rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?

- 1 = Low interest/perception
- 3 = Intermediate interest/perception
- 5 = High interest/perception

Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions?

- 1 = Low
- 3 = Medium
- 5 = High

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

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

The frequency of occurrence of each impact was determined from historical 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 as reported in the various reports reviewed were determined through consultation with the communities and consensus of opinions of environmental professionals. The overall impact rating is determined as shown in Table 5.6. The potential and associated impacts of the project are presented in Table 5.7.

Table 5.6: 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	
F + I	≥6	High
P	= 5	
Positive		Positive

Table 5.7: Potential and Associated Impacts Identification, Qualification, Quantification and Rating

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
Mobilization	Movement of equipment and personnel, Rig movement	Loss of livelihood	X		X		X	X	X		L	0	3	3	5	3	14	8	HIGH
		Increase in traffic, potential for accidents and injuries	X		X		X		X	X	L/ W	3	3	3	3	5	17	6	HIGH
		Influx of people causing Pressure on health and other Infrastructure	X		X		X	X	X		L	0	3	3	3	5	14	6	HIGH
		Increase in sexually transmitted disease and other communicable diseases	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Reduction in air quality	X		X		X	X	X		L/ W	3	5	5	5	5	23	10	HIGH

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Loss of vegetation and wildlife	X		X		X	X	X		L	0	1	3	3	3	10	6	HIGH
		Habitat fragmentation	X		X		X	X	X	X	L	0	1	3	3	3	10	6	HIGH
		Loss of aquatic species (Fisheries, Planktons and benthic fauna)	X		X		X		X		L	3	3	3	3	3	15	6	HIGH
		Distortion of aquatic environment (physical components)	X		X		X		X		L	3	3	3	3	3	15	6	HIGH
		Increase in noise and vibration	X		X			X	X		L	3	3	3	3	3	15	6	HIGH
		Increase in crime rate	X		X		X	X		X	L	0	3	1	3	3	10	4	MEDIUM
			X		X		X	X	X	X	L	3	3	3	5	5	19	8	HIGH

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
	Drilling and well hook-up	Increase in light nuisance	X		X	X	X		X		L	0	3	3	3	1	10	6	HIGH
		Generation of drilling waste	X		X		X		X		L	5	5	5	5	5	25	10	HIGH
		Contamination of environment	X		X	X	X		X		L	3	3	3	3	3	15	6	HIGH
		Work related injury/fatality of workforce	X		X		X	X	X	X	L	3	3	3	5	5	19	8	HIGH
		Non work related injury/fatality of workforce	X		X		X	X	X	X	L	0	3	3	3	5	14	6	HIGH
		Increase in explosion potential (Well blowout)	X		X	X	X		X	X	W	0	5	1	5	5	16	6	HIGH
		Increase in diseases STIs, HIV/AIDS	X		X		X	X	X	X	L	0	5	5	5	5	20	10	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Increase in endemic diseases	X		X		X	X	X	X	L/W	0	5	3	5	5	18	8	HIGH
		Emergent Infectious diseases resulting from displacement of disease vectors	X		X	X	X	X	X	X	L/W	0	3	3	5	5	16	8	HIGH
		Loss of biodiversity	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Potential for development of infrastructures and economic enhancement		X	X		X	X		X	L	-	-	-	-	-	-	-	P
		Increase in traffic volume & accident potential/injuries	X		X		X	X	X	X	L	0	5	3	3	3	14	6	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Tank leaks	X		X		X		X		L	3	5	3	5	3	19	8	HIGH
		Influx of insect pests	X		X	X	X	X	X	X	L	0	5	5	5	5	20	10	HIGH
		Opportunity for direct and indirect Employment (Unskilled labour)		X	X		X		X		L	-	-	-	-	-	-	-	P
		Opportunity for wealth creation		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Opportunity for Corporate Social Responsibility		X	X	X	X	X	X	X	L	-	-	-	-	-	-	-	P
		Gender imbalance	X		X		X	X	X		L	0	1	5	3	3	12	8	HIGH
		Potential for skills acquisition		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Pressure on existing infrastructure and services (Water, Electricity, Recreational facilities, Health facilities, and others)	X		X		X		X		L	0	3	5	5	3	16	10	HIGH
		Third party agitation	X		X		X	X	X		L/ W	0	5	5	5	3	18	10	HIGH
		Attack from wild/predatory animals (Snakes, Scorpions)	X		X		X	X	X		L	0	1	3	3	3	10	6	HIGH
		Exposure to radioactive materials	X		X	X	X		X		L	3	5	3	3	3	17	6	HIGH
		Crime and insecurity (Kidnapping,	X		X		X		X		L	0	5	5	5	5	20	10	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Hostage-taking, armed robbery, Militancy)																	
Commissioning	Well testing,	Potential for explosion	X		X		X	X	X	X	L	0	5	5	5	3	18	10	HIGH
	Commissioning & Handover	Increase in Business opportunities		X	X	X	X	X	X		L/ W	-	-	-	-	-	-	-	P
		Gas flaring from well tests	X		X		X		X		L	3	5	5	5	5	23	10	HIGH
		Increase in noise & vibration nuisance	X		X		X	X	X	X	L	3	3	3	5	5	19	8	HIGH
		Generation of waste (Pigging waste, domestic waste, metal scraps, plastics)	X		X			X	X		L	3	3	3	3	3	15	6	HIGH
		Contamination of environment	X		X	X	X		X		L	3	3	3	3	3	15	6	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Work related injury/fatality of workforce	X		X		X	X	X	X	L	3	3	3	5	5	19	8	HIGH
		Non work related injury/fatality of workforce	X		X		X	X	X	X	L	0	3	3	3	5	14	6	HIGH
		Increase in explosion potential	X		X		X	X	X	X	L	0	5	5	5	3	18	10	HIGH
		Increase in diseases STIs, HIV/AIDS	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Increase in endemic diseases (Malaria, Typhoid, RTI)	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Development of infrastructures and economic		X	X	X	X	X	X		L/ W	-	-	-	-	-	-	-	P

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		enhancement (GMoU)																	
		Increase in traffic volume & accident potential/injuries	X		X		X	X	X	X	L	0	5	3	3	3	14	6	HIGH
		Tank leaks	X		X		X		X		L	3	5	3	5	3	19	8	HIGH
		Opportunity for direct and indirect Employment (Unskilled labour)		X	X		X		X		L	-	-	-	-	-	-	-	P
		Opportunity for wealth creation		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Loss of Employment (local labour) (Boom burst cycle)	X		X	X	x		x		L	3	5	5	3	5	21	8	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Third party agitation	X		X		X	X	X		L/ W	0	5	5	5	3	18	10	HIGH
		Attack from wild animals (Snakes, Scorpions)	X		X		X	X	X		L	0	1	3	3	3	10	6	HIGH
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy)	X		X		X		X		L	0	5	5	5	5	20	10	HIGH
		Increased exposure to carcinogenic substances	X		X		X		X		L	3	5	3	5	3	19	8	HIGH
		Alcohol and drug abuse	X		X			X	X	X	L/ W	0	5	5	5	5	20	10	HIGH
		Increase traffic, potential for	X		X		X	X	X	X	L	0	5	3	3	3	14	6	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
Demobilization		accidents and injuries																	
		Impairment in air quality	X		X		X		X		L	3	3	3	3	5	17	6	HIGH
		Increase in noise and vibration	X		X		X	X	X	X	L	3	3	3	5	5	19	8	HIGH
		Increase in crime rate	X		X		X		X		L	0	5	5	5	5	20	10	HIGH
		Waste generation (Scrap metals, Woods, Food waste)	X		X			X	X		L	3	3	3	3	3	15	6	HIGH
		Opportunity for contracting		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Opportunity for direct and indirect Employment (Unskilled labour)		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Loss of Employment (local labour)	X		X	X	x		x		L	3	5	5	3	5	21	8	HIGH
		Third party agitation	X		X		X	X	X		L/ W	0	5	5	5	3	18	10	HIGH
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy)	X		X		X		X		L	0	5	5	5	5	20	10	HIGH
		Increase in RTIs due to dust particles	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Social dislocation	x		x		x		x		L	0	5	5	5	5	20	10	HIGH
		Increased exposure to carcinogenic substances	X		X		X		X		L	0	5	3	5	3	16	8	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Alcohol and drug abuse	X		X		X		X		L	0	3	3	3	3	12	6	HIGH
Operation	Well work-over, Gas production,	Potential for environmental contamination due to gas leaks	X		X		X		X		L	3	3	3	3	5	17	6	HIGH
		Increase in business opportunities		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Increase in potential for injury/fatality of workforce & third parties	X		X		X	X	X	X	L	0	5	3	3	3	14	6	HIGH
		Revenue generation for government and SPDC		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Increase in potential for	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH

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Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		sabotage of facilities																	
		Reduction in gas flaring		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Increase in diseases STIs HIV/AIDS	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Prevalence in endemic diseases (Malaria, Typhoid, RTI)	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH
		Opportunity for contracting		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P
		Opportunity for direct and indirect Employment (Unskilled labour)		X	X	X	X	X	X		L	-	-	-	-	-	-	-	P

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Third party agitation	X		X		X	X	X		L/ W	0	3	3	3	3	12	6	HIGH
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy) and other social vices	X		X		X		X		L	0	5	5	5	5	20	10	HIGH
		Waste generation (Scrap metals, Woods, Food waste)	X		X			X	X		L	3	3	3	3	3	15	6	HIGH
		Increased exposure to carcinogenic substances	X		X		X		X		L	0	5	3	5	3	16	8	HIGH
		Alcohol and drug abuse	X		X		X		X		L	0	3	3	3	3	12	6	HIGH

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		Contamination of surface water/Sediment	X		X	X	X		X		L	3	3	3	3	3	15	6	HIGH
Decommissioning and abandonment	Removal of surface installations Plugging of wells Site restoration	Increase in potential for water contamination	X		X	X	X		X		L	3	3	3	3	3	15	6	HIGH
		Increase in litigation potential	X		X	X	X	X	X		L/ W	3	3	3	3	3	15	6	HIGH
		Loss of revenue for Govt. & SPDC	X		X		X	X		X	L/ W	0	5	3	3	3	14	6	HIGH
		Loss of job by community surveillance team	X		X	X	X		X		L	3	5	5	3	5	21	8	HIGH
		Increase in usable land		X	X		X		X		L	-	-	-	-	-	-	-	P

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		resource to the community																	
		Opportunity for contracting		X	X		X		X		L	-	-	-	-	-	-	-	P
		Opportunity for direct and indirect Employment (Unskilled labour)		X	X		X		X		L	-	-	-	-	-	-	-	P
		Third party agitation	X		X		X	X	X		L/ W	0	3	3	3	3	12	6	HIGH
		Crime and insecurity (Kidnapping, Hostage-taking, armed robbery, Militancy) and other social vices	X		X		X		X		L	0	5	5	5	5	20	10	HIGH
		Waste generation	X		X			X	X		L	3	3	3	3	3	15	6	HIGH

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project phase	Project activity	Description of impact	IMPACT QUALIFICATION									IMPACT QUANTIFICATION							
			ADVERSE	BENEFICIAL	DIRECT	INDIRECT	SHORT TERM (<3 months)	LONG TERM (>3 Months)	REVERSIBLE	IRREVERSIBLE	LOCAL OR WIDESPREAD	LEGAL	RISK FACTOR	FREQUENCY	IMPORTANCE	PUBLIC INTEREST	TOTAL	F + I	IMPACT RATING
		(Scrap metals, Woods, Food waste)																	
		Increased exposure to carcinogenic substances	X		X		X		X		L	0	5	3	5	3	16	8	HIGH
		Alcohol and drug abuse	X		X		X		X		L	0	3	3	3	3	12	6	HIGH
		Prevalence of STIs HIV/AIDS	X		X		X	X	X	X	L	0	3	3	3	3	12	6	HIGH

5.8: Existing impacts of facilities in the study area

Project Phase	Project Activity	Environmental Aspects	Observed Impacts
OPERATIONS AND MAINTENANCE	Operation of Flowstations, (at Yokri, North Bank, South Bank, Estuary and Forcados estuary, Forcados Terminal (at Ogulagha) clusters, pipelines and manifolds	Air Quality	When 2001 data was compared with 2012/13 and the 2018 using ANOVA (non-parameteric) at 95% confidence level the results did not show any significant difference. However, VOCs showed a marginal decreasing (P=0.06) trend which was attributed to improved management of associated gas in line with government's flare out policy. Although not statistically significant, noise and SPM showed apparent increasing trends. The increasing trend in noise is attributed to varied oil and gas operations as well as ship traffic in the area while that of the SPM is associated with the worsening particulate pollution (black soot) in the Niger Delta with illegal refining of petroleum products as a major culprit. Comparison of results of PM10 particulate fraction in the proposed project area and control (t-test) showed that the project area had a significantly higher concentration suggesting that ongoing activities in the area such as illegal refining and Flow station operation have negative impact on particulate levels.
		Surface water	Comparison of 2001 surface water (physicochemical & microbiological) quality data with 2012/2013 and the 2018 data using ANOVA (non-parametric) at 95% confidence level showed significant increasing/decreasing trends in many parameters particularly from 2012 (wet season) to 2018 (wet season). Increasing trends were recorded in salt related parameters (pH, conductivity, TDS, major cations), organic pollution indicators (BOD, COD), heavy metals (Zn, Fe,Cu), bacteria (THB, Total

Project Phase	Project Activity	Environmental Aspects	Observed Impacts
			coliforms). Significant decreasing trends were recorded in dissolved oxygen, phosphate, chloride, sulphate and fungi. The increase in BOD and COD and the concomitant decrease in DO is attributed to a general increase in organic pollution not limited to the project area but possibly associated with both marine and land-based inputs. For the salt parameters such as conductivity the increase was higher around the proposed NAG well compared to control showing that operations within area including Forcados terminal and other associated facilities had significant impact on salt content of surface waters. A similar effect was seen in bacterial and heavy metal trends.
		Sediment	Comparison of 2001 sediment physicochemical and microbiological parameters from Estuary Flow station and NAG wells with 2012/2013 and 2018 data using anova (non-parametric) at 95% confidence level showed significant differences ($p<0.05$) particularly between the 2012/13 and 2018 data. Significant increasing trends were recorded in exchangeable cations (salt ions), hydrocarbons (O&G, TPH), heavy metals (Cd, Zn, Cu, Fe, Cr). For exchangeable cations and the heavy metals, the increase was widespread including the controls indicating that the source of the impact may include both operations from the Forcados Terminal and land-based inputs.

Project Phase	Project Activity	Environmental Aspects	Observed Impacts
			For hydrocarbons, the increase was more prominent around the proposed NAG well areas compared to control indicating direct impact from existing facilities and other marine based activities in the area. In contrast, significant reducing trend was observed in TOC levels, a possible indication of increasing beach erosion and associated supply of organically-poor sediments to the water.
		Socioeconomics	Increase in income of members of the community as a result of employment generating activities from oil and gas exploration

CHAPTER SIX
MITIGATION MEASURES

6.1 Introduction

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

The mitigation measures proposed are in keeping with the following:

- Department of Petroleum Resources guidelines and standards,
- Environmental laws at national, regional and international levels,
- FMEnv (formerly FEPA, 1991) regulations on oil and gas exploration and waste management
- Delta 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 - Minimize the effects or consequences of those significant associated and potential impacts that cannot be prevented to a level as low as reasonably possible by implementing operational and management measures.
- Control - Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practical.

6.2 Mitigation Measures

A summary of the mitigation measures is presented in Tables 6.1. and 6.2. These measures are recommended to ameliorate all the significant impacts of existing facilities and significant associated and potential impacts for the proposed Project.

Table 6.1: Mitigation Measures for Existing Impacts of the Project

Project Activity	Environmental Aspects	Description of Impacts	Rating before mitigation	Mitigation measures	Rating after mitigation
Operations and Maintenance	Air quality	Increase in SPM levels Increase in Noise levels	M	SPDC shall: use only pre-mobbed regularly maintenance of vehicles, vessels, generators and other machines. use of wet scrubbers for all emission sources Upgrade to high efficiency flare nozzle	L
	Surface water	Increase in pH, conductivity, TDS, major cations), BOD and COD Increase in Zn, Fe and Cu Increase in THB, Total coliforms and decrease in dissolved oxygen, phosphate, chloride, sulphate	M	SPDC shall: treat all effluents to regulatory limits before discharging into the environment. dispose all waste in line with regulatory approval activate existing oil spill contingency plans in the event of oil spill. ensure that disposal of drilling wastes is in line with regulatory standards activate existing oil spill contingency plans in the event of oil spill. manage all radioactive wastes according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the waste shall be placed. These bunkers shall be inspected by NNRA. control the rate of release of hydrotest water	L

Project Activity	Environmental Aspects	Description of Impacts	Rating before mitigation	Mitigation measures	Rating after mitigation
				ensure that inhibited hydrotest water is properly evacuated out of site to the appropriate treatment plant	
	Sediment	Increase in O&G, TPH Increase in Cd, Zn, Cu, Fe, Cr Increase in exchangeable cation	M	SPDC shall: treat all effluents to regulatory limits before discharging into the environment. dispose all waste in line with regulatory approval activate existing oil spill contingency plans in the event of oil spill. ensure that disposal of drilling wastes is in line with regulatory standards activate existing oil spill contingency plans in the event of oil spill. manage all radioactive wastes according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the waste shall be placed. These bunkers shall be inspected by NNRA. control the rate of release of hydrotest water ensure that inhibited hydrotest water is properly evacuated out of site to the appropriate treatment plant	L

Table 6.2: Mitigation Measures for Significant Associated and Potential Impacts of the Proposed Project

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
Mobilization	Impairment of air quality from emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed regularly maintenance of vehicles, vessels, generators and other machines. use of wet scrubbers for all emission sources use of mufflers for vehicle exhaust. Upgrade to high efficiency flare nozzle	L
	Increase in incidence of STIs including HIV/AIDS	H	SPDC shall ensure: pre-employment and regular medical check-up for project work force condoms are provided for workers access control into the camp is ensured Health awareness is conducted for workers on the mode of transmission of STIs (including HIV/AIDS)	L
	Increase in noise and vibration/levels	H	SPDC shall:	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			use only pre-mobbed and regularly maintained equipment and vehicles	
	Interference with water transport	H	SPDC shall: ensure that the cluster is located outside the border of the navigation fairway in keeping with government regulations requiring the fairway to be kept free and open to water transport traffic ensure that Vessel/boat operators observe recommended speed limits ensure that only certified vessel/boat operators shall be employed.	L
	Kidnappings	H	SPDC shall: make adequate security arrangements throughout the activity ensure that security orientation and awareness is conducted for workforce.	L
	Influx of workers into the host Communities/ change in local population	H	SPDC shall: ensure that movement of unauthorized persons into camps is strictly restricted	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			provide basic recreational facilities for workers within their camps	
	Changes in culture, lifestyle and habits	H	SPDC shall: carry out enlightenment campaigns to encourage positive influences on cultural values and healthy lifestyles (e.g. breast-feeding habits, alcohol and drug use, exercise, and high moral values with regard to sexuality etc.) and discourage adverse influences (e.g. prostitution, drug abuse, alcoholism etc.)	L
	Increase in social vices	H	SPDC shall ensure: awareness campaign and health education is undertaken in the community	L
	Increase in inflation level	H	SPDC shall: enhance the local communities by supporting entrepreneurial skill development through training and empowerment schemes.	L
	Pressure on existing infrastructures and utilities	H	SPDC shall: make adequate accommodation arrangement prior to mobilization of workforce to reduce pressure on local housing.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			support the available health facility. provide basic recreational facilities for workers within their camps. extend water supply from camps/worksites to communities at strategic points	
	Third party agitations	H	SPDC shall: ensure effective consultation with stakeholders ensure commitment and transparent adherence to P-GMoU programmes. identify and address legacy issues promptly.	L
Construction	Loss of flora and fauna	H	SPDC shall: ensure that hunting by the workforce is prohibited educate construction workers and host communities on the sensitive nature of the biodiversity of the area and the need for conservation	L
	Loss of habitat	H	SPDC shall:	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			encourage the re-vegetation of land cleared for temporary use within the ROW. ensure that there is no land take or clearing of vegetation outside ROWs.	
	Third party agitation	H	SPDC shall: ensure that all host communities are represented in the employment of locals during land clearing and excavation to avert any conflict that could arise from perceptions of unfairness abide by all P-GMoUs signed with the host communities. encourage the use of host community contractors ensure access control is implemented at work site ensure compliance with all HSE policies and standards	M
	Increased level of noise and vibration with possible hearing loss	H	SPDC shall: use only pre-mobbed and regularly maintained equipment and vehicles.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			use equipment with low noise level. ensure that PPE are provided and used by all site workers. alert communities in advance of the activities that are likely to increase noise and vibration levels ensure effective access control to work sites.	
	Increase in dust, fumes, and reduction in air quality	H	SPDC shall: use only pre-mobbed and regularly maintained equipment, machines and vehicles. spray construction sites with water to reduce dust levels especially during dry season.	L
	Threats to health of workers (wildlife attack, insect bites, injuries etc)	H	SPDC shall: provide and ensure usage of PPE by field workers. ensure that an adequate numbers of trained first aiders are available at work sites ensure that anti-venom/anti-histamine is provided on site to mitigate snake bites and insect stings.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			ensure that awareness is created among site workers on the likelihood of exposure to poisonous wildlife and plants. enforce Expatriate malaria policy. undertake Vector control to reduce incidence of malaria (such as regular spraying of camp and provision of insecticide treated nets) (ITN). undertake Awareness campaign to enlighten the communities/field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values. provide site clinic to take care of minor illnesses for all workers. provide condoms for construction workers.	
	Influx of labour and followers (dependants, bounty seekers, CSWs, etc)	H	SPDC shall: liaise with the appropriate NGOs to provide Health awareness campaigns and seminars for the community on STIs (including HIV/AIDS)	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			abuse of drugs, alcohol and other relevant matters. support skills acquisition and empowerment schemes for community.	
	Opportunity for contracting and employment	P	SPDC shall: ensure adherence to local content policy.	
	Third party agitation	H	SPDC shall: ensure effective consultation with stakeholders ensure commitment and transparent adherence to P-GMoU programmes. identify and address legacy issues	L
	Traditional occupation (farming, fishing, hunting) could be adversely affected from construction operations	H	SPDC shall: support skills acquisition and empowerment schemes to facilitate occupational proficiency, productivity, and sustainability.	L
Drilling	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed vehicles regularly maintainance of vehicles, vessels, generators and other machines.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			use of wet scrubbers for all emission sources use of mufflers for vehicle exhaust. Upgrade to high efficiency flare nozzle	
	Noise and vibration nuisance	H	SPDC shall: use only pre-mobbed and regularly maintained equipment with low noise level. ensure that appropriate PPE are provided and used. ensure use of sound-proof power generating sources.	L
	Contamination of surface and groundwater	H	SPDC shall: treat all effluents to regulatory limits before discharging into the environment. dispose all waste in line with regulatory approval activate existing oil spill contingency plans in the event of oil spill. ensure that disposal of drilling wastes is in line with regulatory standards	L
	Increase in social vices	H	SPDC shall ensure:	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and STIs in the communities and among workers throughout the life of the project. ensure that contractor enforces the alcohol and drug policy for staff	
	Injuries and death from blowouts	H	SPDC shall ensure that: only skilled personnel and certified equipment are used high quality chemicals and materials are used emergency response procedures are in place Job hazard identification is conducted daily pep talks are conducted on identified hazards	L
	Opportunities for business and employment	P	SPDC shall: ensure adherence to local content policy	L
	Sediment and Surface water pollution from	H	SPDC shall: treat drill cuttings in approved thermal desorption unit (TDU).	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
	chemicals, drill cuttings, and mud		recover drilling mud for re-use. evacuate all new wells into the closest existing flowstation. drill wells with Pseudo Oil Based Mud in top hole. provide Rig with improved solid control equipment so as to assist in preventing dumping of mud. Treat water based mud in TDU. grind excess cement into slurry and take to TDU. retrieve and transfer stimulation chemicals carefully into flow-back tanks and treat in TDU recycle brine for initial completion; treat excess brine as other chemicals and sent to TDU. develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice.	

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			segregated all industrial wastes such as plastics, metals, rubber and wood on site and collect in designated containers and transport to base for disposal	
	Third party agitation	H	SPDC shall: ensure effective consultation with stakeholders. ensure commitment and transparent adherence to P-GMoU programmes. identify and address legacy issues. identify and properly engage the communities through regular consultation with stakeholders (Government, Communitiy, NGOs, CBOs etc) and implement MOUs	L
	Accidents, injuries and possible fatalities	H	SPDC shall ensure that: only skilled/certified personnel, and certified equipment are used emergency response procedures are in place. Job hazard identification has been conducted.	L
	Increase in noise and vibration levels	H	SPDC shall	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			use only pre-mobbed and regularly maintained equipment. use equipment with low noise level ensure that appropriate PPE are provided and used	
	Contamination of the environment by wastes	H	SPDC shall ensure: regular collection and monitoring of wastes from cradle to grave in accordance with SPDC's waste management plan. all oily wastes are properly segregated and contained before proper disposal. sanitary wastes are treated in a sewage treatment plant. domestic non-hazardous wastes are disposed at government approved dump sites domestic hazardous wastes are segregated and sent to approved waste disposal sites. sanitary wastes are bagged and treated at approved Sewage treatment Plant.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			sediment materials are collected by waste management contractor and disposed at dumpsites whenever necessary. top hole drill cuttings aree sent to TDU mud cuttings are turned to slurry and sent to TDU. waste fluids such as spent mud, deck wash-off and storm water are collected and sent to TDU. work over fluids such as brine and inhibited water are collected and sent to TDU. rags (clothing, worn coveralls, shirt, trousers), are segregated and sent to approved dump site. miscellaneous domestic waste, old tooth brushes/disposable razors etc/old footwear, hand gloves etc and garbage, are segregated and sent to approved dump site. general paper waste are segregated and sent to approved recycling plant. plastic containers are sent to approved recycling plant.	

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			chemical drums are sent to approved waste manager. kitchen waste (garbage) are segregated and sent to approved composite site. forest tree cuttings, wood scraps (survey stakes, crating/pallets) are offered to local communities as fire wood/fabrication materials. adequate waste management is enforce on site. disposal of drilling wastes is in line with regulatory standards.	
Pipe Laying	Noise and Reduction in air quality (generation of dust; exhaust fumes)	H	SPDC shall: use only pre-mobbed and regularly maintained equipment and vehicles. ensure that appropriate PPE are provided and used. install mufflers on machineries and use low noise equipment. ensure that staff use hearing protection.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			adhere strictly to noise regulations including noise mapping and restriction of entry into high noise zones. ensure that all mobile and stationary internal combustion engines are properly maintained. inform communities in advance of likely increase in noise level during trenching. ensure that water is sprayed regularly to reduce dust levels during dry season.	
	Contamination of surface water bodies	H	SPDC shall: treat all effluents to regulatory limits before discharging into the environment. dispose all waste in line with regulatory approval. activate existing oil spill contingency plans in the event of oil spill. manage all radioactive wastes according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the waste shall be placed. These bunkers shall be inspected by NNRA.	L

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
	Injury/fatalities in workforce	H	SPDC shall: ensure only skilled personnel and certified equipment are used. ensure that emergency response procedures are in place. ensure that trenches are backfilled as quickly as possible. put adequate number of barriers and warning signs close to open trenches. ensure that Safe Handling Of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of materials. ensure that job hazard analysis is done. ensure that HSE standards are strictly adhered to. ensure that Permit to work and proper briefing is given before any work action.	L
	Job creation	P	SPDC shall: Ensure adherence to local content policy	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
	Skills acquisition	P	SPDC shall: enhance the local communities by supporting entrepreneurial skill development through training and empowerment schemes	L
	Business opportunities/Economic enhancement	P	SPDC shall: ensure that the P-GMoU is strictly adhered to.	L
	Destruction of vegetation and fauna population	H	SPDC shall ensure that: trenching activities is restricted to ROW. SPDC policy on no hunting by workers is enforced.	L
	Increase in potential for water traffic volume and risk of accidents/ injury	H	SPDC shall ensure that: compliance with SPDC journey management policy for water transport only pre-mobbed vehicles are used daily pep talk is carried out for water transportation vehicle monitoring and communication devices are installed and monitored.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			community awareness is raised on unusual activity through the community relations team. first aid boxes are provided in operational vehicles. Emergency response plan is in place	
	Surface water degradation from waste disposal ,spills and leaks	H	SPDC shall ensure that: Safe Handling of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals. Appropriate waste management procedures will be employed. Appropriate remediation techniques will be employed (RENA)	L
	Potential for inhalation of welding fumes and injuries to eyes associated to glares and sparks.	H	SPDC shall: ensure that job hazard analysis is done. ensure that workers adhere to work method statement associated with welding. ensure that adequate safety measures (appropriate PPE) are put in place to avoid inhalation of welding fumes.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
	Potential for conflicts arising from labour issues (welders)	H	SPDC shall: encourage the use of host community contractors. ensure sourcing of relevant workforce from host communities. ensure access control is implemented at work site. ensure compliance with all HSE policies and standards	L
	Contamination of surface water and from inhibited hydrotest water	H	SPDC shall: control the rate of release of hydrotest water ensure that inhibited hydrotest water is properly evacuated out of site to the appropriate treatment plant	L
	Potential increase in incidents (arising for example from high pressure of pipes during hydrotest)	H	SPDC shall place warning signs, barrier tapes near the high pressure pipes to restrict people during hydrotesting. JHA will be performed Regular pep talks	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
Demobilization	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: use only pre-mobbed regularly maintenance of vessels, generators and other machines. use of wet scrubbers for all emission sources use of mufflers for vehicle exhaust. Upgrade to high efficiency flare nozzle	L
	Increase in potential for water traffic volume and risk of accidents/ injury	H	SPDC shall ensure that: compliance with SPDC journey management policy for water transport only pre-mobbed vehicles are used daily pep talk is carried out for water transportation vehicle monitoring, and communication devices are installed and monitored. community awareness is raised on unusual activity through the community relations team. first aid boxes are provided in operational vehicles.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			Emergency response plan is in place	
	Improper disposal of materials removed from site.	H	SPDC shall ensure: all removed materials are properly disposed of and monitored from cradle to grave. scrap metals are collected, segregated and sent to approved dump sites. plastic wastes are sent to approved waste recycling depot (WRD). contaminated soils are excavated and sent to TDU. radioactive wastes/materials are managed according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the wastes shall be placed. These bunkers shall be inspected by NNRA. SPDC waste management policy is enforced.	L
	Increase in noise and vibration level	H	SPDC shall: use only pre-mobbed and regularly maintained equipment and vehicles/sea going vessels.	L
	Loss of employment/ income	H	SPDC shall:	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities. ensure the implementation of the local content policy	
Operations and Maintenance	Environmental pollution arising from improper disposal of lubricants and oily debris	H	SPDC shall: ensure all oily wastes are properly segregated and contained before disposal. ensure all oily wastes are properly disposed of and monitored from cradle to grave. ensure regular clean-up of equipment at site. ensure that chemicals are stored in bund walled areas with rain protection provide containment for chemicals and liquid discharges. SPDC waste management policy shall be enforced ensure that a controlled fuelling, maintenance and servicing protocol for construction	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			machinery at worksite is established and followed to minimize leaks and spills spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of used chemical drums and containers are sent to an approved WRD. small chemicals spills, crude oil and aqueous effluents are cleaned and the area restored to its original status	
	Equipment failure and damage leading to injuries/ fatality	H	SPDC shall ensure that: only skilled personnel and certified equipment are used. certified first Aiders are available at every site. First aid boxes and emergency response procedures are in place hazard identification has been conducted. community members are not allowed to settle near the gas plant fence. emergency response procedures are in place. Safe Handling Of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			available on site to provide information on safe handling of chemicals. HSE standards are strictly adhered to. Permit to work and proper briefing is given before any work action.	
	Revenue generation to government and company	P	SPDC shall: adhere to P-GMoU programmes.	
	Increase in noise levels	H	SPDC shall: use only pre-mobbed and regularly maintained equipment and vehicles and vessels	L
	Gas leaks	H	SPDC shall ensure: that a controlled fuelling, maintenance and servicing protocol for operation machinery at worksite is established and followed to minimise leaks emergency response shall be activated in the event of an incidence	L
	Employment and income generating opportunity	P	SPDC shall ensure adherence to local content policy	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
Decommissioning and Abandonment				
	Increase in noise and vibration/levels	H	SPDC shall use only pre-mobbed and regularly maintained equipment and vehicles Appropriate PPEs	L
	Interference with water transport	H	SPDC shall ensure Vessel/boat operators observe recommended speed limits only certified vessel/boat operators are employed.	L
	Kidnappings	H	SPDC shall : make adequate security arrangements, and project site ensure that security orientation and awareness is conducted for workforce.	L
	Impairment of air quality from fumes, dust, including greenhouse gases	H	SPDC shall: ensure Vessel/boat operators observe recommended speed limits	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			only certified vessel/boat operators are employed.	
	Third party agitations	H	SPDC shall ensure effective consultation with stakeholders ensure commitment and transparent adherence to P-GMoU programmes. identify and address legacy issues promptly.	L
	Potential for falls into exposed trenches (by animals, unsuspecting passers-by)	H	SPDC shall: ensure that trenches are backfilled quickly. shall put adequate number of barriers and warning signs close to open trenches.	L
	Contamination of surfacewater	H	SPDC shall: treat all effluents to regulatory limits before discharging into the environment. dispose all waste in line with regulatory approval activate existing oil spill contingency plans in the event of oil spill.	L

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation
			ensure that disposal of drilling wastes is in line with regulatory standards.	
	Injury/ fatalities in workforce	H	SPDC shall ensure that: only skilled personnel, certified equipment, and pre-mobbed vehicles and vessels are used. emergency response procedures are in place. Safe Handling Of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals. job hazard analysis is done.. HSE standards are strictly adhered to. Permit to work and proper briefing is provided before any work action.	L

CHAPTER SEVEN
ENVIRONMENTAL MANAGEMENT PLAN

7.1 General

Environmental management is concerned with a planned and integrated programme aimed at ensuring that adverse impacts of a proposed project are contained and brought to acceptable minimum levels, while the positive impacts are enhanced to optimize the benefits. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project development, from feasibility study to abandonment.

In keeping with Shell policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design, up to the present stage of EIA and will continue throughout the project life cycle. This report is part of the environmental management process and is intended to provide an environmental input into the planning and execution of the project.

The Environmental Management Plan was developed in accordance with the provisions of ISO 14001, sections 4.3.2 - 4.3.4, which are reflected in SPDC HSE-MS Manual, sections 1.4 and 4.2 from which the project's HSE -MS is derived. The project's HSE-MS addresses the overall approach adopted for management of HSE risks through the project development phases.

Good environmental management, which is part of SPDC's HSE-MS goals, has the following long-term objectives:

- Ensure compliance with legislation and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified in this environmental impact assessment are implemented, a comprehensive EMP was developed (Table 7.1).

7.2 SPDC's Corporate HSE Programme

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislation but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be affected directly or indirectly by their activities.

The Environmental Management activities instigated by SPDC are intended to implement the above policy and the policy will be applied to all stages of this project from project feasibility to decommissioning.

7.3 Environmental Assessment

Environmental Assessment is a project-targeted process whereby established procedure are used for examining and assessing environmental effects, both direct and indirect, from feasibility studies, pre-conceptual design, conceptual design, detailed design, site preparation and construction, commissioning, operation and maintenance and abandonment. The Environmental Assessment began as soon as the project team was assembled, including an Environmental focal point. The role of an environmental focal point is to advise the project manager and ensure that environmental matters are fully considered, and that impacts of the project on the environment, and of the environment on the project, are minimized.

SPDC has established procedures for assessing the impacts of projects on the environment. These procedures include:

- Identifying the source and characteristics of all wastes generated;
- Quantifying emissions and discharges to the environment;
- Quantifying and qualifying land-take and its direct effect on terrestrial ecology.

In assessing the environment of this project, it has been determined that:

- The environment is ecologically rich and sensitive; therefore, extreme care needs to be taken to minimize adverse impacts;
- Identifying sensitive marine habitats prior to commencement of construction operations and taking special care to avoid them during construction will minimize damage to aquatic fauna. These areas include mangrove shorelines, tidal flats, marshes, etc.
- All chemical spills, gas leaks and fire contingency plans must be well in place before operation commences.

This environmental assessment will continue to evolve along with the project and is in fact the iterative process of impact mitigation, monitoring and audit and will continue throughout the life of this project.

7.4 Basis for Monitoring/ Surveillance

The work scope that outlines the activities to be carried out is given in chapter 3 of this report. Based on the project activities, baseline data and the identified impacts, the monitoring objectives are given below.

7.5 Monitoring Objectives

To measure and quantify the impacts of the project development on the receiving environment, the following objectives are established:

- to monitor emissions and discharges at all stages of project development to ensure they meet local, national and SPDC standards;

- to determine whether environmental changes are results of development or a result of natural variation;
- to determine the effectiveness of the ameliorating measures;
- to determine long term impact.
- determine the duration of return to normalcy of the water quality of the project area and enrich our data bank.

7.6 Impact Indicators to be monitored

In identifying impact indicators, priority is given to environmentally sensitive areas, which in this case, is the marine environment. The project area is a Brownfield, with flowstations, pipe/flowlines and dredged slots, and thus has residual identified impacts from past studies. Based on the results of baseline studies and consideration of FMEnv/ DPR limits, Table 7.1 gives the proposed monitoring programme for the FYIP.

7.7 Monitoring Focal Point

During all phases of project development (site preparation, construction/installation, operations, maintenance and abandonment), SPDC shall incorporate into the project team, an appropriately qualified environmental specialist, who will function as an Environmental Adviser (EA), to liaise with the Contractor, Quality Assurance Engineers and relevant SPDC departments on all environmental matters. The specialist shall be the focal point for all environmental matters, which will include all actions relating to detailed design reviews and monitoring of construction, operation, decommissioning and abandonment phases of the project.

7.8 Resourcing

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. 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 development of this project.

7.9 Environmental Audits

SPDC, as part of its programme on environmental management had instituted audit schemes aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management. This audit is developed and reviewed annually by SPDC environmental audit committee. The audits are focused on areas of project perceived as having the highest environmental risk.

SPDC integrated audit programme is such that external members such as SIPM or other Shell companies could participate. It is 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 requirements/targets.

7.10 Responsibilities and Training

Within SPDC, environmental protection, like safety, is a line responsibility for which staff at all levels has accountability. The environmental specialist assists the line management with advice on environmental matters from an expert point of view. However, responsibility and accountability are clearly defined, from senior management who allocate resources and monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace and surrounding area. All staff will be made aware of their responsibilities through induction and training courses as outlined in the projects' HSE-MS document. In addition, procedures, guidelines and notices will advise staff on how to respond in the event of an environmental emergency. The Shell Corporate Environment Department is responsible for monitoring and auditing the environmental activities of this project.

7.1: Environmental Monitoring Plan for FYIP NAG Project

Environmental component	ASSOCIATED LIMITS		MONITORING PROGRAMME				
	Regulation / Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency during Project Life cycle	Phase 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 (µg/m3) Total SPM: 60-90 Carbon monoxide: 10 SO2: 100-150 NO2: 150	Particulates, NO2, SO2, VOC, CO, H2S, NH3, Noise levels, heavy and trace metals in ambient air	Around the NAG well	Weekly	During well drilling During pipeline laying	In-situ measurement using Portable Hand-held Environmental sensor meters
Surface water	Baseline data	-	pH, TSS, Turbidity, Heavy metals and Organics	Around the NAG well (upstream and downstream)	Monthly	During well drilling During pipeline laying	Sample collection and analysis in an external approved laboratory.
Sediment	Baseline data	-	pH, Heavy metals, Exchangeable cations and Organics	Around the NAG well (upstream and downstream)	Monthly	During well drilling During pipeline laying	Sample collection and analysis in an external approved laboratory.
Sewage Effluent	DPR EGASPIN II 3.5.6 Table II-6 (limitations of treated sanitary	-	Residual Chlorine, BOD, TSS, Fecal Coliform colonies, DO	Sewage Treatment plan discharge point	Weekly	During well drilling	Sample collection and analysis in an external approved laboratory.

Environmental component	ASSOCIATED LIMITS		MONITORING PROGRAMME				
	Regulation / Standard	Requirements/ Limits	Parameters to be monitored	Sampling Location	Frequency during Project Life cycle	Phase during Project Life cycle	Data collection method
	wastewater)						
Effluent (storm water)		p H: 6.5 to 8.5 EC:900mhos/cm Oil and grease: <5mg/l Turbidity: ≤10% of the receiving medium	Physio-chemical parameters (pH, Total Suspended Solids, Alkalinity, Nitrate, Turbidity, Sulphate and Salinity, Oil and grease, TPH, PAH. Heavy metals and other metals (Ni, Zn, Cu, Fe, Mn, Pb, Cr, and V)	Storm water exit point from the rig	Monthly	During well drilling	Sample collection and analysis in an external approved laboratory.

Table 7.2: Environmental Management Plan for FYIP NAG Project

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
Mobilization	Impairment of air quality from emissions of air pollutants including greenhouse gases	H	SPDC shall: · use only pre-mobbed vessels and vehicles · regular maintenance of vehicles, vessels, generators and other machines. · use of wet scrubbers for all emission sources · use of mufflers for vehicle exhaust. · Upgrade to high efficiency flare nozzle	L	• Premob certificates • Maintenance records • Compliance Monitoring Reports	• Monthly • Monthly • Quarterly	Project Manager
	Increase in incidence of STIs including HIV/AIDS in neighbouring community	H	SPDC shall ensure: · pre-employment and regular medical check-up for project work force · condoms are provided for workers · access control into the camp is ensured · Health awareness is conducted for workers on the mode of transmission of STIs (including HIV/AIDS)	L	• Medical records • Stocking records and availability of condoms • Perimeter fence/ID card/Access Control • Records of awareness campaign programs	• Monthly • Monthly • Periodic • Quarterly	Project Manager
	Increase in noise and vibration/levels	H	SPDC shall: · use only pre-mobbed and regularly maintained equipment and vehicles	L	• Premob certificates • Maintenance records	• Monthly • Monthly	Project Manager
		H	SPDC shall:	L		• Monthly	

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Interference with water transport		· ensure that the cluster is located outside the border of the navigation fairway in keeping with government regulations requiring the fairway to be kept free and open to water transport traffic · ensure that Vessel/boat operators observe recommended speed limits · ensure that only certified vessel/boat operators shall be employed.		• Journey management Procedure • Journey management Records • Community Engagement Records • Government Engagement Records • Employment Records		Project Manager
	Kidnappings	H	SPDC shall: · make adequate security arrangements throughout the activity · ensure that security orientation and awareness are conducted for workforce.	L	• Security Management procedure • Journey management procedure • Record of security situation/updates • Site Inspection records	• Monthly	Project Manager
	Influx of workers into the host Communities/ Increase in local population	H	SPDC shall: · ensure that movement of unauthorized persons into camps is restricted · provide basic recreational facilities for workers within their camps	L	• Records of Access control. • Documentary evidence of implementation and maintenance. • Documentary evidence of access control implementation and maintenance	• Quarterly	Project Manager
		H	SPDC shall:	L		• Quarterly	

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Changes in culture, lifestyle and habits		· carry out enlightenment campaigns to encourage positive influences on cultural values and healthy lifestyles (e.g. breast-feeding habits, alcohol and drug use, exercise, and high moral values with regard to sexuality etc.) and discourage adverse influences (e.g. prostitution, drug abuse, alcoholism etc.)		• Records of enlightenment programs		Project Manager
	Increase in social vices	H	SPDC shall ensure: · awareness campaign and health education is undertaken in the community	L	· Records of campaigns and programs on health	· Quarterly	Project Manager
	Increase in inflation level	H	SPDC shall: · Support entrepreneurial skill development iin the host communities through training and empowerment schemes.	L	· Documentation on beneficiaries	· One off	Project Manager
	Pressure on existing infrastructures and utilities	H	SPDC shall: · make adequate accommodation arrangement prior to mobilization of workforce to reduce pressure on local housing. · support the available health facility. · provide basic recreational facilities for workers within their camps.	L	• Audit records of staff accommodation • Record of support to health facility • Recreation facilities in camps • Functional SPDC-supported water projects in communities	• Quarterly • Monthly • Monthly • Monthly	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· extend water supply from camps/worksites to communities at strategic points				
	Third party agitations	H	SPDC shall: · ensure effective consultation with stakeholders · ensure commitment and transparent adherence to P-GMoU/GMOU programmes. · identify and address legacy issues promptly.	L	• Records of stake holder consultations. • P-GMoU/GMOU implementation reports.	• Quarterly	Project Manager
Construction	Loss of flora and fauna	H	SPDC shall: · ensure that hunting by the workforce is prohibited · educate construction workers and host communities on the sensitive nature of the biodiversity of the area and the need for conservation	L	• Records of enlightenment meetings on biodiversity. • Site inspection Reports • Inspection records on limitation to ROW. • Survey Plan	• Monthly Monthly • Monthly	Project Manager
	Loss of habitat	H	SPDC shall: · encourage the re-vegetation of land cleared for temporary use within the ROW. · ensure that there is no land take or clearing of vegetation outside ROWs.	L	• Records of land restoration activities. • Inspection records on limitation to ROW.	• Monthly	Project Manager
	Third party agitation	H	SPDC shall: · abide by all P-GMoUs/GMOU signed	M	• Records of stake holder consultations.	• Quarterly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			with the host communities. · encourage the use of host community contractors · ensure access control is implemented at work site · ensure compliance with all HSE policies and standards		• P-GMoU /GMOU implementation reports • Contracting Records • Records of Access control. • Records of daily toolbox meetings, and HSE meetings.	• Quarterly • Quarterly • Quarterly • Quarterly	
	Increased level of noise and vibration with possible hearing loss	H	SPDC shall: · use only pre-mobbed and regularly maintained equipment and vehicles. · use equipment with low noise level. · ensure that PPE are provided and used by all site workers. · alert communities in advance of the activities that are likely to increase noise and vibration levels · ensure effective access control to work sites.	L	• Pre-mob and maintenance records • Records of audiometric examination for noise exposed workers. • Records of issuance of PPE and daily use. • Records of Unsafe Acts and Unsafe Conditions (UA/UC) • Environmmental Compliance Monitoring Reports	• Biannually • Yearly. • Monthly • Monthly • Quarterly	Project Manager
	Increase in dust, fumes, and reduction in air quality	H	SPDC shall: · use only pre-mobbed and regularly maintained equipment, machines and vehicles. · spray construction sites with water to reduce dust	L	• Premob certificates • Maintenance records. • Work site HSE inspection reports. • Environmmental	• Monthly • Monthly • Daily/ Weekly Quarterly	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			levels especially during dry season.		Compliance Monitoring Reports		
	Threats to health of workers (insect bites, injuries etc)	H	SPDC shall: · provide and ensure usage of PPE by field workers. · ensure that an adequate number of trained first aiders are available at work sites · ensure that awareness is created among site workers on the likelihood of exposure to poisonous wildlife and plants. · enforce Expatriate malaria policy. · undertake Vector control to reduce incidence of malaria (such as regular spraying of camp and provision of insecticide treated nets) (ITN). · undertake Awareness campaign to enlighten the communities/field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values.	L	• Records of issuance of PPE • Records of Unsafe Acts and Unsafe Conditions • Record of First Aid box inventory • Work site HSE inspection reports	• Biannually • Weekly • Monthly • Quarterly	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· provide site clinic to take care of minor illnesses for all workers. · provide condoms for construction workers.				
	Influx of labour and followers (dependants, bounty seekers, CSWs, etc)	H	SPDC shall: · liaise with the appropriate NGOs to provide Health awareness campaigns and seminars for the community on STIs (including HIV/AIDS) abuse of drugs, alcohol and other relevant matters. · support skills acquisition and empowerment schemes for community.	L	• Records of awareness campaign programs. • Records of Skill acquisition programs	• Biannually	Project Manager
	Third party agitation	H	SPDC shall: · ensure effective consultation with stakeholders · ensure commitment and transparent adherence to P-GMoU programmes. · identify and address legacy issues	L	• Records/reports of Stakeholders consultation meetings. • P-GMoU Implementation reports.	• Annually	Project Manager
	Traditional occupation (farming, fishing, hunting) could be adversely affected from construction operations	H	SPDC shall: · support skill acquisition and empowerment schemes to facilitate occupational proficiency, productivity, and sustainability.	L	• Records of Skill acquisition programs • P-GMoU Implementation reports.	• Annually	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
Drilling	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: · use only pre-mobbed vehicles/vessels · regular maintainance of vehicles, vessels, generators and other machines. · use of wet scrubbers for all emission sources · use of mufflers for vehicle exhaust. · Upgrade to high efficiency flare nozzle	L	• Equipment Premob and maintenance records. • Environmental Compliance Monitoring Reports	•Annually • Monthly • Quarterly	Project Manager
	Noise and vibration nuisance	H	SPDC shall: · use only pre-mobbed and regularly maintained equipment with low noise level. · ensure that appropriate PPE are provided and used. · ensure use of sound-proof power generating sources.	L	• Equipment Premob and maintenance records • PPE issuance records. • Reports of HSE monitoring • Environmental Compliance Monitoring Reports	• Biannually • Monthly • Quarterly	Project Manager
	Contamination of surface and groundwater	H	SPDC shall: · treat all effluents to regulatory limits before discharging into the environment. · dispose all waste in line with regulatory approval · activate existing oil spill contingency plans in the event of oil spill.	L	• Effluent monitoring records • Ground water monitoring records. • Waste Consignment note • Environmental Compliance Monitoring Reports	• Weekly/ Monthly • Monthly • Quarterly	Project Manager

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· ensure that disposal of drilling wastes is in line with regulatory standards				
	Increase in social vices	H	SPDC shall ensure: · intensive enlightenment campaign and health education for the abatement of abuse of drugs, alcohol and STIs in the communities and among workers throughout the life of the project. · ensure that contractor enforces the alcohol and drug policy for staff	L	• Reports on Awareness campaign programs during HSE Meetings. • HSE drug and alcohol monitoring records.	• Annually	Project Manager
	Injuries and death from blowouts	H	SPDC shall ensure that: · only skilled personnel and certified equipment are used · high quality chemicals and materials are used · emergency response procedures are in place · Job hazard identification is conducted · daily pep talks are conducted on identified hazards	L	• Certification of workforce • Evidence of MSDS and Technical specification details for chemicals • Emergency response plan • HAZID register. • Pep-talk records • Site inspection Reports	• Quarterly • Monthly • Weekly	Project Manager
	Sediment and Surface water pollution from chemicals, drill cuttings, and mud	H	SPDC shall: · treat drill cuttings in approved thermal desorption unit (TDU). · recover drilling mud for re-use. · evacuate all new wells into the closest existing flowstation.	L	• Drill cutting treatment records • Drilling mud recovery record • Environmental Compliance Monitoring Report • Waste Plan and Waste	• Monthly • Quarterly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· drill wells with Pseudo Oil Based Mud in top hole. · provide Rig with improved solid control equipment so as to assist in preventing dumping of mud. · Treat water based mud in TDU. · retrieve and transfer stimulation chemicals carefully into flow-back tanks and treat in TDU · recycle brine for initial completion; treat excess brine as other chemicals and sent to TDU. · develop and implement waste management plans for all wastes generated in accordance with regulatory requirements and standard practice. · segregated all industrial wastes such as plastics, metals, rubber and wood on site and collect in designated containers and transport to base for disposal		consignment note		
	Third party agitation	H	SPDC shall: · ensure effective consultation with stakeholders. · ensure commitment and transparent adherence to P-GMoU programmes.	L	• P-GMoU Implementation records. • Community Engagement Reports	• Monthly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· identify and address legacy issues. · identify and properly engage the communities through regular consultation with stakeholders (Government, Communitiy, NGOs, CBOs etc) and implement MOUs				
	Accidents, injuries and possible fatalities	H	SPDC shall ensure that: · only skilled/certified personnel, and certified equipment are used · emergency response procedures are in place. · Job hazard identification has been conducted.	L	• Certification of workforce • Emergency response plan • MSDS and Technical specification • HAZID register • Incident investigation Reports • Site Inspection reports • HSE Audits	• Weekly	Project Manager
	Increase in noise and vibration levels	H	SPDC shall · use only pre-mobbed and regularly maintained equipment. · use equipment with low noise level · ensure that appropriate PPE are provided and used	L	• Premob certificates • Maintenance records • Monitor noise levels • Records of PPE issuance and use • Environmental Compliance Monitoring Reports • Impact Mitigation Monitoring Reports	• Monthly • Quarterly • Anually	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Contamination of the environment by wastes	H	SPDC shall ensure: · regular collection and monitoring of wastes from cradle to grave in accordance with SPDC's waste management plan. · all oily wastes are properly segregated and contained before proper disposal. · sanitary wastes are treated in a sewage treatment plant. · domestic non-hazardous wastes are disposed at government approved dump sites · domestic hazardous wastes are segregated and sent to approved waste disposal sites. · sanitary wastes are bagged and treated at approved Sewage Treatment Plant. · top hole drill cuttings are sent to TDU · mud cuttings are turned to slurry and sent to TDU. · waste fluids such as spent mud, deck wash-off and storm water are collected and sent to TDU.	L	• SPDC Waste management plan • Waste consignment note • Environmental Compliance Monitoring Reports	• Monthly • Quarterly • Weekly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· work over fluids such as brine and inhibited water are collected and sent to TDU.				
			· rags (clothing, worn coveralls, shirt, trousers), are segregated and sent to approved dump site.				
			· miscellaneous domestic waste, old tooth brushes/disposable razors etc/old footwear, hand gloves etc and garbage, are segregated and sent to approved dump site.				
			· general paper waste are segregated and sent to approved recycling plant.				
			· plastic containers are sent to approved recycling plant.				
			· chemical drums are sent to approved waste manager.				
			· kitchen waste (garbage) are segregated and sent to approved composite site.				
			· forest tree cuttings, wood scraps (survey stakes, crating/pallets) are offered to local communities as fire wood/fabrication materials.				
			· adequate waste management is enforced on site.				

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· disposal of drilling wastes in line with regulatory standards.				
Pipe Laying	Noise and reduction in air quality (generation of dust; exhaust fumes)	H	SPDC shall: · use only pre-mobbed and regularly maintained equipment. · ensure that appropriate PPE are provided and used. · install mufflers on machineries and use low noise equipment. · ensure that staff use hearing protection. · adhere strictly to noise regulations including noise mapping and restriction of entry into high noise zones. · ensure that all mobile and stationary internal combustion engines are properly maintained.	L	• Premob certificates • Maintenance records • Records of PPE issuance • Environmental compliance Monitoring Reports • HSE inspection reports.	• Monthly	Project Manager
	Contamination of surface water bodies	H	SPDC shall: · treat all effluents to regulatory limits before discharging into the environment. · dispose all waste in line with regulatory approval. · activate Forcados -Yokri existing oil spill contingency response in the event of oil spill.	L	• Environmental Compliance Monitoring Report • Waste consignment note • Records of Spill containment.	Monthly Quarterly Quarterly	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· manage all radioactive wastes according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the waste shall be placed. These bunkers shall be inspected by NNRA.				
	Injury/fatalities in workforce	H	SPDC shall:	L	• Certification of workforce • Emergency response plan • HAZID register • HSE inspection records • Records of toolbox meetings	Monthly	Project Manager
			· ensure only skilled personnel and certified equipment are used.				
			· ensure that emergency response procedures are in place.				
			· ensure that trenches are backfilled as quickly as possible.				
			· put adequate number of barriers and warning signs close to open trenches.				
			· ensure that Safe Handling Of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of materials.				
			· ensure that job hazard analysis is done.				
			· ensure that HSE standards are strictly adhered to.				

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· ensure that Permit to work and proper briefing is given before commencing any work activity.				
	Increase in potential for water traffic volume and risk of accidents/ injury	H	SPDC shall ensure that: · compliance with SPDC journey management policy for water transport · only pre-mobbed vehicles are used · daily pep talk is carried out for water transportation · vehicle monitoring, and communication devices are installed and monitored. · community awareness is raised on unusual activity through the community relations team. · first aid boxes are provided in operational vehicles. · Emergency response plan is in place	L	• Journey management records • Premob certificates • Pep-talk records	Monthly	Project Manager
	Surface water degradation from waste disposal ,spills and leaks	H	SPDC shall ensure that: · Safe Handling of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals. · Appropriate waste management procedures will be employed.	L	• HSE inspection reports	Monthly	Project Manager

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· Appropriate remediation techniques will be employed (RENA)				
	Potential for inhalation of welding fumes and injuries to eyes associated to glares and sparks.	H	SPDC shall: · ensure that job hazard analysis is done. · ensure that workers adhere to work method statement associated with welding. · ensure that adequate safety measures (appropriate PPE) are put in place to avoid inhalation of welding fumes.	L	• HAZID register • HSE inspection reports • Records of Toolbox meetings. • Records of issuance of PPE	Monthly	Project Manager
	Potential for conflicts arising from labour issues	H	SPDC shall: · encourage the use of host community contractors. · ensure sourcing of relevant workforce from host communities. · ensure access control is implemented at work site. · ensure compliance with all HSE policies and standards	L	• List of community contractors. • Employment records • GMoU implementation records. • Access control register	Quarterly	Project Manager
	Contamination of surface water and from inhibited hydrotest water	H	SPDC shall: · control the rate of release of hydrotest water · ensure that inhibited hydrotest water is properly evacuated out of site to the appropriate treatment plant	L	• HSE inspection reports • Waste consignment note	• Weekly/ Monthly	Project Manager
		H	SPDC shall place	L			

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Potential increase in incidents (arising for example from high pressure of pipes during hydrotest)		· warning signs, barrier tapes near the high-pressure pipes to restrict people during hydrotesting. · JHA for the activity shall be carried out prior to the activity · Regular pep talks		• HSE inspection reports	• Weekly/ Monthly	Project Manager
	Impairment of air quality by emissions of air pollutants including greenhouse gases	H	SPDC shall: · use only pre-mobbed equipment and machineries. · regularly maintenance of vehicles, vessels, generators and other machines. · use of wet scrubbers for all emission sources · use of mufflers for vehicle exhaust. · Upgrade to high efficiency flare nozzle	L	• Premob certificates • Maintenance records	Monthly	Project Manager
	Increase in potential for water traffic volume and risk of accidents/ injury	H	SPDC shall ensure (that): · compliance with SPDC journey management policy for water transport · · daily pep talk is carried out for water transportation · vehicle monitoring, and communication devices are installed and monitored. · community awareness is raised on unusual activity	L	• Journey management records • Premob certificates • Pep-talk records	Monthly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			through the community relations team.				
			· first aid boxes are provided in operational vehicles.				
			· Emergency response plan is in place				
	Improper disposal of materials removed from site.	H	SPDC shall ensure:	L	• Waste consignment note • Site Inspection reports	• Monthly • weekly	Project Manager
			· all removed materials are properly disposed of and monitored from cradle to grave.				
			· scrap metals are collected, segregated and sent to approved dump sites.				
			· plastic wastes are sent to approved waste recycling depot (WRD).				
			· contaminated soils are excavated and sent to TDU.				
			· radioactive wastes/materials are managed according to Nigerian Nuclear Regulatory Agency (NNRA) procedure. Bunkers shall be built where the wastes shall be placed. These bunkers shall be inspected by NNRA.				
			· SPDC waste management policy is enforced.				
		H	SPDC shall:	L		*Monthly	

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Increase in noise and vibration level		· use only pre-mobbed and regularly maintained equipment and vehicles/sea going vessels.		• Premob certificates • Maintenance records • Noise level records • Records of audiometric examination for noise exposed workers. • Records of PPE issuance • HSE inspection reports. • Records of Unsafe Acts and Unsafe Conditions (UA/UC) • Environmental Compliance Monitoring Reports		Project Manager
	Loss of employment/ income	H	SPDC shall: · support entrepreneurial skill development and opportunities for community members to cushion the effect of reduction in economic/income generating activities. · ensure the implementation of the local content policy	L	• Records of Implementation of P-GMoU.	• Biannually	Project Manager
Operations and Maintenance	Environmental pollution arising from improper disposal of	H	SPDC shall: · ensure all oily wastes are properly segregated and contained before disposal.	L	• Waste consignment note • HSE inspection and audit records. • Records of	• Quarterly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	lubricants and oily debris		· ensure all oily wastes are properly disposed of and monitored from cradle to grave. · ensure regular clean-up of equipment at site. · ensure that chemicals are stored in bund walled areas with rain protection · provide containment for chemicals and liquid discharges. · SPDC waste management policy shall be enforced · ensure that a controlled fuelling, maintenance and servicing protocol for construction machinery at worksite is established and followed to minimize leaks and spills · spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of · used chemical drums and containers are sent to an approved WRD. · small chemicals spills, crude oil and aqueous effluents are cleaned, and the area restored to its original status		Toolbox meetings • Environmental compliance Monitoring Reports		
	Equipment failure and damage leading	H	SPDC shall ensure that: · only skilled personnel and certified equipment are deployed	L	• Premob certificates • Maintenance records.	• Quarterly	Project Manager

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Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	to injuries/ fatality		· certified first Aiders are available at every site. · First aid boxes and emergency response procedures are in place · hazard identification is conducted for every work activity/ies. · community members are not allowed to settle near the gas plant fence to prevent injury should there be explosion/accidental discharge(s). · emergency response procedures are in place. · Safe Handling of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals. · HSE standards are strictly adhered to. Permit to work and proper briefing is given before any work action.		• Certification of work force • First Aid box inventory • HAZID register • Records Tool box meeting • HSE inspection records. • Emergency response procedure.		
		H	SPDC shall:	L		Quarterly	

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Increase in noise levels		· use only pre-mobbed and regularly maintained equipment and vehicles and vessels		• Premob certificates • Maintenance records • Noise level records • Monitor noise levels. • Records of PPE issuance and use. • HSE inspection and audit reports. • Records of Unsafe Acts and Unsafe Conditions (UA/UC) • Records of audiometric examination for noise exposed workers.		Project Manager
	Gas leaks	H	SPDC shall ensure: · that a controlled fuelling, maintenance and servicing protocol for operation machinery at worksite is established and followed to minimise leaks · emergency response shall be activated in the event of an incidence	L	• HSE inspection and audit records. • Maintenance records. • Emergency response procedure and records. • Site Remediation reports	Monthly	Project Manager
Decommissioning and Abandonment							
		H	SPDC shall	L		Quarterly	

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Increase in noise and vibration/levels		· use only pre-mobbed and regularly maintained equipment and vehicles · Appropriate PPEs		• Premob certificates • Maintenance records • Noise level records • Monitor noise levels. • Records of PPE issuance and use. • HSE inspection and audit reports. • Records of Unsafe Acts and Unsafe Conditions (UA/UC) • Records of audiometric examination for noise exposed workers.		Project Manager
	Interference with water transport	H	SPDC shall · ensure Vessel/boat operators comply with recommended speed limits · only certified vessel/boat operators are employed.	L	Journey management records • Premob certificates • Pep-talk records	Monthly	Project Manager
	Kidnappings	H	SPDC shall : · make adequate security arrangements, and project site · ensure that security orientation and awareness is conducted for workforce.	L	• Security Management procedure • Security Plan • Record of security situation/updates • Journey management procedure	Monthly	Project Manager
		H	SPDC shall:	L		• Monthly	

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
	Impairment of air quality from fumes, dust, including greenhouse gases		· ensure Vessel/boat operators observe recommended speed limits · only certified vessel/boat operators are employed.		• Premob certificates • Maintenance records		Project Manager
	Third party agitations	H	SPDC shall · ensure effective consultation with stakeholders · ensure commitment and transparent adherence to GMoU programmes. · identify and address legacy issues promptly.	L	• Records of stake holder consultations. • GMoU implementation reports. • Community Engagement reports	• Quarterly	Project Manager
	Contamination of surfacewater	H	SPDC shall: · treat all effluents to regulatory limits before discharging into the environment. · dispose all waste in line with regulatory approval · activate existing oil spill contingency plans in the event of oil spill. · ensure that disposal of drilling wastes is in line with regulatory standards.	L	• Environmental Compliance Monitoring reports • Waste Consignment note/Reports	• Quarterly • monthly	Project Manager
	Injury/ fatalities in workforce	H	SPDC shall ensure that: · only skilled personnel, certified equipment, and pre-mobbed vehicles and vessels are used. · emergency response procedures are in place.	L	• Certification of workforce • Emergency response plan • MSDS and Technical specification	• Monthly	Project Manager

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

Project Activity	Description of Impact	Rating before mitigation	Mitigation measures	Rating after mitigation	Parameter for monitoring	Frequency of monitoring/Formal Reporting	Responsible action party
			· Safe Handling Of Chemicals cards (SHOC) / Material Safety Data Sheets (MSDS) are available on site to provide information on safe handling of chemicals.		• HAZID register. • Pep-talk records		
			· job hazard analysis is done..				
			· HSE standards are strictly adhered to.				
			· Permit to work and proper briefing is provided before any work action.				

CHAPTER EIGHT
CONCLUSION

This study has been 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 benefits of the FYIP NAG Project are enormous. These include support of the Federal Government domestic gas supply aspirations and compliance with the flares down policy. The project will therefore enhance air quality and reduce Nigeria's contribution to global warming potentials.

The impacts of existing facilities and the potential impacts of the proposed project activities have been assessed.

Mitigation measures for the impacts (impacts of existing and proposed facilities) have been proffered and incorporated into the EMP. The EMP shall be implemented and maintained throughout the project's life cycle.

Numerous construction activities during the life cycle of this project will provide benefits to the host community such as provision of power and water supply, promotion of human capital development, basic social amenities to the host communities and the promotion of good relationship between SPDC and the host communities. The project will provide employment opportunities for young people during all phases of the development.

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.

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APPENDICES

Appendix 1: Minutes of meeting evidence to support Limited sampling

CRITICAL PROJECTS REVIEW MINUTES OF MEETING BETWEEN DPR/SPDC 12/06/2018

Attendance

- Balogun A.A – Manager Environment Assessment, DPR
- Abdulrahman A.S- Manager Waste Management HSE DPR
- Atebe Odafe – Environmental Desk Officer, DPR
- Samani Idris – Environmental Desk Officer, DPR
- Stanley Amam – Environment Studies Lead SPDC
- Anike Kakayor – Social Performance Adviser SPDC
- Tolu Yemi-Shodimu – Business and Government Relations SPDC

Meeting commenced with a DPR HSE briefing and introductions. DPR commended SPDC in her efforts to ensure compliance with environmental regulations.

Objective of Meeting

1. Discuss and receive DPR steers on critical Projects – a) OML 79 3D Seismic data acquisition b) FYIP NAG Wells EIA c) Belema EES closure d) EA FOD EIA waiver
2. Review progress of pending studies with DPR

Highlights/Discussions

1. OML 79 Seismic data acquisition:

SPDC thanked DPR for approval received and noted that approval comes 4 months before EIA expiry in October 2018 and so will present challenges with implementing activity. SPDC informed that the earliest date to field will be September 2018 to allow for vessel sourcing and other pre-deployment preparations and expected completion in March 2019. SPDC also noted that discussions/applications for OML79 seismic data acquisition was concluded with DPR since Q3 2017 and SPDC has since been awaiting DPR response.

Action

- DPR committed to reviewing the correspondences on subject to determine the decision on way forward.

2. EA FOD:

SPDC acknowledged and thanked DPR for the waiver letter on EA FOD and requested a reconsideration of the waiver fees of $25k per well stating that the EES/BM revalidation for EA would commence in July 2018 and was a good ground for re-evaluation of DPRs decision. DPR stated that the rates are guided by regulations and therefore are unable to state otherwise .

Recommendation

- DPR recommended that the EIA/EES/BM revalidation for the EA Asset and FOD should commence immediately having been issued an approved ToR and noting that SPDC should deploy to field , complete studies and submit report applications by November 2018.
- DPR committed to holding a focused and fast-tracked workshop with SPDC to review and authorize the EIA study by December 2018 in readiness for the FOD drilling campaign to commence January 2019.
- This route is agreed to be the best approach to securing the EIA Permit for FOD activities planned for January 2018

3. Belema EES

SPDC requested a response to the letter sent to DPR requesting approval to use acquired wet season data in 2017 to close out the EES study for Belema Facilities. This is premised on a) SPDCs inability to carry out the Dry Season Field data gathering due to the community occupation of Belema Field and b) the subsequent shutdown of the field for over 300 days c) acquired wet season data is over 300days old and may not present a current profile of the environment.

Recommendation:

- SPDC to check internally that request letter was indeed delivered to DPR
- DPR was agreeable that the EES study can be closed out using the acquired wet season data.

4. FYIP NAG wells

SPDC requested DPRs response to the letter sent 24th April 2018 to use FYIP EMP to keep the FYIP NAG EIA alive in managing the mitigations to the NAG wells drilling activity.

Recommendation

DPR advised SPDC to do limited sampling for the FYIP NAG EIA and use that data to revalidate the EIA and update the EMP for the project.

5. Other Pending Studies

SPDC requested status of pending ToRs, EES and EIA/ESR/PIAR reports approvals

Action

- DPR advised SPDC to send an email with the current list of pending studies and they will be treated urgently
- SPDC to send list today 12/06/208

Meeting ended 10:40am

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Appendix 2: Sampling coordinates for Revalidation Study

S/NO	Sample	POINT_X	POINT_Y
1	AQ1	318722.4562	152599.6653
2	AQ2	318691.9888	151633.6733
3	AQ3	317941.3238	152105.6015
4	AQ4	319494.3507	152077.2955
5	AQC1	318799.9353	153637.2337
6	AQC2	318639.1922	150449.414
7	SW1	318722.4562	152599.6653
8	SW2	318691.9888	151633.6733
9	SW3	317941.3238	152105.6015
10	SW4	319494.3507	152077.2955
11	SWC1	318799.9353	153637.2337
12	SWC2	318639.1922	150449.414
13	SD1	318722.4562	152599.6653
14	SD2	318691.9888	151633.6733
15	SD3	317941.3238	152105.6015
16	SD4	319494.3507	152077.2955
17	SDC1	318799.9353	153637.2337
18	SDC2	318639.1922	150449.414

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APPENDIX 3: Social and health questionnaire

SOCIO-ECONOMIC/SIA SURVEY QUESTIONNAIRE FOR FORCADOS-YORKRI INTEGRATED PROJECT EIA STUDY

Questionnaire Number: ……………………………………….

Name of Settlement/Community:…………………………….

Settlement Type: ………………………………………………..

(Town, Village, Fishing Port, Hamlet, other)

L.G.A/State:…………………………………………………….

Ethnic Group:……………………………………………………

Name of Interviewer:……………………………………………

Date:…………………………………………………………….

Section A: Respondent’s Socioeconomic/Health Data

Sex

Male

Female

Age

20-29 years

30-39 years

40-49 years

50-59 years

60-69 years

70+ and above

3. Marital Status of Respondent

Single

Married

Divorced

Separated

Widowed

If married: i. Number of wives (if male): ………………

Number of children: ………………………………………………

No. of males: …………….. Females: …………………………

Number of dependants: ………………………..

Total number of persons in Household: ………………………..

5. Respondent's highest level of education

Primary school

Secondary school

Vocational/Technical school

Tertiary school

No Formal Education

Any other (please specify) …………………….

6. Highest level of education of respondent's spouse

6.1 Primary school

6.2 Secondary school

6.3 Vocational/Technical school

6.4 Tertiary school

6.5 No Formal Education

6.6 Any other (please specify) …………………….

7. Age and Sex structure of household members

Age in years	Male	Female	Total
0-4			
5-12			
13-18			
19-25			
26-59			
60-69			
70+ and above			

How many of your children presently attend the following categories of schools?

School	Boys	Girls	Total
Primary			
Secondary	`		
Vocational/Tech			
Tertiary			
Any other			

Please state your religion:………………………………

How long have you lived in the settlement/community?

Less than 1 year

1-5 years

6-10 years

11-15 years

16-20 years

Above 20 years

Since birth

If non-native, where do you come from: ………………………………… (Village/LGA/State)?

What is your main source of income (Occupation)

Farming

Fishing

Technician/Artisan

Trading

Business/Contractor

Civil Servant

Retired

Student/Apprentice

Unemployed

Others (specify):……………………………………………

Which is/are your other source(s) of income (secondary occupations)?

Farming

Fishing

Trading

Technician/Artisan (specify): ……………………………

Others (specify): ………………………………………….

Estimated income of Respondent in a month (N)

Less than 1,000

1,000-5,000

5001-10,000

10,001-15,000

15,001-20,000

20,001-25,000

25,001-30,000

30,001-35,000

35,001-40,0000

40,001-45,000

45,001-50,000

Above 50,000

15. Indicate from the table below, your expenditure pattern in order of preference (1, 2, …..) with 1 being the highest preference

Expenditure Item	Scale of Preference
Food	
Education	
Health Care	
Utility bills	
Durable Assets	
Others (specify) ………	

16 If engaged in more than one economic activity, please estimate amount and percentage income from each:

Occupation	Amount	%
Farming		
Fishing		
Trading		
Business/Contract		
Civil Servant		

Technician/Artisan		
Others (please specify)		

17. If you are a farmer, how did you acquire the land on which you farm?

Family inheritance

17.2 Rented/leased it

17.3 Bought it

17.4 Sharecropping

17.5 Others (Specify) ………………………………

18. What crops do you grow in your farm? (Please mention according to importance)

18.1:……………………………………………………………………………

18.2: …………………………………………………………………………..

18.3: …………………………………...

18.4: …………………………………………………………………………

18.5: …………………………………………………………………………

How would you describe your crop harvest in the most recent past (five years back)?

Increasing

Decreasing

19.3 The same

20. If decreasing, what in your opinion is responsible?

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

………………………………………………………………………...

As a farmer, what constraints do you experience that work against maximum productivity?

Insufficient land to farm

Inadequate/lack of capital/money

Poor technology/local tools used

Insufficient labour hands

Any other (specify): ……………………………………………….

If fishing is your primary or subsidiary occupation, where do you carry out your fishing?

River/Creek (please name river/creek) …………………

Ponds

Flooded areas

Sea/Ocean

23. What fishing gear(s) do you use?

Net (with canoe)

Hook

Trap/basket

All of the above

Any other (specify) …………………………..

23. How would you describe your fish catch/harvest in the most recent times (past five years)?

23.1 Increasing

23.2 Decreasing

23.3 The same

24. If decreasing, what in your opinion do you think is responsible?

…………………………………………………………………………

………………………………………………………………………..

…………………………………………………………………………..

25. Is there any restriction on where you fish?

Yes

No

26. If yes, what is/are the restriction(s)?

……………………………………………………….

……………………………………………………….

………………………………………………………..

27. Which of the following type of house do you own/live in?

Sticks/bamboo with thatch roof

Mud with thatch roof

Mud with zinc roof (indicate if plastered) ……………...

Wood/plank with zinc roof

Zinc with zinc roof

Concrete/block with thatch roof

Concrete/block with zinc roof

Others (specify). ……………………………………..

28. How many rooms are in this house in which you live?......

29. Which is your MAIN source of water supply in the DRY SEASON

Rain water

River/Creek/Stream/pond water (please specify) ………

Public hand-dug well system

Own hand-dug well in residence/compound

Public tap

Piped water in residence/compound

Community Bore-hole (provided by whom?) ………………………………………………………………………..

Vendor/buys from private borehole

Others (specify). ……………………………………………….

Which is your MAIN source of water supply in the RAINY SEASON

Rain water

River/Creek/Stream/pond water (please specify which and name) ……………………………………

Public hand-dug well system

Own hand-dug well in residence/compound

Public tap

Piped water in residence/compound

Community bore-hole (provided by whom?) …………………………………………………………

30.8 Personal borehole/buys from private borehole (please specify): …………………………………………………………..

Others (specify). ………………………………………………..

31. Does your household have the following amenities?

1) Electricity	Yes	No
2) Generator	Yes	No
3) Television	Yes	No
3) Radio	Yes	No
4) Refrigerator	Yes	No

5) Electric fan	Yes	No
6) Telephone (mobile/land line)	Yes	No

32. If single parent/widow/elderly/disabled/very sick Respondent, do you have any monetary support? (Interviewer to tick whichever is applicable to respondent)

1) Yes 2) No

32b. If yes, indicate the source(s) …………………………..

…………………………………………………………………………

32c. For the elderly/disabled/very sick Respondent, what major health challenges do you face? …………………………

……………………………………………………………………….

33. What is the name of the nearest urban centre to this settlement? ………..

34. Which is your USUAL means of transport to the nearest urban centre and/or other villages?

1) Trekking 2) Canoe 3) Speed boat 4) Bicycle

5) Motorcycle 6) Car/bus 7) Other (specify)………….

35. How far is it in kilometers or travel time (minutes/hr) to the nearest urban centre?

Section B: Socioeconomic Sensitivity/ Attitudes/Perceptions

B1. Which of the following important environmental resources in your community do you value most?

Forest resources

River/Creek water

Ancestral sites

Animals

Others (please specify): ....……………………………..

B2. Please indicate the environmental problems which your settlement/community experiences

Soil infertility

Pest attack/invasion

Erosion problems

Flooding

Oil pollution/spillage

Others (specify): …………………………………………….

B3. Would you say your economic activity has been affected in any way in the past (5 years or so)?

Yes 2. No

B4. If yes, in what specific way(s) have you been affected?

…………………………………………………………………………………………………… ………………………………………………………

B5. Have you observe an increase in industrial (oil & gas) activities in the area? 1) Yes 2) No

B6. If yes, has the increased activities affected you in any way?

1) Yes 2) No

B7. If yes please explain how?

……………………………………………………………………

………..

B8. Please name the companies operating within your

Community/settlement area

………………………………………………………………….

…………………………………………………………………

B9. Name the Company(ies) whose operational activities have

affected you the most in the area

…………………………………………………………………………

…………………………………………………………………………

B10. Is there any oil facility close to your community?

1) Yes 2) No

B11. If yes, can you name the facility (ies) and the owner?

…………………………………………………………………………

…………………………………………………………....................

B12. Has the above mentioned facility caused your community any environmental and social problems since its establishment in the area?

Yes 2) No

B13. If yes, please state specifically the problem

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

B14. Have your community benefited in one way or the other from the presence of the facility(ies)?
1) Yes 2) No

B15. If yes, can you tell us exactly the benefits so far received by your community?

1. …………………………………………………………………………
2. …………………………………………………………………………
3. ………………………………………………………………………..
4. ………………………………………………………………………..

B16. What personal benefits have you received from the

company(ies)' presence and operations in this area?

Employment for me and/or my relative (specify) …….

Scholarship award for child(ren) and/or relative

Community project (please specify): ………………

Skills acquisition programme

Any other (specify?): ……………………………….

None

B17. Do you think that the proposed Forcados-Yorkri Integrated Project Development activities would affect you in any way? 1) Yes 2) No

B18. If yes, please state how?

…………………………………………………………………

…………………………………………………………………

B19. Do you have any objection to the proposed project development and activities? 1) Yes 2) No

B20. If 'yes", please state reason(s)

…………………………………………………………………

…………………………………………………………………

…………………………………………………………………

B21. How would you rate your community's relationship with SPDC?

1) Very Good 2) Good 3) Fair 4) Poor5) Very Poor

B22. Which of the under-listed social problems have your community experienced in the recent past (tick as many as applicable)?

Youth delinquency

Land dispute

Chieftaincy tussle

Inter-family problems

Inter-village tribal conflicts

Unemployment

Alcoholism/prostitution

B23. Please state reasons or causes of observed behaviors/problems

……………………………………………………………………………………………………
………………………………………………

B24. What are your recommended solutions to solving observed community problem(s) as above?

…………………………………………………………………………

B25. Please state your expectations from the continued operations of the company in this your area

……………………………………………………………………………………………………
…………………………………………………….

……………………………………………………………………….

Appendix 4: Health Impact Assessment Questionnaire

SECTION 1: BASIC DATA

Name of community ____

Date of interview: ……………………………………………………………………………………………….

SECTION 2: HOUSEHOLD DETAILS

Line No.	Name of ALL Members of Household	RELATIONSHIP TO HEAD OF HOUSEHOLD	RESIDENCE	SEX	AGES	IF AGED 6 YEARS OR OLDER			
						EDUCATION		MAIN OCCUPATION	MARITAL STATUS
	Please give me the names of the persons who live in your household, starting with the head of the household.	01= wife or husband 02= son or daughter 03= son or daughter–in-law 04= grandchild 05= parent 06= parent– in–law 07= brother or sister 08= other relative 09= not related 99= NK	Does (NAME) usually live here?	Is (NAME) male or female?	How old is (NAME)? IN YEARS	Has (NAME) ever been to school?	IF ATTENDED SCHOOL	01= farming 02= trading 03= fishing 04= civil servant 05= company worker 06= business / Contractor 07= student 08= apprentice 09= housewife only 10= pensioner only 11= artisan 12= Professional 13= Other	01= Married 02= Single 03= Living with partner 04= Divorced 05= Separated 06= Widowed

Head		HEAD	YES NO 1 2	M F 1 2		Yes No 1 2		YES NO 1 2		
02			1 2	1 2		1 2		1 2		
03			1 2	1 2		1 2		1 2		
04			1 2	1 2		1 2		1 2		
05			1 2	1 2		1 2		1 2		

SECTION 3: Environmental Health Data:

s/no	Questions and filters	Categories
	What is the main source of drinking water for members of your household	River/Stream Well Rain Water Public pipe-borne water Mono pump

		Piped into toilets and kitchen Borehole (Commercial) Borehole (private) Commercial tanker Bottled water Sachet (pure) water
	What is the main source of water for cooking and washing for members of your household	River/Stream Well Rain Water Public pipe-borne water Mono pump Piped into toilets and kitchen Borehole (Commercial) Borehole (private) Commercial tanker
	What is the average distance you have to cover to fetch water from the main water source in your community	Piped supply Less than 15 minutes 15 – 30 minutes 31 – 60 minutes More than one hour

	How long does it take to fetch enough water that will take care of the needs of the household for a day	Piped supply Less than 30 minutes 31 – 60 minutes 1 – 2 hours More than two hours
	Who usually fetch the water for the household?	Adult women Adult women and children Adult men Children Any member of the household
	Do you do anything to the water to make it safer to drink?	Yes (Go to the next question) No (Skip the next question)
	What do you usually do to make the water safer to drink? (Don't read out the categories, but circle as they are mentioned)	Boiling Alum Cloth filtration

		Waterguard Allowed to settle Household commercial filter Others: …………………………………
	What kind of toilet facility do members of your household usually use?	Water closet toilet Pour flush (squat toilet) Pit latrine Bucket toilet Jetty-type (overhung toilet) Open defecation/ bush Disposal with refuse
	Do you share this toilet facility with other households?	Yes (Go to the next question) No (Skip the next question)
	How many households use this toilet facility?	Less than five households More than ten household

	Do you wash your hands after using the toilet	Yes No
	INTERVIEWER: DON'T ask the respondent, but look at his residential house, and record the following observations	The type of house: The materials used for the roof: The material used for the floor The number of windows:
	How many members of your household sleep in a room?	
	Do you have a separate room which is used as a kitchen? (Please observe and record your finding)	
	What type of fuel does your household mainly use for cooking?	Electricity Gas Kerosene stove Firewood

	Which types of wastes does your household regularly generate?	Food and kitchen wastes Agricultural wastes Electronics Wastes from manufacturing activities
	Can you estimate the quantity of wastes generated by your household in a day?	1 – 2 kg/day 2 – 5 kg/day More than 5 kg/day
	Do you store these wastes in a container?	Yes No
	How do you dispose these wastes?	Dumped at the nearest bush Refuse pit Burning River/ stream Communal dump site Collected by waste disposal authority

SECTION 4: Nutritional status

s/no	Questions and filters	Categories
	What are the major foods items eaten in your household?	
	How many times does the children in household eat in a day	
	How many times does the adults in household eat in a day	
	Can you tell me what your household ate yesterday for breakfast, lunch and dinner (24-hour dietary recall)	
	Have you had any worry about what to eat the next day in recent times?	
	Anthropometric measurements: Please let me take the measurements of your under-five children No: Age: Sex: Weight; Height:	No: Age: Sex: Weight; Height:

	MUAC:	MUAC:
	No: Age: Sex: Weight; Height: MUAC:	No: Age: Sex: Weight; Height: MUAC:

SECTION 5: Lifestyle and use of alcohol and tobacco

s/no	Questions and filters	Categories
	Do you have sexual partners not married to you?	Yes (Go to the next question) No (Skip the next question)
	How many are they?	
	Have you ever had a sexually Transmissible Infection before?	Yes (Go to the next question) No (Skip the next question
	If yes, how did you treat it?	Self medication Chemist Native treatment Private hospital Government hospital
	Do you know how HIV/AIDS can infect somebody?	Yes (Go to the next question) No (Skip the next question
	Can you name the methods	Able to mention just 1 - 3 Mentioned more than three

	Has any case of HIV/AIDS been reported in your community?	Yes (Go to the next question) No (Skip the next question
	Do you smoke?	Yes (Go to the next question) No (Skip the next question
	How many sticks of cigarette do you smoke in a day?	
	Does your smoking affect your ability to take care of your household?	Yes No
	Do you take alcohol regularly?	Yes (Go to the next question) No (Skip the next question
	How many bottles of your favorite alcoholic drink do you take in a week?	
	Have you been drunk before?	Yes (Go to the next question) No (Skip the next question
	How often many times have you been drunk in the past two months?	

SECTION 6: Morbidity and Mortality information

Please list the common health problems of members of your household?

Health problem (Local name)	Approximate English name	How common?	How severe?	Any seasonal trend?

Household Mortality information

s/no	Questions and filters	Categories
	Has there been any death of a child in the household in the past one year?	Yes (Go to the next question) No (Skip the next question
	If yes, how old is the child?	
	What sickness killed him?	
	Was the child taken to the hospital?	

	If no, why	
	Has there been any death of a pregnant woman in the household in the past one year?	
	If yes, what killed the woman?	
	Was the woman taken to the hospital?	
	If no, why	

SECTION 7: Health Service information

s/no	Questions and filters	Categories
	Tell me the government facilities that serve your community?	
	How far are they from the community?	Within 30 minutes walking distance 30 – 60 minutes walking distance More than one hour walking distance
	Are you satisfied with the quality of services in the health facilities	Yes No
	Are the government health facilities adequately staffed and properly equipped?	Yes No
	Does the staff treat patients with courtesy?	Yes No
	What are the things that will encourage members of the community to use government health facilities?	
	Is the cost of modern medical care affordable to most members of the community?	Yes No

	If no, what are your suggestions to ensure that medical care are affordable to all?	

SECTION 8: Health Impact of the project

s/no	Questions and filters	Categories
	Are you aware of the FOCARDOS YORKI INTEGRATED PROJECT ?	Yes No
	In what ways do you foresee that the project may POSITIVELY change the lives of the people of your community	
	In what ways do you foresee that the project may NEGATIVELY change the lives of the people of the community	
	What are the best ways of ensuring that the POSITVE effects of the project get to every member of the community?	
	What are the best ways of handling the adverse effects of the project?	
	Do you think the project would have any health effect?	
	If yes, can you list the possible health effects?	
Health effect	Those most likely to be affected	Possible remedial actions

Appendix 5: Detailed Results of Air quality measurements in the FYIP NAG Field (2001-2018)

Parameters	2001 EIA FYIP	2012 EE EIA DRY SEASON		2012 EE EIA WET SEASON		2018						DPR	FMEnv
		AQ 9	AQ 12	AQ 9	AQ 12	AQ 1	AQ 2	AQ 3	AQ 4	AQ C1	AQ C2		
Noise (dB(A)		64.1	61.4	62.8	62.6	66.9	68.2	62.4	68.2	69.6	62.1	80-100	90
CH4 ppm						0.84	1.22	1.42	1.32	1.14	0.25	NS	NS
SO2, ppm	<0.01	0.17	0.21	<0.001	<0.001	<0.01	0.01	<0.01	0.13	0.02	0.01	0.04	0.01
NO2, ppm	<0.01	0.09	<0.001	<0.001	<0.001	0.02	0.02	0.01	0.01	0.12	0.01	0.08	0.04
VOC, ppm		3.3	2.6	2.3	2.68	0.86	1.86	1.77	1.6	1.28	0.56	NS	0.09
SPM, µg/m3		9.37	10.65	4.32	4.26	10.29	17.49	14.63	14.23	13.99	10.59	60-90	250
PM2.5, µg/m3						4.13	6.91	7.28	8.52	9.62	7.24	NS	NS
PM10, µg/m3						3.74	4.55	5.47	3.11	1.05	1.56	NS	NS
H2S, ppm		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NS	NS

Appendix 6: Detailed results of physicochemical and microbiological measurements in surface waters of the FYIP NAG Field

PARAMETERS	SW 1	SW 2	SW3	SW4	SW C1	SW C2
Physico-chemical:						
pH	7.5	7.8	7.8	7.9	7.7	7.8
Temperature, oC	27.8	28.3	28.5	28.8	29.7	29.2
Electrical Conductivity, μS/cm	16,340	42,157	34,860	13,650	12,040	23,250
Turbidity, NTU	13.40	81.70	28.20	25.10	16.50	19.10
Dissolved Oxygen, mg/l	5.43	5.41	5.42	5.40	5.38	5.38
Biological Oxygen Demand (BOD), mg/l	7.32	8.31	4.11	4.30	6.27	6.27
Chemical Oxygen Demand (COD), mg/l	15.21	14.40	18.20	9.58	12.55	13.28
Total Dissolved Solids (TDS), mg/l	8,660	22,260	18,470	7,234	6,301	12,322
Total Suspended solids (TSS), mg/l	19.80	34.60	32.00	25.20	24.20	26.00

Colour, Pt.Co.	40	50	30	25	40	40
Odour	unobjectionable	unobjectionable	unobjectionable	unobjectionable	unobjectionable	unobjectionable
Alkalinity, mg/l	439.96	419.96	459.96	399.96	219.98	419.96
Appearance	Light Brown	Brownish	Light Brown	Light Brown	Light Brown	Light Brown
Chlorides, mg/l	2836	9926	3899	3545	1772	6381
Nitrate, mg/l	0.534	0.600	0.500	0.600	0.534	0.567
Phosphorus, mg/l	<0.001	0.090	0.018	<0.001	0.013	0.029
Carbonate, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Salinity, ‰	11.40	32.10	26.70	9.90	8.20	16.6
Redox potential (±mV)	+184.40	+135.50	+184.60	+184.70	+184.80	+186.10
Phenol, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anions:						
Chloride (Cl-), mg/l	4.330	1130	9235	3545	53.18	4.254
Sulphate (SO42-), mg/l	38.25	49.71	25.08	26.71	24.63	15.97
Nitrite (NO2-), mg/l	0.01	0.03	<0.01	<0.01	0.02	0.02

Bicarbonate (CO_3^{2-}) mg/l	536.80	512.40	561.20	488.00	268.40	512.40
Exchangeable Cations:						
Na^{2+}, mg/l	3546	8461	8069	3640	1953	4333
K^+, mg/l	188.58	443.70	430.29	223.72	118.82	223.89
Ca^{2+}, mg/l	75.40	109.37	108.30	70.74	64.78	87.43
Mg^{2+}, mg/l	359.11	1280	1225	425.84	355.39	287.34
Heavy metals: (mg/l)						
Cadmium (Cd^{2+})	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc, (Zn^{2+})	0.551	0.624	0.619	0.609	0.566	0.544
Iron (Fe^{2+} & Fe^{3+})	0.445	3.680	1.019	0.580	0.641	0.500
Copper (Cu^{2+})	0.036	0.034	0.023	0.023	0.029	0.032
Chromium (Cr^{3+}/ Cr^{6+})	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni^{2+})	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Lead (Pb^{2+})	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium (V^{2+})	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As^{2+})	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury (Hg^{2+})	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Barium (Ba2+)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium (Mg2+)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver, Ag+	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cobalt (Co2+)	<0.001	0.084	0.010	0.294	<0.001	0.246
Organics: mg/l						
Total Petroleum Hydrocarbon (TPH)	<0.031	0.006	0.212	<0.031	0.361	<0.031
Total Hydrocarbon Content, mg/l	0.220	0.118	0.241	<0.001	0.610	0.290
Oil and grease, mg/l	0.210	0.112	0.240	<0.001	0.270	0.261
BTEX, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PAH, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aliphatic Hydrocarbon, mg/l	<0.031	0.007	0.241	<0.031	0.305	<0.031
Microbiology:						
HUB, x 102cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil
THB, x 102cfu/ml	1.25	1.00	1.10	2.00	1.00	1.00
HUF, x 102cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil

Total Fungi x 102cfu/ml	1.00	1.00	1.03	1.05	Nil	Nil
Total Coliform, MPN/100ml	29	14	20	27	23	34
Faecal Coliform Count, MPN/100ml	Nil	Nil	Nil	Nil	14	Nil

Appendix 7: Surface water physicochemical and microbiological trending data for the FYIP NAG field (2001 to 2018).

PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	SD	Min	Max
pH	7.903	0.27	7.55	8.3	7.36	0.23	7.1	7.7	7.354	0.13	7.14	7.55	7.75	0.17	7.5	7.9	7.75		7.7	7.8
Temperature, oC	27.193	1.46	24.4	29.6	28.68	0.2	28.3	28.9	28.69	0.42	27.9	29.3	28.35	0.42	27.8	28.8	29.45		29.2	29.7
Electrical Conductivity, mS/cm	12.121	6.33	3.55	22.5	13563.1	3231.58	9733	19840	11627.6	4760.45	876	18300	26751.75	13941.85	13650	42157	17645		12040	23250
Turbidity, NTU					1.29	0.12	1.11	1.55	89.06	276.5	1.32	876	37.1	30.41	13.4	81.7	17.8		16.5	19.1
Dissolved Oxygen, mg/l	8.846	0.67	7.49	9.76	7.67	0.91	6.5	8.8	9.335	1.58	5.66	11.32	5.415	0.01	5.4	5.43	5.38		5.38	5.38
Biological Oxygen Demand (BOD), mg/l	4.081	0.86	2.7	5.6	2.308	0.53	1.65	3.32	0.716	0.18	0.51	1.1	6.01a	2.12	4.11	8.31	6.27a		6.27	6.27
Chemical Oxygen Demand (COD), mg/l	104.688	64.79	25	254	9.136	2.58	5.25	15.23	7.909	2.09	4.92	11.46	14.3475	3.57	9.58	18.2	12.915		12.55	13.28
Total Dissolved Solids (TDS), mg/l	7.891	4.09	2.31	14.6	7189.76	1712.78	5158.5	10515	5813.8	2380.22	438	9150	14156	7357.66	7234	22260	9311.5		6301	12322
Total Suspended solids (TSS), mg/l	24.875	23.06	7	104	8.189	1.51	5.43	10.16	8.968	0.75	7.82	10.16	27.9	6.7	19.8	34.6	25.1		24.2	26
Colour, Pt.Co.													36.25	11.09	25	50	40		40	40
Odour																				
Alkalinity, mg/l													429.96	25.82	399.96	459.96	319.97		219.98	419.96
Appearance																				
Nitrate, mg/l	0.735b	0.3	0.1	0.96	10.826a	4.94	3.85	21.19	2.722b	1.94	1.16	5.93	0.5585b	0.05	0.5	0.6	0.5505b		0.534	0.567
Phosphorus, mg/l	0.504b	0.24	0.19	0.97	1.237	0.77	0.28	3.17	0.053	0.04	0.01	0.14	0.054	0.051	0.018	0.09	0.021		0.013	0.029

PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	SD	Min	Max
Carbonate, mg/l					<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.02	0	<0.02	<0.02			0	0
Salinity, oo/o													20.03	11.06	9.9	32.1	12.4		8.2	16.6
Redox potential (±mV)													172.3	24.53	135.5	184.7	185.45		184.8	186.1
Phenol, mg/l					<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.01	0	<0.01	<0.01			0	0
Anions:																				
Chloride (Cl^-), mg/l					7331.57	3624.43	426.2	12562.3	5879.21	2958.49	318.6	9843.7	3478.58	4112.06	4.33	9235	28.717		4.254	53.18
Sulphate (SO_4^{2-}), mg/l					372.87	102.23	278.3	613.97	284.9	132.93	19.72	436.55	34.94	11.46	25.08	49.71	20.3		15.97	24.63
Nitrite (NO_2^-), mg/l													0.02	0.01	0.01	0.03	0.02		0.02	0.02
Bicarbonate (CO_3^{2-}) mg/l													524.6	31.5	488	561.2	390.4		268.4	512.4
Exchangeable Cations:																				
Na^{2+}, mg/l													5929	2702.4	3546	8461	3143		1953	4333
K^+, mg/l													321.57	134.16	188.58	443.7	171.355		118.82	223.89
Ca^{2+}, mg/l													90.95	20.74	70.74	109.37	76.105		64.78	87.43
Mg^{2+}, mg/l													822.49	497.79	359.11	1280	321.365		287.34	355.39
Heavy metals:																				
Cadmium (Cd^{2+})(mg/l)	<0.01	0	<0.01	<0.01	0.003	0	0.002	0.005	<0.001	0	<0.001	<0.001	<0.005	0	<0.005	<0.005	0		0	0

EIA REVALIDATION FOR FORCADOS-YOKRI INTEGRATED PROJECT (NAG WELLS)

PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	SD	Min	Max
Zinc, (Zn2+)(mg/l)	<0.01	0	<0.01	<0.01	0.2324	0.07	0.129	0.335	0.0612	0.025	0.027	0.109	0.60075	0.03	0.55	0.62	0.555		0.544	0.566
Iron (Fe2+ & Fe3+)(mg/l)					0.02	0	0.011	0.026	0.009	0.004	0.002	0.014	1.43	1.52	0.45	3.68	0.571		0.5	0.641
Copper (Cu2+)(mg/l)	<0.01	0	<0.01	<0.01	0.0075	0	0.007	0.008	0.005	0	0.005	0.005	0.029	0.01	0.02	0.04	0.0305		0.029	0.032
Chromium (Cr3+/ Cr6+)	<0.01a	0	<0.01	<0.01	0.006	0	0.005	0.007	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	0		0	0
Nickel (Ni2+) (mg/l)	<0.01	0	<0.01	<0.01	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.002	0	<0.002	<0.002	0.0020		0	0
Lead (Pb2+)	<0.01a	0	<0.01	<0.01	<0.001	0	<0.001	<0.001	0.002	0	0.002	0.002	<0.002b	0	<0.002	<0.002	0		0	0
Vanadium (V2+)(mg/l)	<0.01	0	<0.01	<0.01	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	0		0	0
Arsenic (As2+)(mg/l)					<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001			0	0
Mercury (Hg2+)(mg/l)													<0.001	0	<0.001	<0.001			0	0
Barium (Ba2+)(mg/l)	<0.01	0	<0.01	<0.01	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001			0	0
Manganese (Mn2+)(mg/l)					0.01	0.01	0.002	0.016	0.002	0.001	0.002	0.003	<0.001	0	<0.001	<0.001			0	0
Silver, Ag+ (mg/l)													<0.002	0	<0.002	<0.002			0	0
Cobalt (Co2+)(mg/l)													0.129	0.147	0.01	0.294	0.246		0.246	0.246
Organics: mg/l																				

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PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	SD	Min	Max
Total Petroleum Hydrocarbon (TPH)	<0.01	<0.01	0	0	<0.001	0	<0.001	<0.001	<0.001c	0	<0.001	<0.001	0.109	0.146	0.006	0.212	0.361		0.361	0.361
Total Hydrocarbon Content, mg/l													0.193	0.066	0.118	0.241	0.45		0.29	0.61
Oil and grease, mg/l					<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	0.187	0.067	0.112	0.24	0.266		0.261	0.27
BTEX, mg/l													<0.001	0	<0.001	<0.001			0	0
PAH, mg/l					<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001			0	0
Aliphatic Hydrocarbon, mg/l													0.124	0.165	0.007	0.241			0.305	0.305
Microbiology:																			0	0
HUB, x 102cfu/ml					3.51	0.49	2.67	3.98	3.05	0.32	2.35	3.45							0	0
THB, x 102cfu/ml					0.6	0.11	0.45	0.79	0.52	0.11	0.39	0.73	1.34	0.45	1	2			1	1
HUF, x 102cfu/ml					0.07	0.04	0.01	0.13	0.13	0.08	0.04	0.28							0	0
Total Fungi x 102cfu/ml					2.41	0.57	1.21	3.16	1.77	0.24	1.34	2.1	1.02	0.02	1	1.05			0	0
Total Coliform, MPN/100ml					36.4	6.85	23	42	16.6	4.99	9	27	22.5	6.86	14	29	28.5		23	34
Faecal Coliform Count, MPN/100ml																	14		14	14

Appendix 8: Detailed results of physicochemical and microbiological measurements in sediments of the FYIP NAG Field (2018)

PARAMETERS	SED 1	SED 2	SED 3	SED 4	SED CNTRL1	SED CNTRL2
pH	6.2	6.4	6.7	6.0	6.1	6.6
Redox Potential (±mV)	+155.33	+102.20	+105.38	+115.00	+126.00	+107.35
TOC, %	0.070	0.080	0.036	0.070	0.089	0.036
Texture	Sandy	Sandy - Clayey	Sandy	Sandy-Clayey	Sandy-Clayey	Sandy
Exchangeable Cations (mg/Kg)						
Sodium	2395	2811	2613	2134	3017	4630
Potassium	1316	1382	1130	1299	1485	2251
Calcium	251.65	283.91	319.37	313.36	322.58	233.01
Magnesium	1026	792.42	813.85	1006	930.98	2452
Anions						
Chloride,(Cl-), mg/kg	2268	1544	2268	1843	2197	709.59
Sulphate, (SO42-), mg/kg	14.23	112.59	147.35	148.20	126.82	149.20
Nitrate (NO3-), mg/kg	1.89	2.35	2.40	2.65	4.92	5.17
Carbonate (CO32-), %	0.02	1.55	0.02	0.88	1.27	0.36
Aliphatic hydrocarbon, mg/kg	18.52	36.22	31.28	18.52	9.58	4.44
Organics, (mg/kg)						

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PARAMETERS	SED 1	SED 2	SED 3	SED 4	SED CNTRL1	SED CNTRL2
TPH,	20.20	41.96	44.03	23.14	12.14	5.03
THC,	18.52	39.54	37.28	26.27	14.62	4.78
Oil and Grease	19.58	44.62	45.28	24.29	16.24	4.09
BTEX	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phenol	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PAH	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Heavy Metals (mg/kg)						
Cadmium (Cd)	1.306	1.143	0.987	1.224	0.969	1.847
Zinc, (Zn)	36.715	67.041	91.045	58.968	30.955	186.114
Iron (Fe)	2844	2379	2214	2802	2709	3405
Copper (Cu)	4.869	10.110	10.634	9.424	8.606	9.219
Chromium (Cr)	10.439	10.922	12.806	8.945	11.332	12.100
Nickel (Ni)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium (V)	15.869	12.346	14.956	13.333	12.896	15.619
Arsenic (As)	80.817	69.182	54.912	73.303	70.603	134.169
Mercury (Hg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (Ba)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium (Mg)	19.631	22.706	16.241	18.843	34.926	28.382
Silver (Ag)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt (Co)	19.764	12.485	14.068	15.700	15.879	17.756
Microbiology:						
HUB, x104 cfu/g	Nil	1.06	1.07	1.00	Nil	1.20
THB, x104 cfu/g	2.00	1.05	1.00	3.500	4.50	4.70

PARAMETERS	SED 1	SED 2	SED 3	SED 4	SED CNTRL1	SED CNTRL2
HUF, x104 cfu/g	Nil	Nil	1.00	Nil	Nil	Nil
TF, x104 cfu/g	1.15	1.00	1.00	2.10	3.00	3.20
SRB , x103 cfu/g	Nil	Nil	Nil	Nil	Nil	Nil

Appendix 9: Sediment physicochemical and microbiological trending data for the FYIP NAG field (2001 to 2018).

PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max
pH	7.25	0.30	7	8.17	6.27	0.62	5.29	6.92	6.83	0.33	6.39	7.34	6.325	0.29861	6	6.7	6.350	0.354	6.100	6.600
Redox Potential (±mV)	154.20	50.09	100	218									119.478	24.5133	102.2	155.33	116.675	13.188	107.350	126.000
TOC, %					2.62	0.64	1.98	3.87	2.02	0.56	1.38	3.42	0.064	0.01925	0.036	0.08	0.063	0.037	0.036	0.089
Sodium	877.40	511.98	101.00	1644.00	490.82	197.64	87.40	722.20	389.85	182.44	50.60	655.50	2488.25	290.929	2134	2811	3823.500	1140.563	3017.000	4630.000
Potassium	194.40	163.34	12.00	541.00	249.46	91.77	66.47	336.26	130.59	62.02	15.64	211.14	1281.75	107.314	1130	1382	1868.000	541.644	1485.000	2251.000
Calcium	312.73	210.89	72.00	699.00	144.60	45.93	52.00	192.00	81.40	29.81	24.00	122.00	292.073	31.0855	251.65	319.37	277.795	63.336	233.010	322.580
Magnesium	999.13	506.88	191.00	1714.00	223.80	113.32	37.20	428.40	170.88	89.45	18.00	280.80	909.568	123.479	792.42	1026	1691.490	1075.524	930.980	2452.000
Chloride,(Cl^-), mg/kg													1980.75	353.436	1544	2268	1453.295	1051.758	709.590	2197.000
Sulphate, (SO_4^{2-}), mg/kg													105.593	63.1273	14.23	148.2	138.010	15.825	126.820	149.200
Nitrate (NO_3^-), mg/kg	3.71	0.39	2.90	4.24									2.3225	0.31679	1.89	2.65	5.045	0.177	4.920	5.170
Carbonate (CO_3^{2-}), %													0.6175	0.74218	0.02	1.55	0.815	0.643	0.360	1.270
Aliphatic hydrocarbon, mg/kg													26.135	9.02136	18.52	36.22	7.010	3.635	4.440	9.580

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PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max
TPH,					2.39	0.65	1.54	3.26	1.82	0.51	1.19	2.87	32.3325	12.3992	20.2	44.03	8.585	5.028	5.030	12.140
THC,													30.4025	9.81606	18.52	39.54	9.700	6.958	4.780	14.620
Oil and Grease					2.90	0.76	1.96	4.15	2.41	0.50	1.78	3.19	33.4425	13.4288	19.58	45.28	10.165	8.591	4.090	16.240
BTEX																				
Phenol																				
PAH																				
Cadmium (Cd)					1.34	0.52	0.88	2.35	0.61	0.57	0.04	2.12	1.165	0.13605	0.987	1.306	1.408	0.621	0.969	1.847
Zinc, (Zn)	13.6	7.61	4	27	22.62	7.99	9.15	33.11	16.14	7.49	6.09	29.85	63.4423	22.4294	36.715	91.045	108.535	109.714	30.955	186.114
Iron (Fe)					370.57	82.56	202.19	472.11	211.12	53.20	112.76	271.42	2559.75	311.821	2214	2844	3057.000	492.146	2709.000	3405.000
Copper (Cu)	3.82	2.18	2.00	9.00	2.33	1.01	1.10	4.66	0.68	0.63	0.12	2.20	8.75925	2.6404	4.869	10.634	8.913	0.433	8.606	9.219
Chromium (Cr)	7.46	4.01	2.00	15.00	1.60	1.54	0.26	5.59	0.94	1.63	0.08	5.29	10.778	1.59252	8.945	12.806	11.716	0.543	11.332	12.100
Nickel (Ni)	7.46	4.01	2.00	15.00	1.07	0.39	0.55	1.59	0.43	0.31	0.12	1.23					0.000			
Lead (Pb)	3.63	1.30	2.00	6.00	2.09	1.49	0.55	4.66	0.81	0.91	0.12	3.21					0.000			
Vanadium (V)	12.85	5.44	8.00	25.00	0.01	0.00	0.01	0.02					14.126	1.58369	12.346	15.869	14.258	1.925	12.896	15.619

PARAMETERS	2001				2012 DRY				2012 WET				2018 WET				2018 CONTROL			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max
Arsenic (As)													69.5535	10.8848	54.912	80.817	102.386	44.948	70.603	134.169
Mercury (Hg)																				
Barium (Ba)	15.17	4.86	8.00	24.00	2.63	1.26	0.40	4.59	0.65	0.57	0.05	1.35								
Manganese (Mn)					66.25	21.74	34.51	106.52	55.31	17.20	29.19	80.52	19.3553	2.66236	16.241	22.706	31.654	4.627	28.382	34.926
Silver (Ag)																				
Cobalt (Co)													15.5043	3.1285	12.485	19.764	16.818	1.327	15.879	17.756
HUB, x104 cfu/g													1.04333	0.03786	1	1.07	1.200		1.200	1.200
THB, x104 cfu/g					3.63	0.88	2.54	4.97	3.37	0.93	2.21	5.43	1.8875	1.16931	1	3.5	4.600	0.141	4.500	4.700
HUF, x104 cfu/g					6.75	1.99	3.79	8.81	5.45	1.57	3.98	9.28	1							
TF, x104 cfu/g					1.34	0.40	0.78	1.92	0.83	0.49	0.21	1.79	1.3125	0.52974	1	2.1	3.100	0.141	3.000	3.200
SRB , x103 cfu/g					2.95	0.81	1.77	3.92	2.38	0.87	1.18	4.27								

APPENDIX 10: Checklist and Relative abundance of Phytoplankton in the FYIP NAG field (2018)

	NAG SW1	NAG SW2	NAG SW3	NAG SW4	Total	%Total	NAG SW CNTRL1	NAG SW CNTRL 2	Total	%Total
Bacillariophyta										
Achnanthes affinis	0	0	18	11	29	0.34	69	60	129	2.36
Achnanthes	0	0	0	0	0	0.00	0	0	0	0.00
Amphiprora costata	35	39	11	38	123	1.46	57	56	113	2.07
Amphora ovalis	75	0	71	0	146	1.74	0	62	62	1.14
Bacillaria paradoxa	23	24	25	38	110	1.31	25	24	49	0.90
Bacteriastrum	0	0	0	0	0	0.00	0	0	0	0.00
Biddulphia aurita	0	0	0	0	0	0.00	0	0	0	0.00
Biddulphia laevis	29	0	73	0	102	1.21	0	0	0	0.00
Biddulphia. Sp	4	10	45	15	74	0.88	69	59	128	2.34
Biddulphia longicruris	3	16	29	17	65	0.77	24	16	40	0.73
Chaetoceros decepens	22	10	48	0	80	0.95	22	11	33	0.60
Chaetoceros mulleri	76	0	0	0	76	0.90	36	39	75	1.37
Cheatoceros decipens	0	0	0	0	0	0.00	0	0	0	0.00
Cheatoceros didyma	31	0	0	11	42	0.50	109	105	214	3.92
Cheatoceros emeroli	34	0	0	0	34	0.40	45	45	90	1.65
corethrone sp	73	0	0	0	73	0.87	0	0	0	0.00
Coscinodiscus centalis	36	0	0	17	53	0.63	111	132	243	4.45
Coscinodiscus radiata	0	0	0	0	0	0.00	0	0	0	0.00
Coscinodiscus rothii	0	0	0	0	0	0.00	15	0	15	0.27
Cosinosira oestrupi	0	0	0	0	0	0.00	0	0	0	0.00
Cyclotella	7	60	45	47	159	1.89	47	46	93	1.70
Cyclotella striata	0	0	0	0	0	0.00	0	0	0	0.00
Cymbella lacustris	21	64	29	38	152	1.81	56	51	107	1.96
Cymbella ovals	68	27	68	0	163	1.94	76	68	144	2.64
Diatoma hiemale	0	0	0	0	0	0.00	0	0	0	0.00
Ditylum brightwelli	10	21	36	0	67	0.80	0	111	111	2.03
Eunotia gracilis	0	0	0	0	0	0.00	0	0	0	0.00

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	NAG SW1	NAG SW2	NAG SW3	NAG SW4	Total	%Total	NAG SW CNTRL1	NAG SW CNTRL 2	Total	%Total
Gyrosigma	14	31	25	11	81	0.96	15	0	15	0.27
Hantzschia amphioxys	10	56	73	0	139	1.65	0	0	0	0.00
Lauderia borealis	32	0	0	59	91	1.08	27	24	51	0.93
Leptocylindricus sp.	11	48	0	0	59	0.70	0	0	0	0.00
Aulocosiera granulata	45	18	0	15	78	0.93	28	29	57	1.04
Melosia moniliformis	0	0	0	0	0	0.00	0	0	0	0.00
N. linearis	39	43	0	17	99	1.18	82	68	150	2.75
Navicula bacillum	45	0	15	28	88	1.05	0	0	0	0.00
Navicula cuspidate	39	0	64	4	107	1.27	21	10	31	0.57
Navicula gracilis	18	26	45	38	127	1.51	12	0	12	0.22
Navicula minima	56	42	21	17	136	1.62	56	54	110	2.01
Nitzschia closterium	37	69	0	28	134	1.59	19	9	28	0.51
Nitzschia linearis	0	0	0	0	0	0.00	0	0	0	0.00
Pinnularia	0	0	0	0	0	0.00	27	28	55	1.01
Pinnularia interrupta	106	24	0	59	189	2.25	35	38	73	1.34
Pinnularia maior	0	0	0	0	0	0.00	0	0	0	0.00
Planktonella sol	45	28	14	48	135	1.61	54	47	101	1.85
Pleurosigma angulatum	31	65	79	101	276	3.28	46	45	91	1.67
Pleurosigma elongatum	47	7	9	21	84	1.00	21	10	31	0.57
Rhizosolenia erensis	0	0	28	0	28	0.33	3	0	3	0.05
Rhizosolenia longiseta	0	41	0	17	58	0.69	15	0	15	0.27
Rhizosolenia marina	0	54	5	35	94	1.12	33	36	69	1.26
Skeletonmema sp	0	25	0	69	94	1.12	32	36	68	1.24
Surirella caproni	0	26	0	0	26	0.31	48	46	94	1.72
Surirella robusta	0	0	38	0	38	0.45	23	12	35	0.64
Synedra acus	7	4	49	31	91	1.08	5	0	5	0.09
Synedra rumpens	0	20	84	34	138	1.64	46	57	103	1.89
Synedra ulna	0	0	0	0	0	0.00	0	0	0	0.00
Tabellaria fenestrata	42	50	20	0	112	1.33	9	16	25	0.46

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	NAG SW1	NAG SW2	NAG SW3	NAG SW4	Total	%Total	NAG SW CNTRL1	NAG SW CNTRL 2	Total	%Total
Thalassiosira sp.	0	0	26	51	77	0.92	18	25	43	0.79
Thalassiothrix	0	35	0	0	35	0.42	34	57	91	1.67
Thallasiothrix sp.	39	28	0	29	96	1.14	0	0	0	0.00
Triceratium sp	21	18	78	16	133	1.58	0	20	20	0.37
Sub-Total	1231	1029	1171	960	4391	52.24	1470	1552	3022	55.33
Cyanophyta										
Anabaena flos-aquae	0	0	0	0	0	0.00	0	0	0	0.00
Anabaena spiroides	0	62	0	20	82	0.98	0	10	10	0.18
Aphanozemenun flos-	0	0	0	45	45	0.54	71	32	103	1.89
Gleocapsa rupestris	0	93	0	0	93	1.11	0	38	38	0.70
Gleocapsa turgida	0	17	0	36	53	0.63	20	94	114	2.09
isocystis planktonica	44	0	54	63	161	1.92	37	62	99	1.81
Isocystis sp.	0	18	0	25	43	0.51	9	43	52	0.95
Lyngbya lutea	10	38	53	25	126	1.50	0	76	76	1.39
Lyngbya aeruginneo-	51	6	0	61	118	1.40	27	0	27	0.49
Lyngbya kutzingiana	19	0	29	65	113	1.34	0	58	58	1.06
Merismopedia elegans	20	5	89	20	134	1.59	0	42	42	0.77
Microcystis	10	0	21	0	31	0.37	0	36	36	0.66
Oscillatoria chalybalea	7	6	28	32	73	0.87	9	78	87	1.59
Oscillatoria formosa	0	0	17	29	46	0.55	0	44	44	0.81
Oscillatoria granulata	38	10	29	40	117	1.39	29	47	76	1.39
Oscillatoria limosa	65	9	27	69	170	2.02	29	82	111	2.03
Oscillatoria limosa	10	12	20	9	51	0.61	0	20	20	0.37
Oscillatoria princeps	32	45	67	24	168	2.00	10	21	31	0.57
Oscillatoria	51	106	6	9	172	2.05	38	20	58	1.06
Oscillatoria sancta	69	0	15	0	84	1.00	41	67	108	1.98
Oscillatoria	0	20	100	15	135	1.61	3	15	18	0.33
Oscillatoria	0	49	4	0	53	0.63	0	42	42	0.77
Phormedium sp	44	0	24	13	81	0.96	44	6	50	0.92

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	NAG SW1	NAG SW2	NAG SW3	NAG SW4	Total	%Total	NAG SW CNTRL1	NAG SW CNTRL 2	Total	%Total
Phormidium brevis	0	0	0	56	56	0.67	0	28	28	0.51
Phormidium	35	57	69	0	161	1.92	21	56	77	1.41
Phormidium molle	2	15	0	82	99	1.18	0	5	5	0.09
Phormidium uncinatum	45	39	0	42	126	1.50	0	14	14	0.26
Phormidium tenue	45	0	0	76	121	1.44	9	56	65	1.19
Pseudoanabaena	17	0	14	50	81	0.96	0	24	24	0.44
Syachucoccus aquatilis	0	0	0	0	0	0.00	0	0	0	0.00
Sub-Total	614	607	666	906	2793	33.23	397	1116	1513	27.70
Chlorophyta										
Closterium lineatum	0	0	0	56	56	0.67	61	10	71	1.30
C. gracile	0	45	0	10	55	0.65	45	111	156	2.86
Scenedesmus	0	0	0	0	0	0.00	0	0	0	0.00
S. quadricauda	67	7	22	36	132	1.57	39	81	120	2.20
Sub-Total	67	52	22	102	243	2.89	145	202	347	6.35
Euglenophyta										
Euglena acus	28	45	92	39	204	2.43	28	45	73	1.34
Euglena oblonga	0	0	43	45	88	1.05	21	67	88	1.61
Euglena caudate	20	0	45	38	103	1.23	0	35	35	0.64
Euglena obtuse	0	10	93	75	178	2.12	59	0	59	1.08
Sub-Total	48	55	273	197	573	6.82	108	147	255	4.67
Dinophyta										
Ceratium hirundinella	0	26	0	18	44	0.52	0	21	21	0.38
Ceratium tripos	0	45	0	0	45	0.54	27	65	92	1.68
Dinophysis caudata	20	35	15	50	120	1.43	83	0	83	1.52
Gonyaulax hurida	0	15	0	0	15	0.18	81	3	84	1.54
Peridininum sp "a'.	34	0	14	51	99	1.18	0	0	0	0.00
Peridininum sp "b'.	0	0	0	0	0	0.00	0	14	14	0.26
Pyrocystis sp.	10	10	63	0	83	0.99	0	31	31	0.57
Sub-Total	64	131	92	119	406	4.83	191	134	325	5.95

	NAG SW1	NAG SW2	NAG SW3	NAG SW4	Total	%Total	NAG SW CNTRL1	NAG SW CNTRL 2	Total	%Total
Total No. (x1000/l)	2024	1874	2224	2284	8406		2311	3151	5462	
Taxa_S	61	59	56	64			63	74		
Individuals	2084	1932	2278	2347			2373	3224		
Dominance_D	0.02306	0.0246	0.02516	0.02081			0.0226	0.01893		
Simpson_1-D	0.9769	0.9754	0.9748	0.9792			0.9774	0.9811		
Shannon_H	3.903	3.858	3.819	3.993			3.937	4.104		
Evenness_e^H/S	0.8122	0.8027	0.8138	0.8471			0.8139	0.8187		
Brillouin	3.83	3.783	3.756	3.923			3.87	4.044		
Menhinick	1.336	1.342	1.173	1.321			1.293	1.303		
Margalef	7.851	7.666	7.114	8.118			7.977	9.036		
Equitability_J	0.9494	0.9461	0.9488	0.9601			0.9503	0.9535		
Fisher_alpha	11.77	11.5	10.38	12.15			11.88	13.5		
Berger-Parker	0.05086	0.05487	0.0439	0.04303			0.04678	0.04094		
Chao-1	61	59	56	64			63	74		

APPENDIX 11: Checklist and Relative abundance of Zooplankton in the FYIP NAG field (2018)

	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL 1	SW CNTRL 2	Total	%Total
Copepoda										
Copepod nauplius usual type	6	3	0	7	16	1.21	6	4	10	1.39
Copepod nauplius longipedia type	10	8	8	4	30	2.27	12	0	12	1.67
Oithonina nanancaea venusta	0	0	4	7	11	0.83	9	4	13	1.81
Calanus finmarchicus	15	11	6	14	46	3.49	0	0	0	0.00
Copila mirabilis	3	20	14	2	39	2.96	0	0	0	0.00
Cycopina longicornis	37	15	26	0	78	5.91	3	1	4	0.56
Cyclops americanus	0	13	0	15	28	2.12	0	0	0	0.00
Diaptomus oregonensis	5	0	7	0	12	0.91	22	1	23	3.20
Eucalanus bungii	0	0	0	4	4	0.30	6	0	6	0.84
Euchaeta marina	34	0	4	0	38	2.88	12	9	21	2.92
oncaea venusta	0	22	6	0	28	2.12	34	4	38	5.29
Pseudocalanus elongatus	0	1	0	9	10	0.76	10	14	24	3.34
Scaphacalanus magus	0	14	0	15	29	2.20	4	0	4	0.56
Eutarpina sp	2	30	20	15	67	5.08	28	25	53	7.38
Sub-Total	112	137	95	92	436	33.06	146	62	208	28.97

	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL 1	SW CNTRL 2	Total	%Total
Rotifera										
Euchlanis dilatata	3	10	2	32	47	3.56	0	21	21	2.92
Asplancha primdata	7	0	9	1	17	1.29	11	11	22	3.06
Nollslca squamula	0	19	0	10	29	2.20	42	20	62	8.64
Brachionus	2	2	21	5	30	2.27	4	11	15	2.09
Kelicottia lagispina	9	35	12	7	63	4.78	2	14	16	2.23
Suchla Irigustra	2	15	12	0	29	2.20	18	0	18	2.51
Keratella testudo	41	0	0	0	41	3.11	0	16	16	2.23
Monomaratta longiseta	4	25	14	10	53	4.02	1	12	13	1.81
Lucan luna	5	4	0	0	9	0.68	17	4	21	2.92
L. climacois	14	0	57	10	81	6.14	14	0	14	1.95
L. Migerensis	7	11	2	3	23	1.74	0	7	7	0.97
Trichocerca vostei	0	1	0	11	12	0.91	6	0	6	0.84
Sub-Total	94	122	129	89	434	32.90	115	116	231	32.17
Hydrozoa										
Obelia	0	18	25	7	50	3.79	29	21	50	6.96
Polychaetes	1	28	1	0	30	2.27	35	0	35	4.87

	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL 1	SW CNTRL 2	Total	%Total
Nereid larvae	21	11	10	5	47	3.56	25	15	40	5.57
Nephtyid larvae	14	15	0	17	46	3.49	18	0	18	2.51
Sub-Total	36	72	36	29	173	13.12	107	36	143	19.92
Decapod Larvae										
shrimp larvae	4	6	3	15	28	2.12	7	5	12	1.67
Crab larvae	0	53	0	15	68	5.16	4	12	16	2.23
Sub-Total	4	59	3	30	96	7.28	11	17	28	3.90
Molluscan Larvae										
Cypris larvae	25	0	34	2	61	4.62	0	7	7	0.97
Pelecypod larvae	16	7	28	4	55	4.17	27	7	34	4.74
Veliger larvae	14	0	0	0	14	1.06	9	4	13	1.81
Sub-Total	55	7	62	6	130	9.86	36	18	54	7.52
Chaetognatha										
Sagitta	14	14	0	0	28	2.12	25	25	50	6.96
Appendicularia										
Oikopleura	0	6	0	16	22	1.67	0	4	4	0.56
Taxa_S	26	28	23	27			29	26		

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	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL 1	SW CNTRL 2	Total	%Total
Individuals	315	417	325	262			440	278		
Dominance_D	0.07019	0.05651	0.07978	0.05396			0.05298	0.05546		
Simpson_1-D	0.9298	0.9435	0.9202	0.946			0.947	0.9445		
Shannon_H	2.89	3.06	2.775	3.08			3.098	3.031		
Evenness_e^H/S	0.6922	0.7617	0.6972	0.8057			0.7638	0.7966		
Brillouin	2.74	2.928	2.642	2.894			2.967	2.86		
Menhinick	1.465	1.371	1.276	1.668			1.383	1.559		
Margalef	4.346	4.475	3.804	4.669			4.6	4.442		
Equitability_J	0.8871	0.9183	0.885	0.9345			0.92	0.9302		
Fisher_alpha	6.721	6.768	5.653	7.553			6.97	7.02		
Berger-Parker	0.1302	0.1271	0.1754	0.1221			0.09545	0.08993		
Chao-1	26	28.5	23	27			29	27		

APPENDIX 12: Checklist Relative abundance of benthos

	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL1	SW CNTRL 2	Total	%Total
Polychaete										
Capitella	1	0	1	1	3	5.56	0	0	0	0
Cirratulus sp	0	1	1	0	2	3.70	1	1	2	7.41
Cossura	0	0	1	0	1	1.85	0	0	0	0
Gycera	2	0	0	0	2	3.70	0	0	0	0
Heteromastus	0	0	1	0	1	1.85	0	0	0	0
Hyposoimus sp	1	1	0	1	3	5.56	2	0	2	7.41
Lumbrinereis	0	0	0	0	0	0.00	0	0	0	0
Nephtys incisa	0	1	0	0	1	1.85	0	0	0	0
Nereis sp	0	1	2	1	4	7.41	1	0	1	3.70
Notomastus	0	0	1	1	2	3.70	0	0	0	0
Scolopsis	0	0	0	2	2	3.70	0	0	0	0
Sternapsis	0	1	0	1	2	3.70	0	0	0	0
Marphysa	1	1	1	2	5	9.26	2	1	3	11.1
Sub-Total	5	6	8	9	28	51.8	6	2	8	29.6
Gastropods										
Tympanotonus	0	0	1	1	2	3.70	0	0	0	0
Littorina sp	0	1	0	0	1	1.85	4	1	5	18.5
Neritina	2	0	1	0	3	5.56	0	1	1	3.70
Tellina	0	0	0	0	0	0.00	0	2	2	7.41
Sub-Total	2	1	2	1	6	11.1	4	4	8	29.6
Bivalve										
Nucula	1	0	1	0	2	3.70	0	0	0	0
Stylaria	1	0	1	1	3	5.56	0	0	0	0
Sub-Total	2	0	2	1	5	9.26	0	0	0	0
Crustacea										
Tianid sp.	1	0	1	0	2	3.70	1	1	2	7.41
Isodus sp	0	0	0	0	0	0.00	0	0	0	0
Alpheus	0	1	0	1	2	3.70	1	2	3	11.1
Leplalpheus sp.	0	1	1	0	2	3.70	1	1	2	7.41
Callianasa	1	1	0	1	3	5.56	1	0	1	3.70
Gammarus	0	0	0	0	0	0.00	0	2	2	7.41
Metagraspus	1	0	1	1	3	5.56	1	0	1	3.70
Ballanus	1	0	0	0	1	1.85	0	0	0	0
Jassa	1	1	0	0	2	3.70	0	0	0	0
Taxa_S	12	11	14	12			10	9		
Individuals	14	11	15	14			15	12		
Dominance_D	0.091	0.090	0.075	0.091			0.1378	0.125		
Simpson_1-D	0.908	0.909	0.924	0.908			0.8622	0.875		

	SW1	SW2	SW3	SW4	Total	%Total	SW CNTRL1	SW CNTRL 2	Total	%Total
Shannon_H	2.441	2.398	2.616	2.441			2.154	2.138		
Evenness_e^H/	0.957	1	0.976	0.957			0.8615	0.942		
Brillouin	1.7	1.591	1.814	1.7			1.556	1.492		
Menhinick	3.207	3.317	3.615	3.207			2.582	2.598		
Margalef	4.168	4.17	4.801	4.168			3.323	3.219		
Equitability_J	0.982	1	0.991	0.982			0.9353	0.973		
Fisher_alpha	39.9	0	102.6	39.9			13.11	16.36		
Berger-Parker	0.142	0.090	0.133	0.142			0.2667	0.166		
Chao-1	27	66	53	27			17	12.75		